Linux Academy | Cloud Assessments

The Data Dossier

Choose a Section

- Introduction
- Case Studies
- Foundational Concepts
- Cloud SQL
- Cloud Datastore
- Cloud Bigtable
- Cloud Spanner
- Real Time Messaging with Cloud Pub/Sub
- Data Pipelines with Cloud Dataflow
- Cloud Dataproc
- BigQuery
- Machine Learning Concepts
- AI Platform
- Pre-trained ML API's
- Cloud Datalab
- Cloud Dataprep
- Data Studio
- Cloud Composer
- Additional Study Resources

Return to Table of Contents

Choose a Lesson
What is a Data Engineer?
Exam and Course Overview

What is a Data Engineer?

Google's definition:

A Professional Data Engineer enables data-driven decision making by collecting, transforming, and visualizing data. The Data Engineer designs, builds, maintains, and troubleshoots data processing systems with a particular emphasis on the security, reliability, fault-tolerance, scalability, fidelity, and efficiency of such systems.

The Data Engineer also analyzes data to gain insight into business outcomes, builds statistical models to support decision-making, and creates machine learning models to automate and simplify key business processes.

What does this include?

- **Build data structures and databases:**
  - **Cloud SQL, Bigtable**
- **Design data processing systems:**
  - **Dataproc, Pub/Sub, Dataflow**
- **Analyze data and enable machine learning:**
  - **BigQuery, Tensorflow, Cloud ML Engine, ML API's**
- **Match business requirements with best practices**
- **Visualize data ("make it look pretty"):**
  - **Data Studio**
- **Make it secure and reliable**

Super-simple definition:

Collect, store, manage, transform, and present data to make it useful.

Return to Table of Contents

Choose a Lesson

What is a Data Engineer?

Exam and Course Overview

Exam and Course Overview

Next

Exam format:

- 50 questions
- 120 minutes (2 hours)
- Case study + individual questions
- Mixture of high level, conceptual, and detailed questions:
  - How to convert from HDFS to GCS
  - Proper Bigtable schema
- Compared to the architect exam it is more focused and more detailed:
  - Architect exam = 'Mile wide/inch deep'
  - Data Engineer exam = 'Half mile wide, 3 inches deep'

Course Focus:

- Very broad range of topics
- Depth will roughly match exam:
  - Plus hands-on examples

Return to Table of Contents

Choose a Lesson

What is a Data Engineer?

Exam and Course Overview

Exam and Course Overview

Previous

Exam topics:

- Building data representations
- Data pipelines
- Data processing infrastructure
- Database options - differences between each
- Schema/queries
- Analyzing data
- Machine learning
- Working with business users/requirements
- Data cleansing
- Visualizing data
- Security
- Monitoring pipelines

Google Cloud services covered:

- Cloud Storage
- Compute Engine
- Dataproc
- Bigtable
- Datastore
- Cloud SQL
- Cloud Spanner
- BigQuery
- Tensorflow
- ML Engine
- Managed ML API's - Translate, Speech, Vision, etc.
- Pub/Sub
- Dataflow
- Data Studio
- Dataprep
- Datalab

Return to Table of Contents

Choose a Lesson

Case Study Overview

Flowlogistic

MJTelco

Flowlogistic Case Study

Next

Link:

https://cloud.google.com/certification/guides/data-engineer/casestudy-flowlogistic

Main themes:

- Transition existing infrastructure to cloud
- Reproduce existing workload ("lift and shift"):
  - First step into cloud transition

Primary cloud objectives:

- Use proprietary inventory-tracking system:
  - Many IoT devices - high amount of real-time (streaming) data
  - Apache Kafka stack unable to handle data ingest volume
  - Interact with both SQL and NoSQL databases
  - Map to Pub/Sub - Dataflow:
    - Global, scalable
- Hadoop analytics in the cloud:
  - Dataproc - managed Hadoop
  - Different data types
  - Apply analytics/machine learning

Other technical considerations:

- Emphasis on data ingest:
  - Streaming and batch
- Migrate existing workload to managed services:
  - SQL - Cloud SQL:
    - Cloud Spanner if over 10TB and global availability needed
  - Cassandra - NoSQL (wide-column store) - Bigtable
  - Kafka - Pub/Sub, Dataflow, BigQuery
- Store data in a 'data lake':
  - Further transition once in the cloud
  - Storage = Cloud Storage, Bigtable, BigQuery
  - Migrate from Hadoop File System (HDFS)

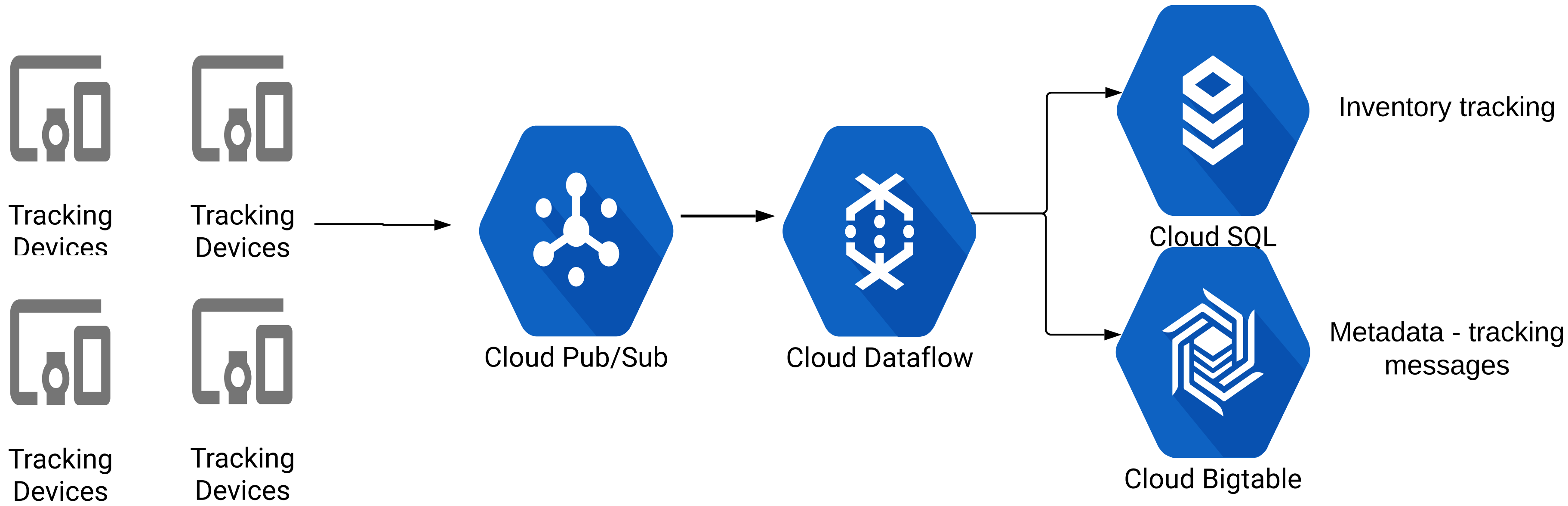
Return to Table of Contents

Flowlogistic Case Study

Choose a Lesson
Case Study Overview
Flowlogistic
MJTelco

Previous
Next

Inventory Tracking Data Flow



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Case Study Overview

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Pub/Sub is used for streaming (real-time) data ingest. Allows asynchronous (many-to-many) messaging via published and subscribed messages.

Choose a Lesson

Case Study Overview

Flowlogistic

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X

Cloud Dataflow is a data processing pipeline, transforming both stream and batch data.

Return to Table of Contents

Choose a Lesson

Case Study Overview

Flowlogistic

MJTelco

X

Cloud SQL is a fully managed MySQL and PostgreSQL database. It is a perfect transition step for migrating SQL workloads.

Return to Table of Contents

Choose a Lesson
Case Study Overview
Flowlogistic
MJTelco

X

Cloud Bigtable is a managed, massively scalable non-relational/NoSQL database based on HBase.

Return to Table of Contents

Choose a Lesson

Case Study Overview

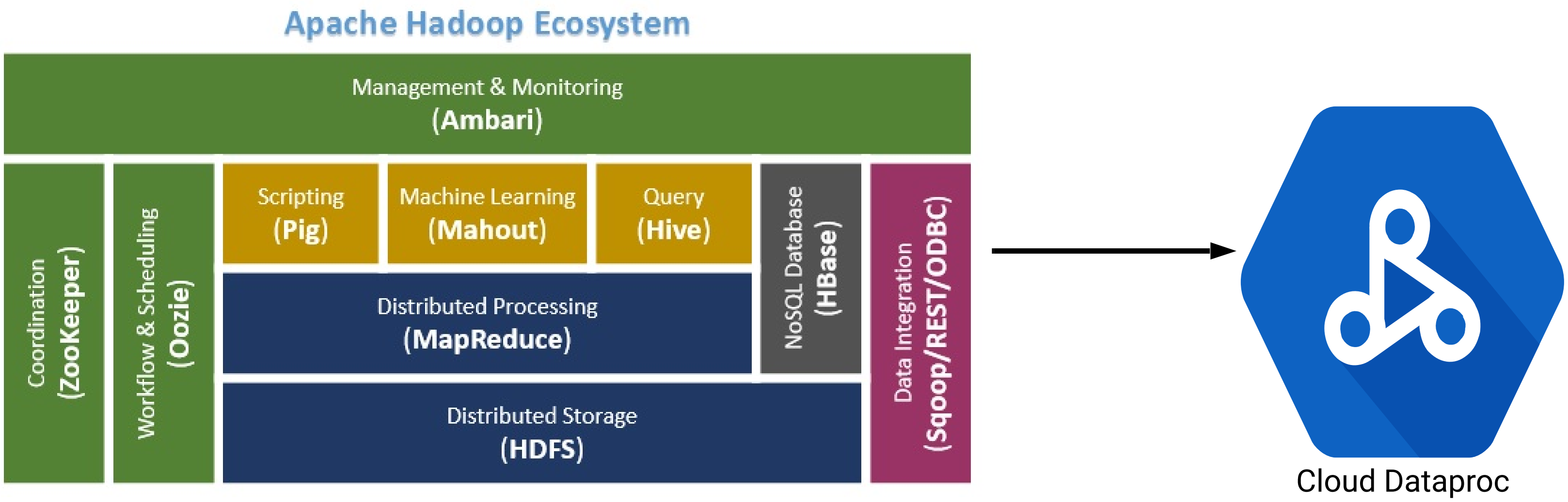
Flowlogistic

MJTelco

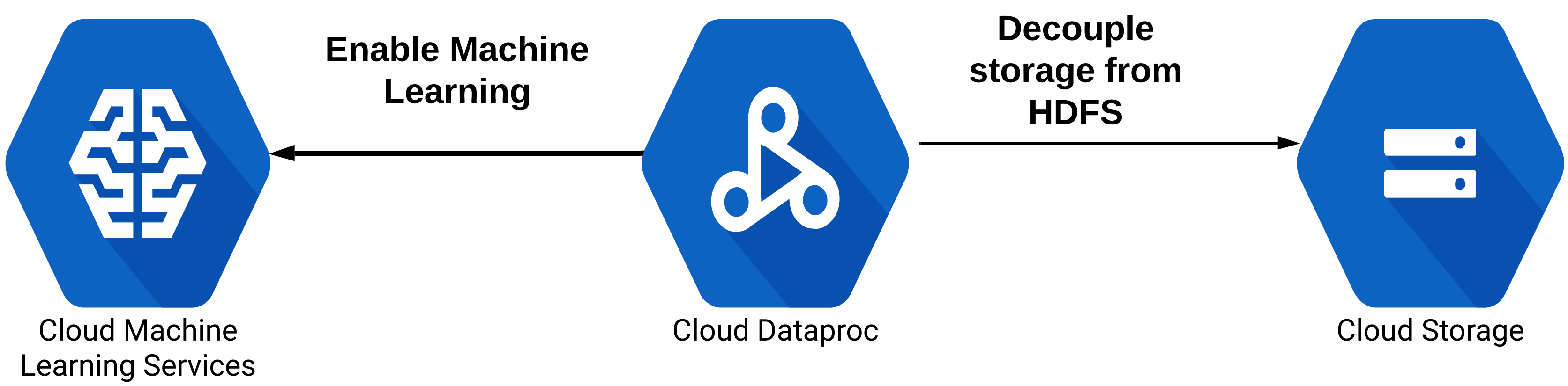
Flowlogistic Case Study

Previous

Phase 1: Initial migration of existing Hadoop analytics



Phase 2: Integrate other Google Cloud Services



Return to Table of Contents

Choose a Lesson

Case Study Overview

Flowlogistic

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X

Cloud Dataproc offers fully managed Apache, Hadoop, and Spark cluster management. It integrates easily with other GCP services.

Return to Table of Contents

Choose a Lesson

Case Study Overview

Flowlogistic

MJTelco

X

Managed machine learning service for predictive analytics.

Return to Table of Contents

Choose a Lesson

Case Study Overview

Flowlogistic

MJTelco

X

Decoupling storage from the Dataproc cluster allows for destroying the cluster when the job is complete as well as widely available, high-performance storage.

Return to Table of Contents

Choose a Lesson
Case Study Overview
Flowlogistic
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Case Study Overview

- Exam has 2 possible case studies
- Exam case studies available from Google's training site:
  https://cloud.google.com/certification/guides/data-engineer
- Different 'themes' to each case study = insight to possible exam questions
- Very good idea to study case studies in advance!
- Case study format:
  - Company Overview
  - Company Background
  - Solution Concept – current goal
  - Existing Technical Environment – where they are now
  - Requirements – boundaries and measures of success
  - C-level statements – what management cares about

Return to Table of Contents

Choose a Lesson

Case Study Overview

Flowlogistic

MJTelco

MJTelco Case Study

Next

Link:

https://cloud.google.com/certification/guides/data-engineer/casestudy-mjtelco

Main themes:

- No legacy infrastructure - fresh approach
- Global data ingest

Primary Cloud Objectives:

- Accept massive data ingest and processing on a global scale:
  - Need no-ops environment
  - Cloud Pub/Sub accepts input from many hosts, globally
- Use machine learning to improve their topology models

Other technical considerations:

- Isolated environments:
  - Use separate projects
- Granting access to data:
  - Use IAM roles
- Analyze up to 2 years worth of telemetry data:
  - Store in Cloud Storage or BigQuery

Return to Table of Contents

Choose a Lesson

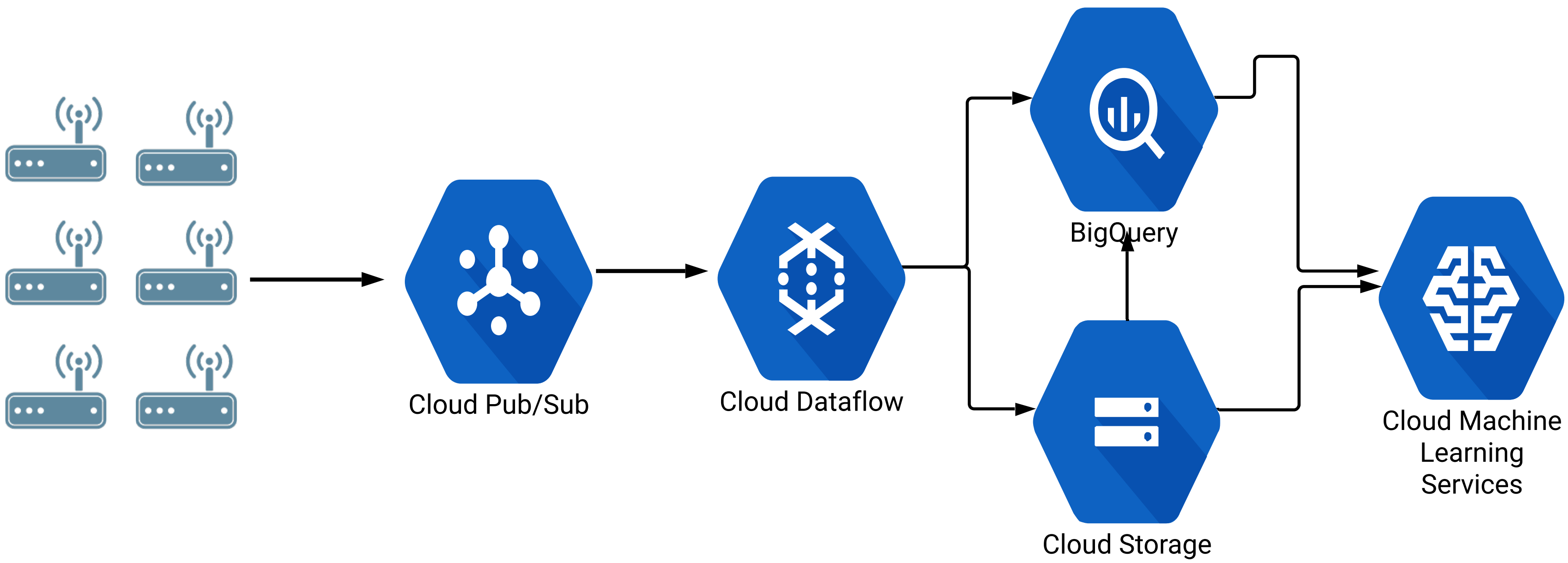
Case Study Overview

Flowlogistic

MJTelco

Previous

Data Flow Model



Return to Table of Contents

Choose a Lesson

Case Study Overview

Flowlogistic

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X

Cloud Storage provides globally available, long-term, high-performance storage for all data types.

Choose a Lesson

Case Study Overview

Flowlogistic

MJTelco

X

Cloud Dataflow is a data processing pipeline, transforming both stream and batch data.

Return to Table of Contents

Choose a Lesson

Case Study Overview

Flowlogistic

MJTelco

X

BigQuery is a no-ops data warehouse used for massively scalable analytics.

Return to Table of Contents

Choose a Lesson
Case Study Overview
Flowlogistic
MJTelco

X

Managed machine learning service for predictive analytics.

Return to Table of Contents

Choose a Lesson

Data Lifecycle

Batch and Streaming Data

Cloud Storage as Staging Ground

Database Types

Monitoring Unmanaged Databases

Data Lifecycle

Next

- Think of data as a tangible object to be collected, stored, and processed
- Lifecycle from initial collection to final visualization
- Needs to be familiar with the lifecycle steps, what GCP services are associated with each step, and how they connect together
- Data Lifecycle steps:
  - Ingest - Pull in the raw data:
    - Streaming/real-time data from devices
    - On-premises batch data
    - Application logs
    - Mobile-app user events and analytics
  - Store - data needs to be stored in a format and location that is both reliable and accessible
  - Process and analyze - Where the magic happens. Transform data from raw format to actionable information
  - Explore and visualize - "Make it look pretty"
    - The final stage is to convert the results of the analysis into a format that is easy to draw insights from and to share with colleagues and peers

Return to Table of Contents

Choose a Lesson

Data Lifecycle

Batch and Streaming Data

Cloud Storage as Staging Ground

Database Types

Monitoring Unmanaged Databases

Data Lifecycle

Previous

Next

Data Lifecycle and Associated Services

Ingest	Store	Process & Analyze	Explore & Visualize
App Engine	Cloud Storage	Cloud Dataflow	Cloud Datalab
Compute Engine	Cloud SQL	Cloud Dataproc	Google Data Studio
Kubernetes Engine	Cloud Datastore	BigQuery	Google Sheets
Cloud Pub/Sub	Cloud Bigtable	Cloud ML	
Stackdriver Logging	BigQuery	Cloud Vision API	
Cloud Transfer Service	Cloud Storage for Firebase	Cloud Speech API	
Transfer Appliance	Cloud Firestore	Translate API	
	Cloud Spanner	Cloud Natural Language API	
		Cloud Dataprep	
		Cloud Video Intelligence API	

Return to Table of Contents

Choose a Lesson

Data Lifecycle

Batch and Streaming Data

Cloud Storage as Staging Ground

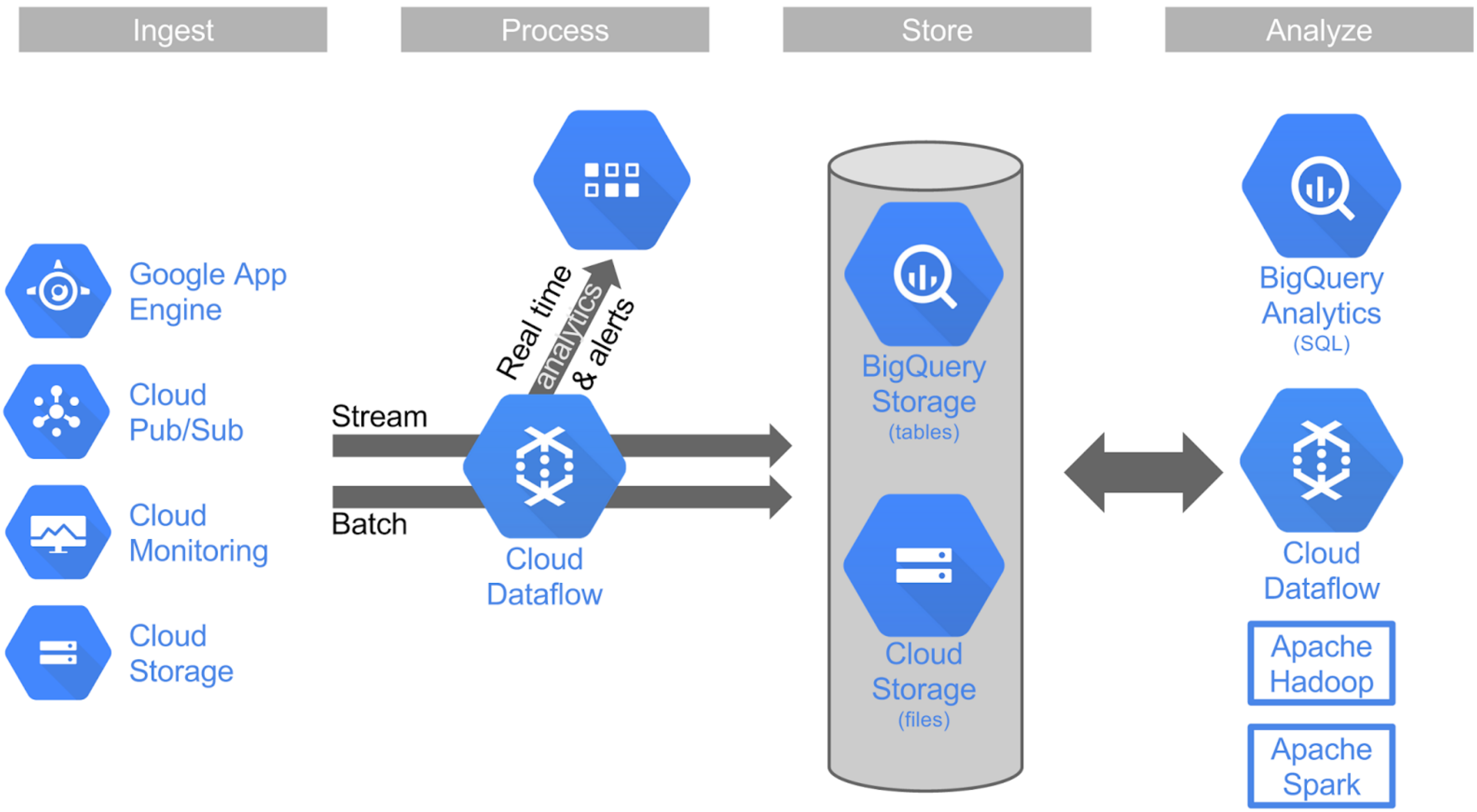
Database Types

Monitoring Unmanaged Databases

Previous

Next

Data Lifecycle is not a Set Order



Return to Table of Contents

Choose a Lesson

Data Lifecycle

Batch and Streaming Data

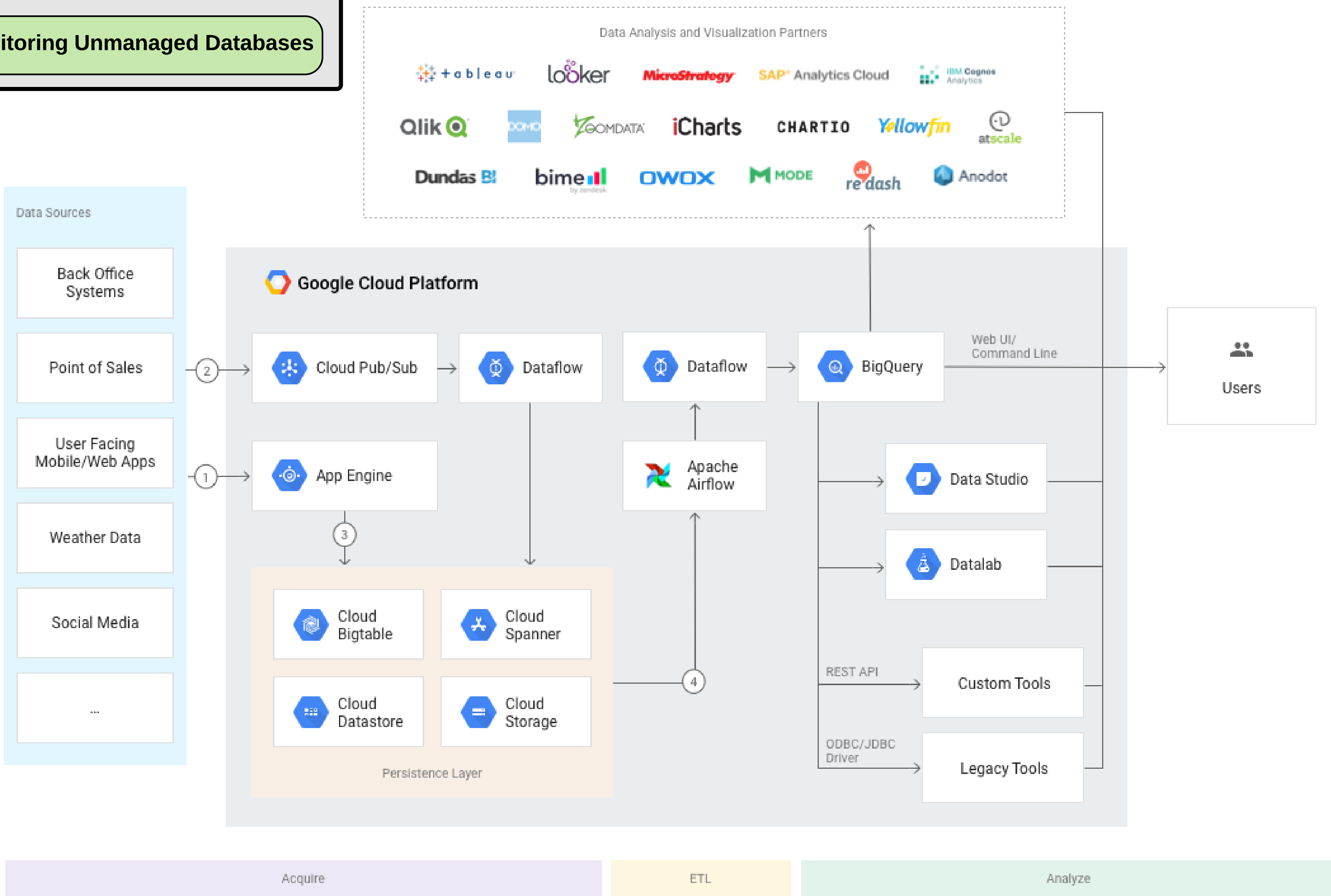
Cloud Storage as Staging Ground

Database Types

Monitoring Unmanaged Databases

Previous

Increasing Complexity of Data Flow



Return to Table of Contents

Choose a Lesson

Data Lifecycle

Batch and Streaming Data

Cloud Storage as Staging Ground

Database Types

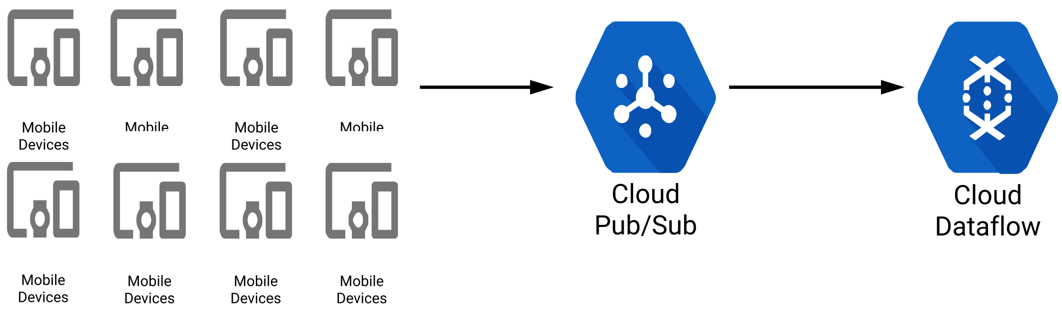
Monitoring Unmanaged Databases

Streaming and Batch Data

Data Lifecycle = Data Ingest

Streaming (or real-time) data:

- Generated and transmitted continuously by many data sources
- Thousands of data inputs, sent simultaneously, in small sizes (KB)
- Commonly used for telemetry - collecting data from a high number of geographically dispersed devices as it's generated
- Examples:
  - Sensors in transportation vehicles - detecting performance and potential issues
  - Financial institution tracks stock market changes
- Data is processed in small pieces as it comes in
- Requires low latency
- Typically paired with Pub/Sub for the streaming data ingest and Dataflow for real-time processing



Batch (or bulk) data:

- Large sets of data that 'pool' up over time
- Transferring from a small number of sources (usually 1)
- Examples:
  - On-premise database migration to GCP
  - Importing legacy data into Cloud Storage
  - Importing large datasets for machine learning analysis
  - gsutil cp [storage_location] gs://[BUCKET] is an example of batch data import
- Low latency is not as important
- Often stored in storage services such as cloud storage, CloudSQL, BigQuery, etc.

Return to Table of Contents

Choose a Lesson
Data Lifecycle
Batch and Streaming Data
Cloud Storage as Staging Ground
Database Types
Monitoring Unmanaged Databases

Cloud Storage

Cloud Storage as Staging Ground

Next

Storage 'swiss army knife':

- GCS holds all data types:
  - All database transfer types, raw data, any format
- Globally available:
  - Multi-regional buckets provide fast access across regions
  - Regional buckets provide fast access for single regions
  - Edge caching for increased performance
- Durable and reliable:
  - Versioning and redundancy
- Lower cost than persistent disk
- Control access:
  - Project, bucket, or object level
  - Useful for ingest, transform, and publish workflows
  - Option for Public read access

Data Engineering perspective:

- Migrating existing workloads:
  - Migrate databases/data into Cloud Storage for import
- Common first step of data lifecycle - get data to GCS
- Staging area for analysis/processing/machine learning import:
  - 'Data lake'

Return to Table of Contents

Choose a Lesson

Data Lifecycle

Batch and Streaming Data

Cloud Storage as Staging Ground

Database Types

Monitoring Unmanaged Databases

Getting data in and out of Cloud Storage

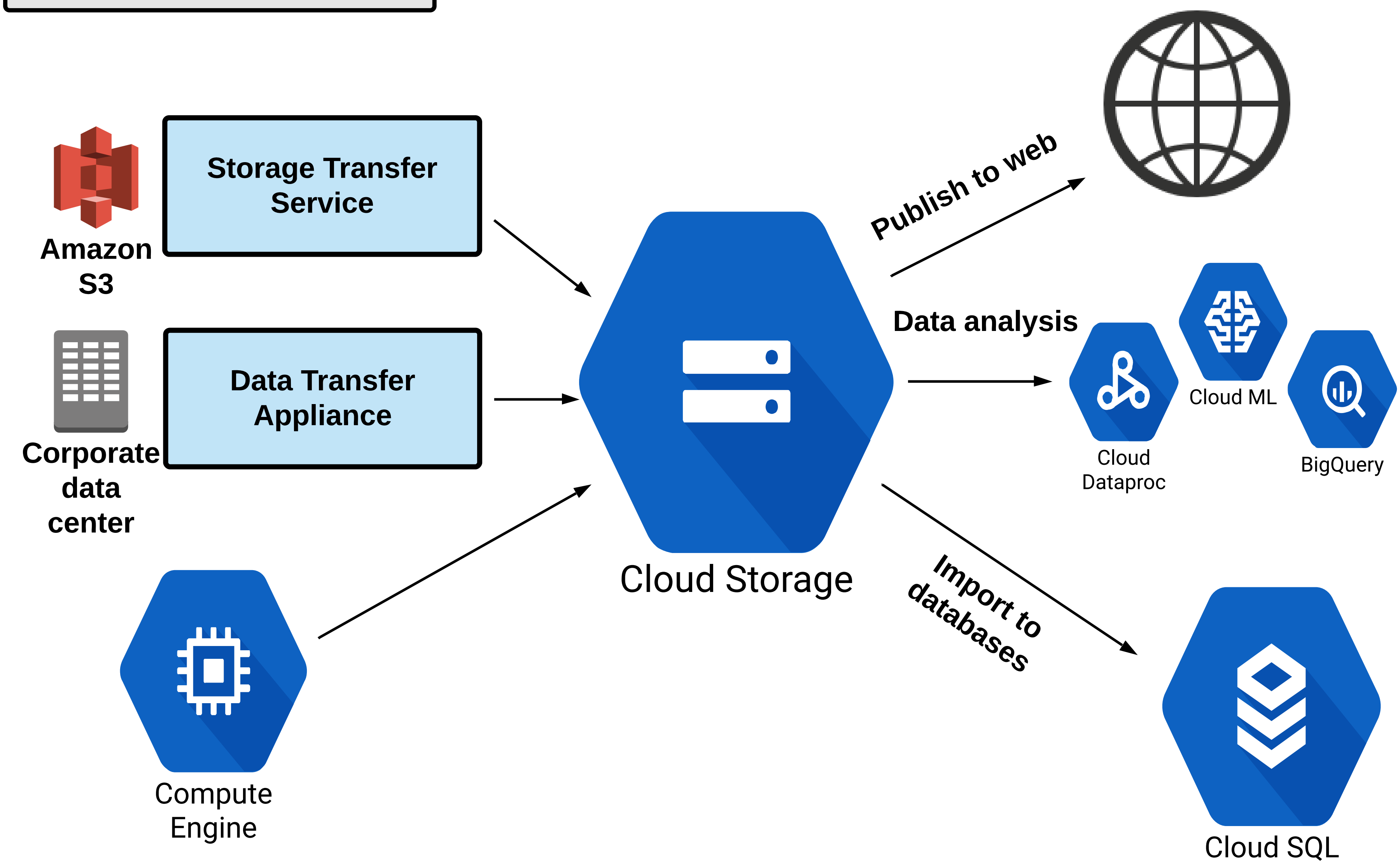
Previous

Storage Transfer Service - S3, GCS, HTTP --> GCS:

- **One time transfer, periodic sync**

Data Transfer Appliance - physically shipped appliance:

- **Load up to 1 petabyte, ship to GCP, loaded into bucket**
- **gsutil, JSON API - "gsutil cp ..."**



Return to Table of Contents

Database Types

Choose a Lesson

Data Lifecycle

Batch and Streaming Data

Cloud Storage as Staging Ground

Database Types

Monitoring Unmanaged Databases

Next

Two primary database types:

- Relational/SQL
- Non-relational/NoSQL

Relational (SQL) database:

- SQL = Structured Query Language
- Structured and standardized:
  - Tables - rows and columns
- Data integrity
- High Consistency
- ACID compliance:
  - Atomicity, Consistency, Isolation, Durability
- Examples:
  - MySQL, Microsoft SQL Server, Oracle, PostgreSQL
- Applications:
  - Accounting systems, inventory
- Pros:
  - Standardized, consistent, reliable, data integrity
- Cons:
  - Poor scaling, not as fast performing, not good for semi-structured data
- "Consistency and reliability over performance"

Return to Table of Contents

Choose a Lesson

Data Lifecycle

Batch and Streaming Data

Cloud Storage as Staging Ground

Database Types

Monitoring Unmanaged Databases

Database Types

Previous

Non-relational (NoSQL) Database:

- **Non-structured (no table)**
- **Different standards - key/value, wide table**
- **Some have ACID compliance (Datastore)**
- **Examples:**
  - **Redis, MongoDB, Cassandra, HBase, Bigtable, RavenDB**
- **Application:**
  - **Internet of Things (IoT), user profiles, high-speed analytics**
- **Pros:**
  - **Scalable, high-performance, not structure-limited**
- **Cons:**
  - **Eventual consistency, data integrity**
- **"Performance over consistency"**

Exam expectations:

- **Understand descriptions between database types**
- **Know which database version matches which description**
- **Example:**
  - **"Need database with high throughput, ACID compliance not necessary, choose three possible options"**

Return to Table of Contents

Choose a Lesson

Data Lifecycle

Batch and Streaming Data

Cloud Storage as Staging Ground

Database Types

Monitoring Unmanaged Databases

Monitoring Unmanaged Databases

Logging and Monitoring in Unmanaged (GCE) Databases

- Examples: Cassandra, MySQL, MariaDB, MongoDB, HBase
- Hosted on Google Compute Engine instances

Built In vs. Additional Monitoring

- Built in = no additional configuration needed
  - No application-level data
- **Stackdriver Logging**
  - Audit logs
    - "Who created this instance?"
  - Does not include application logs
- **Stackdriver Monitoring**
  - Instance performance metrics
    - Disk I/O, CPU usage, network connections
  - No application performance metrics

What if we want application data?

- Use **Stackdriver Agents** – install and configure for the instance

Logging agent vs. **Monitoring agent**

- Logging Agent = Stackdriver Logging = Application Logs
  - Configure with **Fluentd**
- Monitoring Agent = Stackdriver Monitoring = Application performance/metrics/alerts
  - May require plugin configuration

Return to Table of Contents

Choose a Lesson

Choosing a Managed Database

Cloud SQL Basics

Importing Data

SQL Query Best Practices

Choosing a Managed Database

Next

Big picture perspective:

- At minimum, know which managed database is the best solution for any given use case:
  - Relational, non-relational?
  - Transactional, analytics?
  - Scalability?
  - Lift and shift?

	Relational		Non-relational		Object - Unstructured	Data Warehouse
	Cloud SQL	Cloud Spanner	Cloud Datastore	Cloud Bigtable	Cloud Storage	BigQuery
Use Case	Structured data Web framework	RDBMS+scale High transactions	Semi-structured Key-value data	High throughput analytics	Unstructured data Holds everything	Mission critical apps Scale+consistency
e.g.	Medical records Blogs	Global supply chain Retail	Product catalog Game state	Graphs IoT Finance	Multimedia Analytics Disaster recovery	Large data analytics Processing using SQL

Return to Table of Contents

Choose a Lesson

Choosing a Managed Database

Cloud SQL Basics

Importing Data

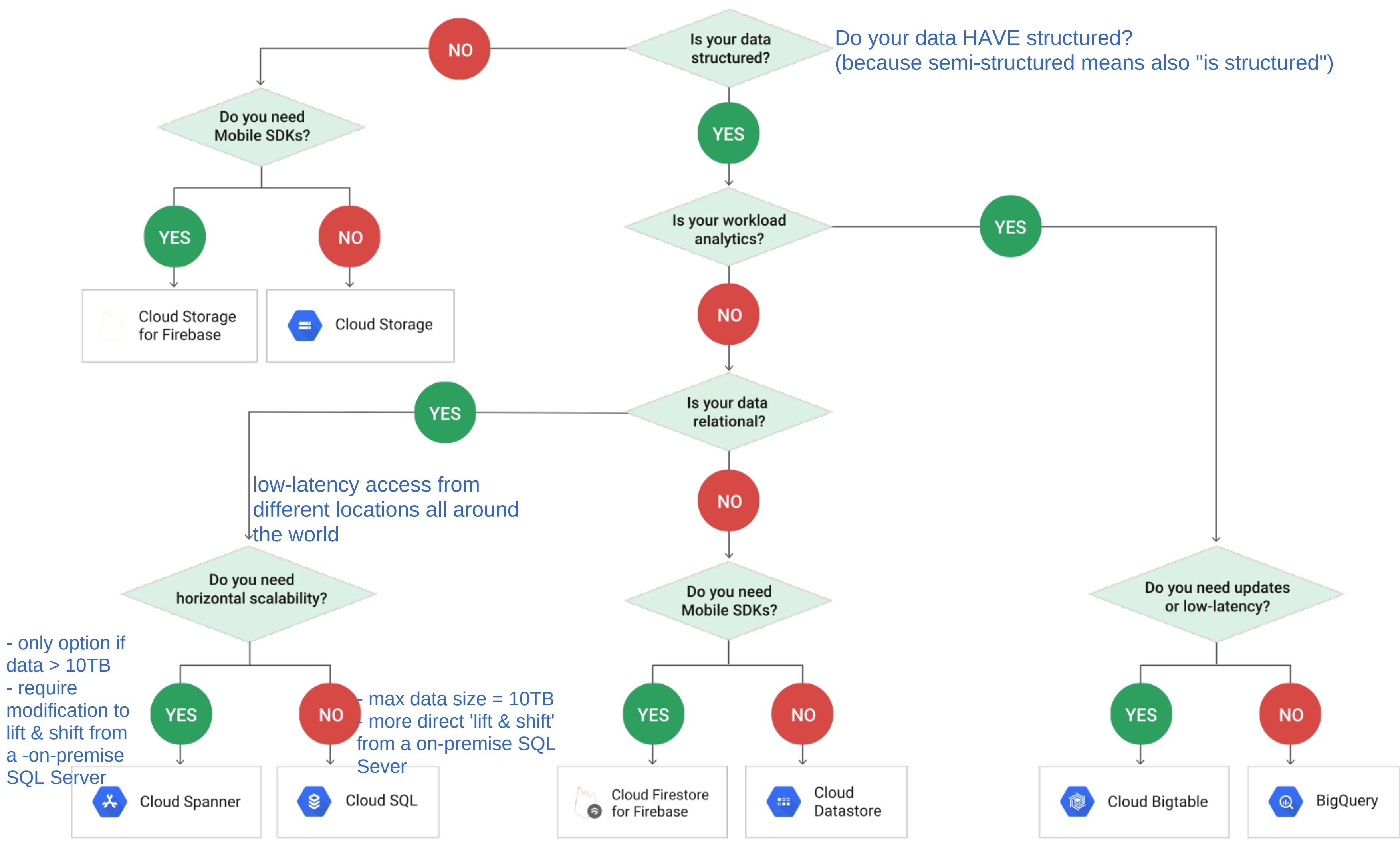
SQL Query Best Practices

Choosing a Managed Database

Previous

Decision tree criteria:

- **Structured (database) or unstructured?** structured store or unstructured store
- **Analytical or transactional?**
- **Relational (SQL) or non-relational (NoSQL)?**
- **Scalability/availability/size requirements?**



Return to Table of Contents

Choose a Lesson

Choosing a Managed Database

Cloud SQL Basics

Importing Data

SQL Query Best Practices

Cloud SQL Basics

What is Cloud SQL?

(resume) is MySQL/PostgreSQL however it's in Managed Format

- **Direct lift and shift of traditional MySQL/PostgreSQL workloads with the maintenance stack managed for you**

What is managed?

- **OS installation/management**
- **Database installation/management**
- **Backups**
- **Scaling - disk space** (if we need to increase the disk size?)
- **Availability:**
  - **Failover**
  - **Read replicas**
- **Monitoring**
- **Authorize network connections/proxy/use SSL**

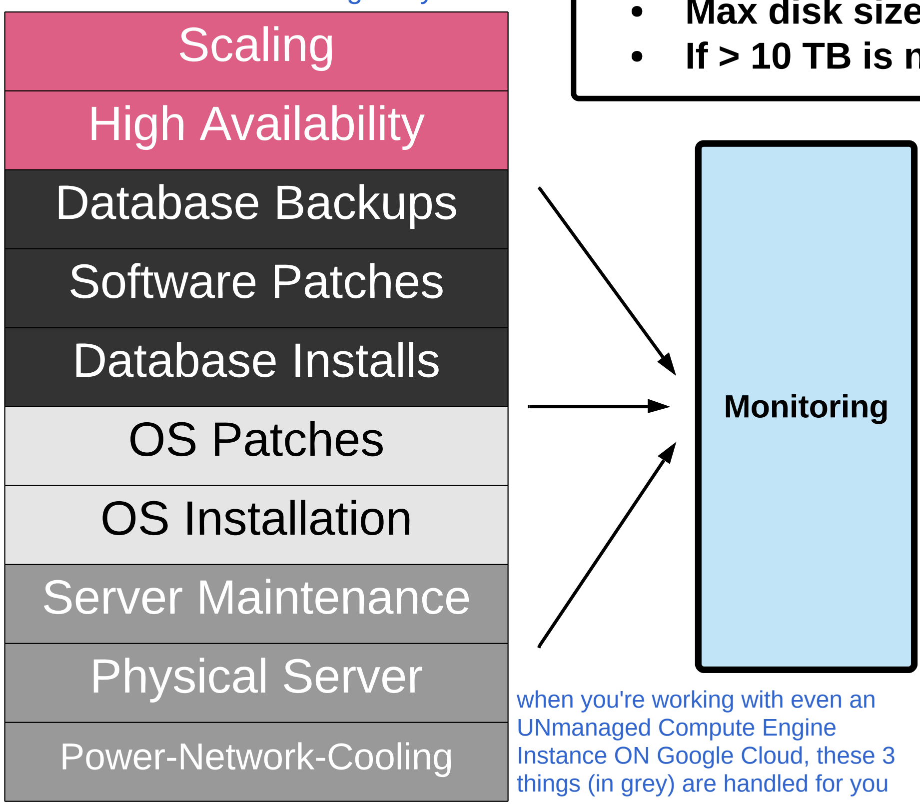
Limitations:

that's not True anymore ???? because the Cross-region read replicas is available now !!!

- **Read replicas limited to the same region as the master:**
  - **Limited global availability**
- **Max disk size of 10 TB**
- **If > 10 TB is needed, or global availability in RDBMS, use Spanner**

failover: a method of protecting computer systems from failure, in which standby equipment automatically takes over when the main system fails.

Maintenance Stack Managed by GCP



In Cloud SQL:
- high memory machine -> high network throughput
- more storage capacity -> more disk throughput/IOPS
- read replicas
  + near realtime replication from master instance
  + offload read requests or analytic traffic from master

when you're working with even an UNmanaged Compute Engine Instance ON Google Cloud, these 3 things (in grey) are handled for you

Return to Table of Contents

Choose a Lesson
Choosing a Managed Database
Cloud SQL Basics
Importing Data
SQL Query Best Practices

Importing Data

Importing data into Cloud SQL:

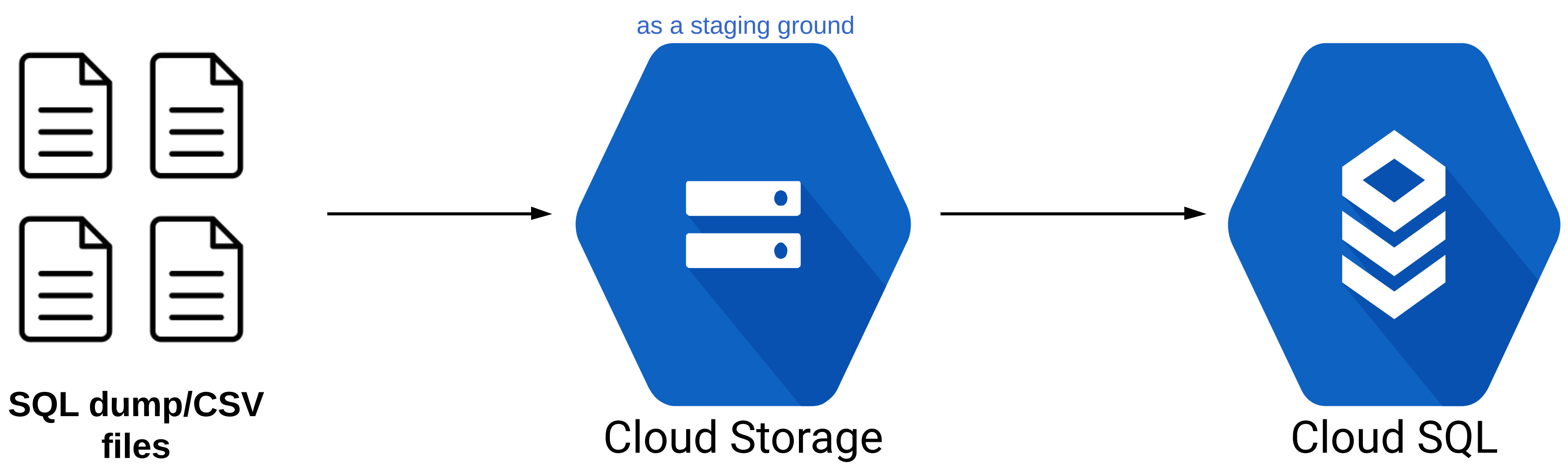
- Cloud Storage as a staging ground
- SQL dump/CSV file format

Export/Import process:

- Export SQL dump/CSV file:
  - SQL dump file cannot contain triggers, views, stored procedures
- Get dump/CSV file into Cloud Storage
- Import from Cloud Storage into Cloud SQL instance

Best Practices:

- Use correct flags for dump file (--'flag_name'):
  - Databases, hex-blob, skip-triggers, set-gtid-purged=OFF, ignore-table
- Compress data to reduce costs:
  - Cloud SQL can import compressed .gz files
- Use InnoDB for Second Generation instances



Return to Table of Contents

Choose a Lesson

Choosing a Managed Database

Cloud SQL Basics

Importing Data

SQL Query Best Practices

SQL Query Best Practices

General SQL efficiency best practices:

- More, smaller tables better than fewer, large tables:
  - Normalization of tables
- Define your SELECT fields instead of using SELECT *:
  - SELECT * acts as a 'select all'
- When joining tables, use INNER JOIN instead of WHERE:
  - WHERE creates more variable combinations = more work

Return to Table of Contents

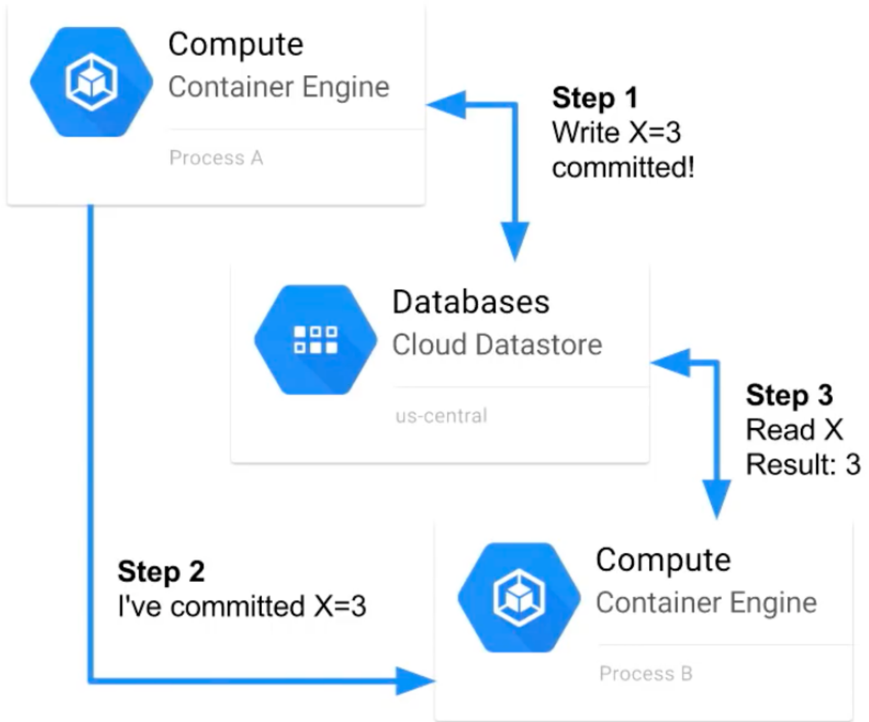
Choose a Lesson

Cloud Datastore Overview
Data Organization
Queries and Indexing
Data Consistency

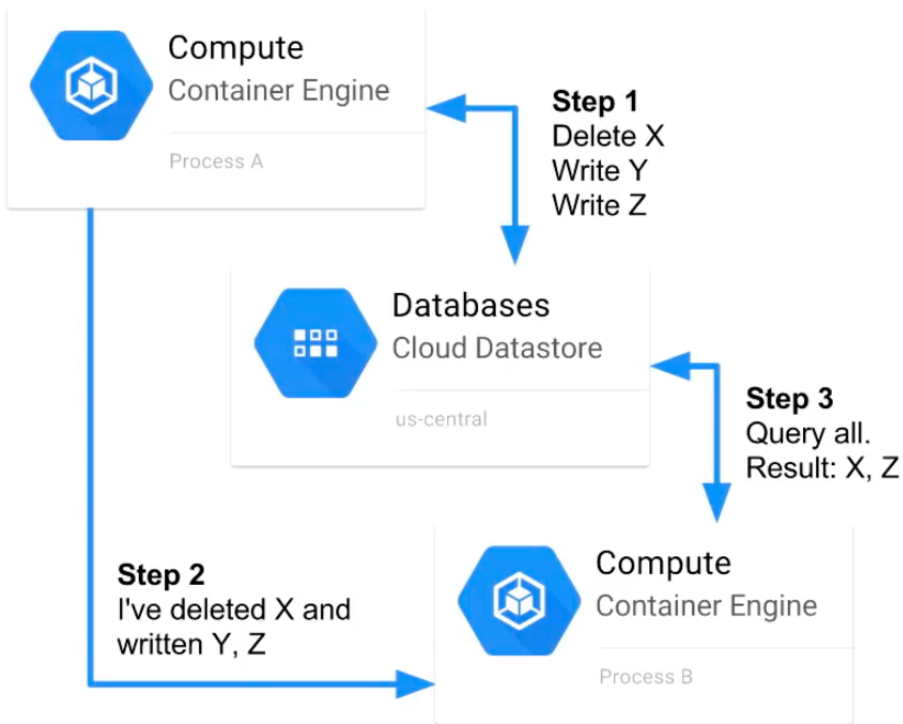
Data Consistency

Previous

Strong



Eventual



Return to Table of Contents

Choose a Lesson

Cloud Datastore Overview

Data Organization

Queries and Indexing

Data Consistency

Data Consistency

Next

What is data consistency in queries?

- "How up to date are these results?"
- "Does the order matter?"
- Strongly consistent = Parallel processes see changes in same order:
  - Query is guaranteed up to date but may take longer to complete
- Eventually consistent = Parallel process can see changes out of order, will eventually see accurate end state:
  - Faster query, but may *sometimes* return stale results
- Performance vs. accuracy
- Ancestor query/key-value operations = strong
- Global queries/projections = eventual

Use cases:

- Strong - financial transaction:
  - Make deposit -- check balance
- Eventual - census population:
  - Order not as important, as long as you get eventual result

Return to Table of Contents

Choose a Lesson

Cloud Datastore Overview

Data Organization

Queries and Indexing

Data Consistency

Queries and Indexing

Previous

Danger - Exploding Indexes!

- **Default - create an entry for every possible combination of property values**
- **Results in higher storage and degraded performance**
- **Solutions:**
  - **Use a custom index.yaml file to narrow index scope**
  - **Do not index properties that don't need indexing**

Return to Table of Contents

Choose a Lesson

Cloud Datastore Overview

Data Organization

Queries and Indexing

Data Consistency

```
indexes:
- kind: Task
  properties:
  - name: tags
  - name: created
- kind: Task
  properties:
  - name: collaborators
  - name: created
```

Queries and Indexing

Next

Query:

- Retrieve an entity from Datastore that meets a set of conditions
- Query includes:
  - Entity kind
  - Filters
  - Sort order
- Query methods:
  - Programmatic
  - Web console
  - Google Query Language (GQL)

Indexing:

- Queries gets results from indexes:
  - Contain entity keys specified by index properties
  - Updated to reflect changes
  - Correct query results available with no additional computation needed

Index types:

- Built-in - default option:
  - Allows single property queries
- Composite - specified with an index configuration file (index.yaml):
  - gcloud datastore create-indexes index.yaml

Return to Table of Contents

Data Organization

Choose a Lesson

Cloud Datastore Overview

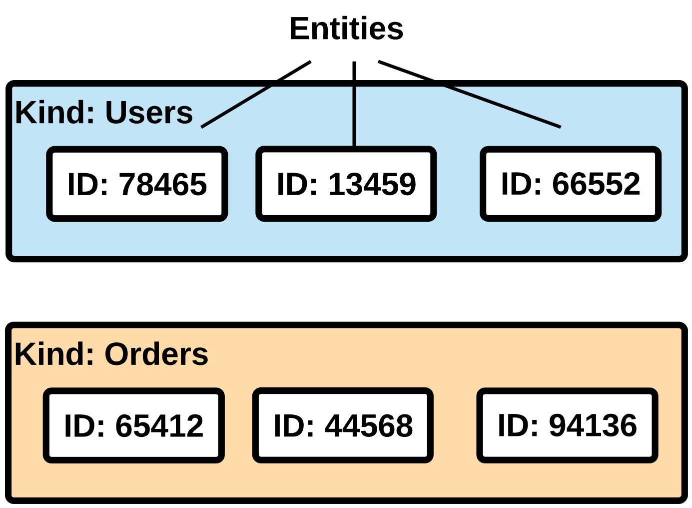
Data Organization

Queries and Indexing

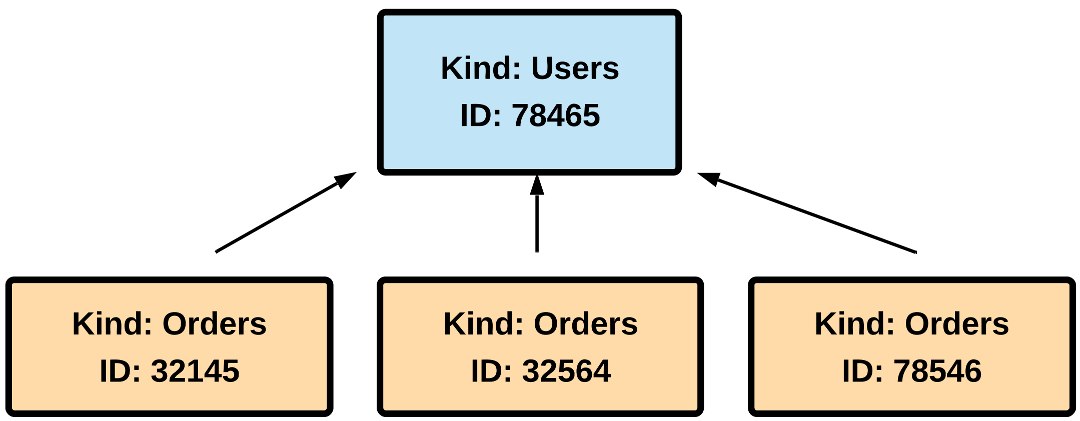
Data Consistency

Previous

Simple Collections of Entities



Hierarchies (Entity Groups)



Return to Table of Contents

Choose a Lesson

Cloud Datastore Overview

Data Organization

Queries and Indexing

Data Consistency

Data Organization

Next

Short version:

- Entities grouped by kind (category)
- Entities can be hierarchical (nested)
- Each entity has one or more properties
- Properties have a value assigned

Concept	Relational Database	Datastore
Category of object	Table	Kind
Single Object	Row	Entity
Individual data for an object	Column	Property
Unique ID for an object	Primary key	Key

Return to Table of Contents

Choose a Lesson
Cloud Datastore Overview
Data Organization
Queries and Indexing
Data Consistency

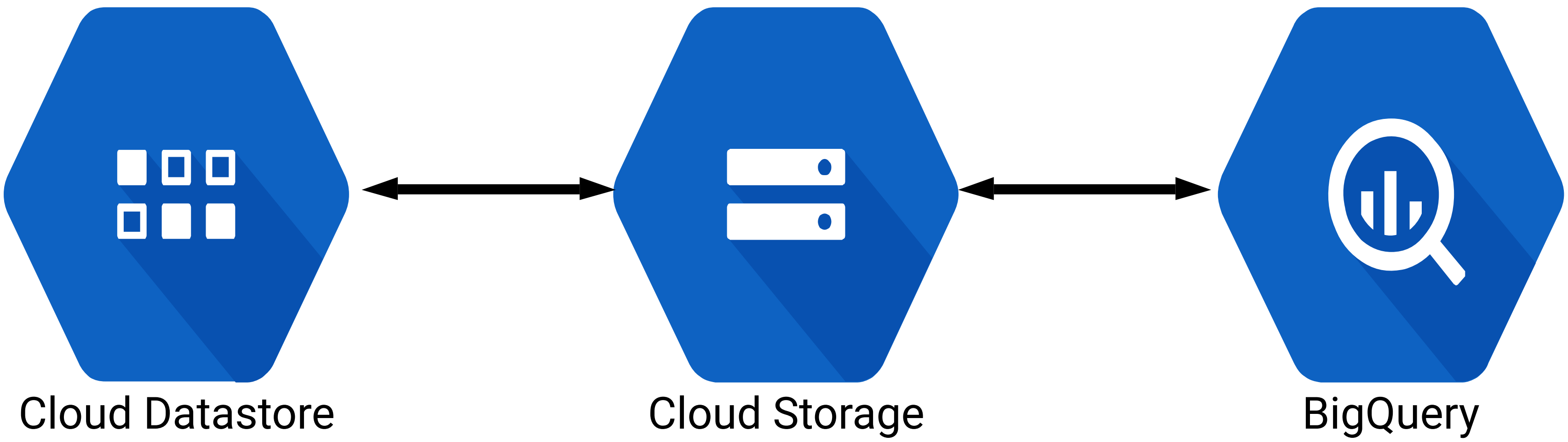
Cloud Datastore Overview

Previous

Other important facts:

- Single Datastore database per project
- Multi-regional for wide access, single region for lower latency and for single location
- Datastore is a transactional database
- Bigtable is an analytical database
- IAM roles:
    - Primitive and predefined
    - Owner, user, viewer, import/export admin, index admin

Backup/Export/Import/Analyze
Managed export/import service



Return to Table of Contents

Choose a Lesson

Cloud Datastore Overview

Data Organization

Queries and Indexing

Data Consistency

Cloud Datastore

Cloud Datastore Overview

Next

What is Cloud Datastore?

- No Ops:
  - No provisioning of instances, compute, storage, etc.
  - Compute layer is abstracted away
- Highly scalable:
  - Multi-region access available
  - Sharding/replication handled automatically
- NoSQL/non-relational database:
  - Flexible structure/relationship between objects

Use Datastore for:

- Applications that need highly available structured data, at scale
- Product catalogs - real-time inventory
- User profiles - mobile apps
- Game save states
- ACID transactions - e.g., transferring funds between accounts

Do not use Datastore for:

- Analytics (full SQL semantics):
  - Use BigQuery/Cloud Spanner
- Extreme scale (10M+ read/writes per second):
  - Use Bigtable
- Don't need ACID transactions/data not highly structured:
  - Use Bigtable
- Lift and shift (existing MySQL):
  - Use Cloud SQL
- Near zero latency (sub-10ms):
  - Use in-memory database (Redis)

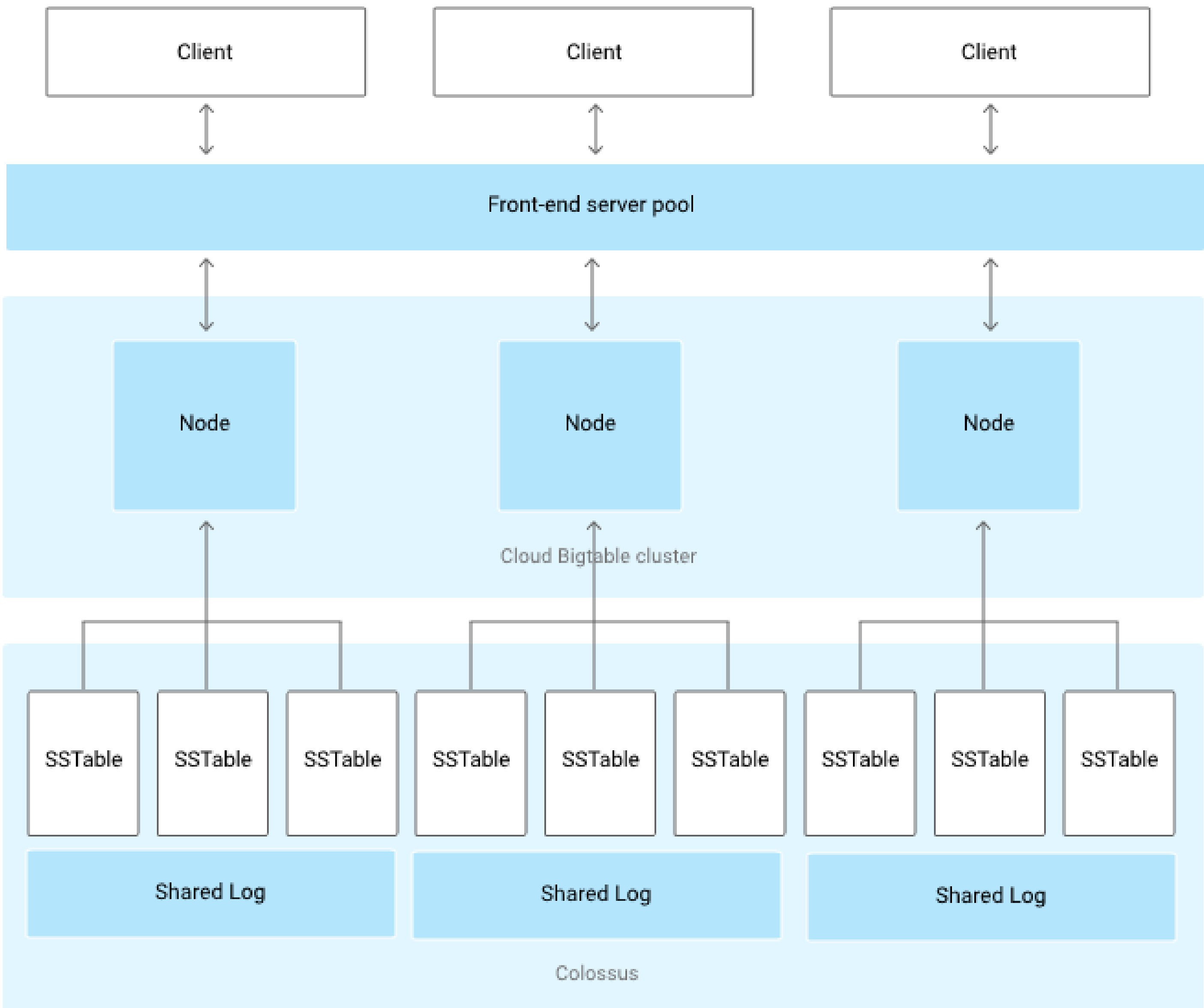
Return to Table of Contents

Cloud Bigtable Overview

Previous

Choose a Lesson
Cloud Bigtable Overview
Instance Configuration
Data Organization
Schema Design

Cloud Bigtable Infrastructure



Return to Table of Contents

Choose a Lesson

Cloud Bigtable Overview
Instance Configuration
Data Organization
Schema Design

Cloud Bigtable

Cloud Bigtable Overview

Next

What is Cloud Bigtable?

- High performance, massively scalable NoSQL database
- Ideal for large analytical workloads

History of Bigtable

- Considered one of the originators for a NoSQL industry
- Developed by Google in 2004
  - Existing database solutions were too slow
  - Needed real-time access to petabytes of data
- Powers Gmail, YouTube, Google Maps, and others

What is it used for?

- High throughput analytics
- Huge datasets

Use Cases

- Financial data – stock prices
- IoT data
- Marketing data – purchase histories

Access Control

- Project wide or instance level
- Read/Write/Manage

Return to Table of Contents

Choose a Lesson

Cloud Bigtable Overview

Instance Configuration

Data Organization

Schema Design

Cloud Bigtable

Instance Configuration

Next

Instance basics

- Not no-ops
  - Must configure nodes
- Entire Bigtable project called 'instance'
  - All nodes and clusters
- Nodes grouped into clusters
  - 1 or more clusters per instance
- Auto-scaling storage
- Instance types
  - Development - low cost, single node
    - No replication
  - Production - 3+ nodes per cluster
    - Replication available, throughput guarantee

Replication and Changes

- Synchronize data between clusters
  - One additional cluster, total
  - (Beta) available cross-region
- Resizing
  - Add and remove nodes and clusters with no downtime
- Changing disk type (e.g. HDD to SSD) requires new instance

Interacting with Bigtable

- Command line - cbt tool or HBase shell
  - cbt tool is simpler and preferred option

Return to Table of Contents

Choose a Lesson

Cloud Bigtable Overview

Instance Configuration

Data Organization

Schema Design

Cloud Bigtable

Instance Configuration

Previous

Bigtable interaction using cbt

- Install the cbt command in Google SDK
  - sudo gcloud components update
  - gcloud components install cbt
- Configure cbt to use your project and instance via .cbtrc file'
  - echo -e "project = [PROJECT_ID]\ninstance = [INSTANCE_ID]" > ~/.cbtrc
- Create table
  - cbt createtable my-table
- List table
  - cbt ls
- Add column family
  - cbt createfamily my-table cf1
- List column family
  - cbt ls my-table
- Add value to row 1, using column family cf1 and column qualifier c1
  - cbt set my-table r1 cf1:c1=test-value
- Delete table (if not deleting instance)
  - cbt deletetable my-table
- Read the contents of your table
  - cbt read my-table

Get help with cbt command using 'cbt --help'

Return to Table of Contents

Choose a Lesson
Cloud Bigtable Overview
Instance Configuration
Data Organization
Schema Design

Data Organization

Data Organization

- One big table (hence the name Bigtable)
- Table can be thousands of columns/billions of rows
- Table is sharded across tablets

Table components

- Row Key
  - First column
- Columns grouped into column families

	Column-Family-1		Column-Family-2	
Row Key	*Column-Qualifier-1*	*Column-Qualifier-2*	*Column-Qualifier-1*	*Column-Qualifier-2*
r1	r1, cf1:cq1	r1, cf1:cq2	r1, cf1:cq1	r1, cf1:cq2
r2	r2, cf1:cq1	r2, cf1:cq2	r2, cf1:cq1	r2, cf1:cq2

Indexing and Queries

- Only the row key is indexed
- Schema design is necessary for efficient queries!
- Field promotion - move fields from column data to row key

Row key	Column data
BATTERY#Corrie#20150301124501001	METRIC:PERCENTAGE:98
BATTERY#Corrie#20150301124501003	METRIC:PERCENTAGE:96
BATTERY#Jo#20150301124501002	METRIC:PERCENTAGE:54
BATTERY#Sam#20150301124501004	METRIC:PERCENTAGE:43
BATTERY#Sam#20150301124501005	METRIC:PERCENTAGE:38

Choose a Lesson

Cloud Bigtable Overview

Instance Configuration

Data Organization

Schema Design

X

Front-end server pool serves client requests to nodes

Choose a Lesson

Cloud Bigtable Overview

Instance Configuration

Data Organization

Schema Design

X

Nodes handle cluster requests. It acts as the compute for processing requests.

No data is stored on the node except for metadata to direct requests to the correct tablet

Return to Table of Contents

Choose a Lesson

Cloud Bigtable Overview

Instance Configuration

Data Organization

Schema Design

X

Bigtable's table is sharded into block of rows, called tablets.

Tablets are stored on Colossus, Google's file system, in SStable format

Storage is separate from the compute nodes, though each tablet is associated with a node.

As a result, replication and recovery of node data is very fast, as only metadata/pointers need to be updated.

Return to Table of Contents

Choose a Lesson

Cloud Bigtable Overview

Instance Configuration

Data Organization

Schema Design

Row Key
memusage+user+timestamp
20-mattu-201805082048

Schema Design

Schema Design

- Per table – Row key is the only indexed item
- Keep all entity info in a single row
- Related entities should be in adjacent rows
  - More efficient reads
- Tables are sparse – empty columns take no space

Schema Efficiency

- Well-defined row keys = less work
  - Multiple values in row key
- Row key (or prefix) should be sufficient for a search
- Goal = spread loads over multiple nodes
  - All on one node = hotspotting

Row Key Best Practices

- Good row keys = distributed load
  - Reverse domain names (com.linuxacademy.support)
  - String identifiers (mattu)
  - Timestamps (reverse, NOT at front/or only identifier)
- Poor row keys = hotspotting
  - Domain names (support.linuxacademy.com)
  - Sequential ID's
  - Timestamps alone/at front

Table Design - Time Series Data

- For time series data, use <u>tall and narrow</u> tables (one event per row)
  - Easier to run queries against data

Return to Table of Contents

Choose a Lesson

Cloud Spanner Overview

Data Organization and Schema

Cloud Spanner Overview

Next

What is Cloud Spanner?

- Fully managed, highly scalable/available, relational database
- Similar architecture to Bigtable
- "NewSQL"

What is it used for?

- Mission critical, relational databases that need strong transactional consistency (ACID compliance)
- Wide scale availability
- Higher workloads than Cloud SQL can support
- Standard SQL format (ANSI 2011)

Horizontal vs. vertical scaling

- Vertical = more compute on single instance (CPU/RAM)
- Horizontal = more instances (nodes) sharing the load

Compared to Cloud SQL

- Cloud SQL = Cloud incarnation of *on-premises* MySQL database
- Spanner = designed from the ground up for the cloud
- Spanner is <u>not</u> a 'drop in' replacement for MySQL
  - Not MySQL/PostreSQL compatible
  - Work required to migrate
  - However, when making transition, don't need to choose between consistency and scalability

Return to Table of Contents

Choose a Lesson

Cloud Spanner Overview

Data Organization and Schema

Cloud Spanner Overview

Previous

Next

Transactional Consistency vs. Scalability
Why not both?

	Cloud Spanner	Traditional Relational	Traditional Non-relational
Schema	Yes	Yes	No
SQL	Yes	Yes	No
Consistency	Strong	Strong	Eventual
Availability	High	Failover	High
Scalability	Horizontal	Vertical	Horizontal
Replication	Automatic	Configurable	Configurable

Primary purpose of Cloud Spanner:
No compromises relational database

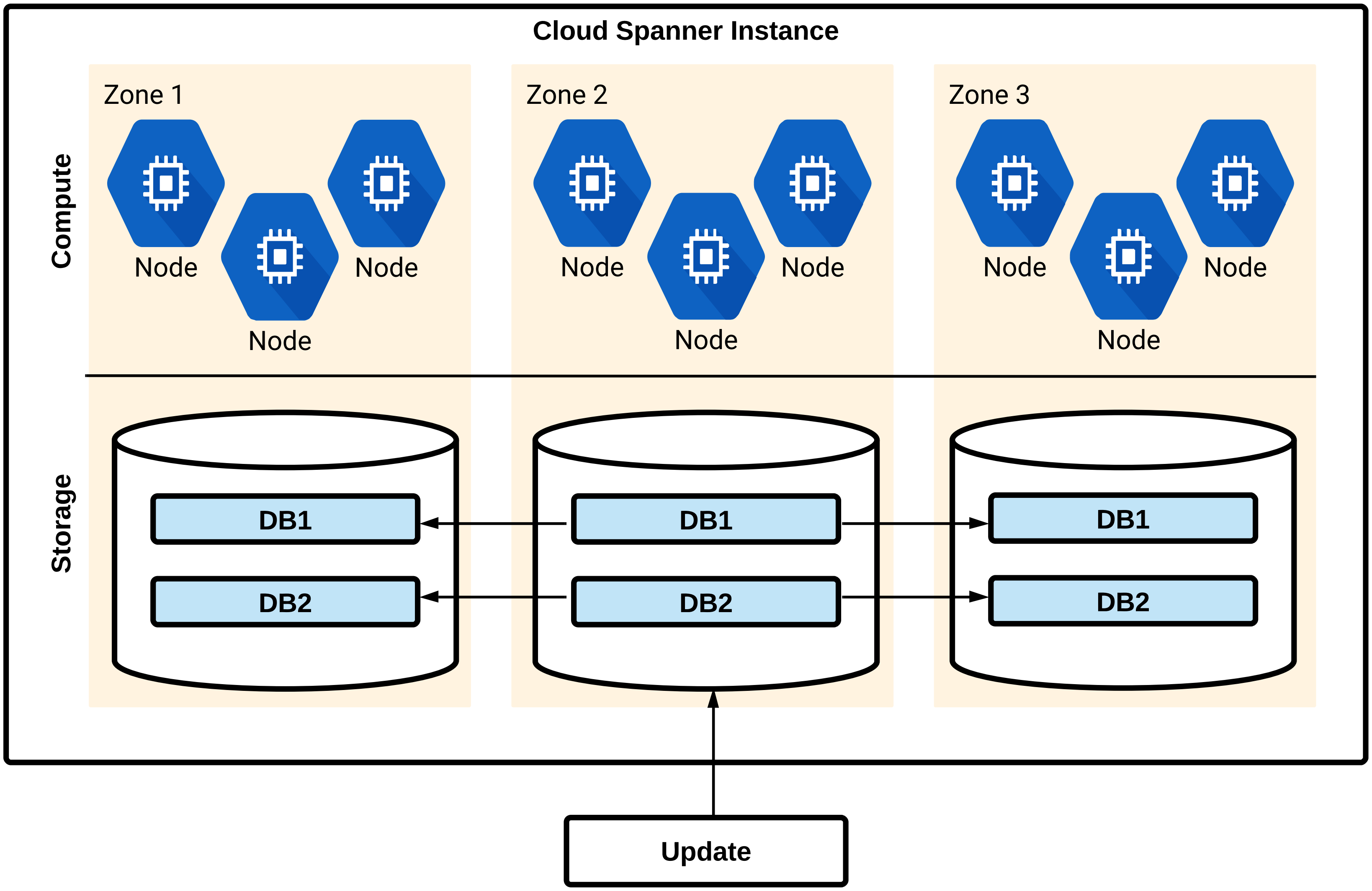
Return to Table of Contents

Choose a Lesson
Cloud Spanner Overview
Data Organization and Schema

Cloud Spanner Overview

Previous
Next

Cloud Spanner Architecture
(similar to Bigtable)



Return to Table of Contents

Choose a Lesson

Cloud Spanner Overview

Data Organization and Schema

Cloud Spanner Overview

Previous

Identity and Access Management (IAM)

- Project, Instance, or Database level
- roles/spanner._____
- Admin - Full access to all Spanner resources
- Database Admin - Create/edit/delete databases, grant access to databases
- Database Reader - read/execute database/schema
- Viewer - view instances and databases
    - Cannot modify or read from database

Return to Table of Contents

Choose a Lesson

Cloud Spanner Overview

Data Organization and Schema

X

Nodes handle computation for queries, similar to that of Bigtable.
Each node serves up to 2 TB of storage.
More nodes = more CPU/RAM = increased throughput

Return to Table of Contents

Choose a Lesson

Cloud Spanner Overview

Data Organization and Schema

X

Storage is replicated across zones (and regions, where applicable). Like Bigtable, storage is separate from computing nodes

Choose a Lesson

Cloud Spanner Overview

Data Organization and Schema

X

Whenever an update is made to a database in one zone/region, it is automatically replicated across zones/regions.

Automatic synchronous replication

- **When data is written, you *know* it is been written**
- **Any reads guarantee data accuracy**

Return to Table of Contents

Choose a Lesson

Cloud Spanner Overview

Data Organization and Schema

Data Organization and Schema

Next

Organization

- **RDBMS = tables**
- **Supports SQL joins, queries, etc**
- **Same SQL dialect as BigQuery**
- **Tables are handled differently**
  - **Parent/child tables**
  - **Interleave Data Layout**

Typical Relational Database
Two sets of related data = Two tables

SingerId	SingerName
1	Beatles
2	U2
3	Pink Floyd

SingerId	AlbumId	AlbumName
1	1	Help!
1	2	Abbey Road
3	1	The Wall

Spanner
Interleave Tables

Singers(1)	"Marc"	"Richards"	<Bytes>		
Albums(1, 1)				"Total Junk"	
Albums(1, 2)				"Go, Go, Go"	
Songs(1, 2, 1)					"42"
Songs(1, 2, 2)					"Nothing Is The Same"
Singers(2)	"Catalina"	"Smith"	<Bytes>		
Albums(2, 1)				"Green"	
Songs(2, 1, 1)					"Let's Get Back Together"
Songs(2, 1, 2)					"Starting Again"
Songs(2, 1, 3)					"I Knew You Were Magic"
Albums(2, 2)				"Forever Hold Your Peace"	
Albums(2, 3)				"Terrified"	
Songs(2, 3, 1)					"Fight Story"

Return to Table of Contents

Choose a Lesson

Cloud Spanner Overview

Data Organization and Schema

Data Organization and Schema

Previous

Primary keys and Schema

- How to tell which child tables to store with which parent tables
- Usually a natural fit
  - 'Customer ID'
  - 'Invoice ID'
- Avoid hotspotting
  - No sequential numbers
  - No timestamps (also sequential)
    - Use descending order if timestamps required

Return to Table of Contents

Choose a Lesson

Streaming Data Challenges

Cloud Pub/Sub Overview

Pub/Sub Hands On

Connecting Kafka to GCP

Monitoring Subscriber Health

Streaming Data Challenges

Next

What is Streaming Data?

- "Unbounded" data
- Infinite, never completes, always flowing

Examples

Traffic Sensors

Credit Card Transactions

Mobile Gaming

Fast action is often necessary

- Quickly collect data, gain insights, and take action
- Sending to storage can add latency
- Use cases:
  - Credit card fraud detection
  - Predicting highway traffic

Return to Table of Contents

Streaming Data Challenges

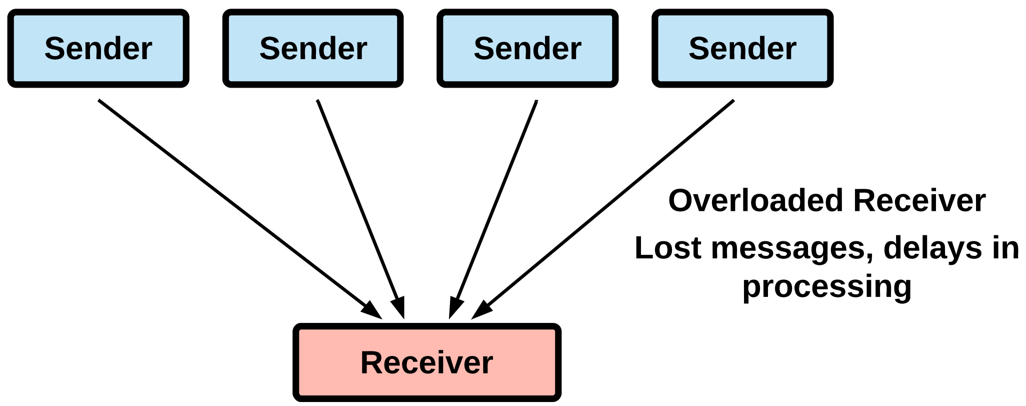
Choose a Lesson
Streaming Data Challenges
Cloud Pub/Sub Overview
Pub/Sub Hands On
Connecting Kafka to GCP
Monitoring Subscriber Health

Previous

Tight vs. Loose Coupling in Systems

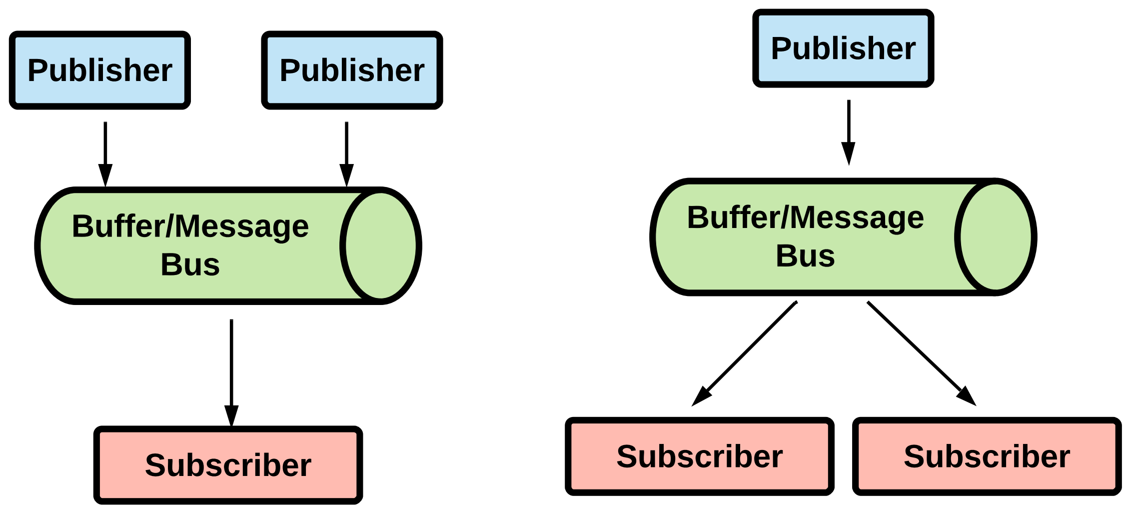
- Tightly (direct) coupled systems more likely to fail
- Loosely coupled systems with 'buffer' scale have better fault tolerance

Tightly-Coupled System



Loosely-Coupled System

- Fault tolerance
- Scalability
- Message queuing



Return to Table of Contents

Choose a Lesson

Streaming Data Challenges

Cloud Pub/Sub Overview

Pub/Sub Hands On

Connecting Kafka to GCP

Monitoring Subscriber Health

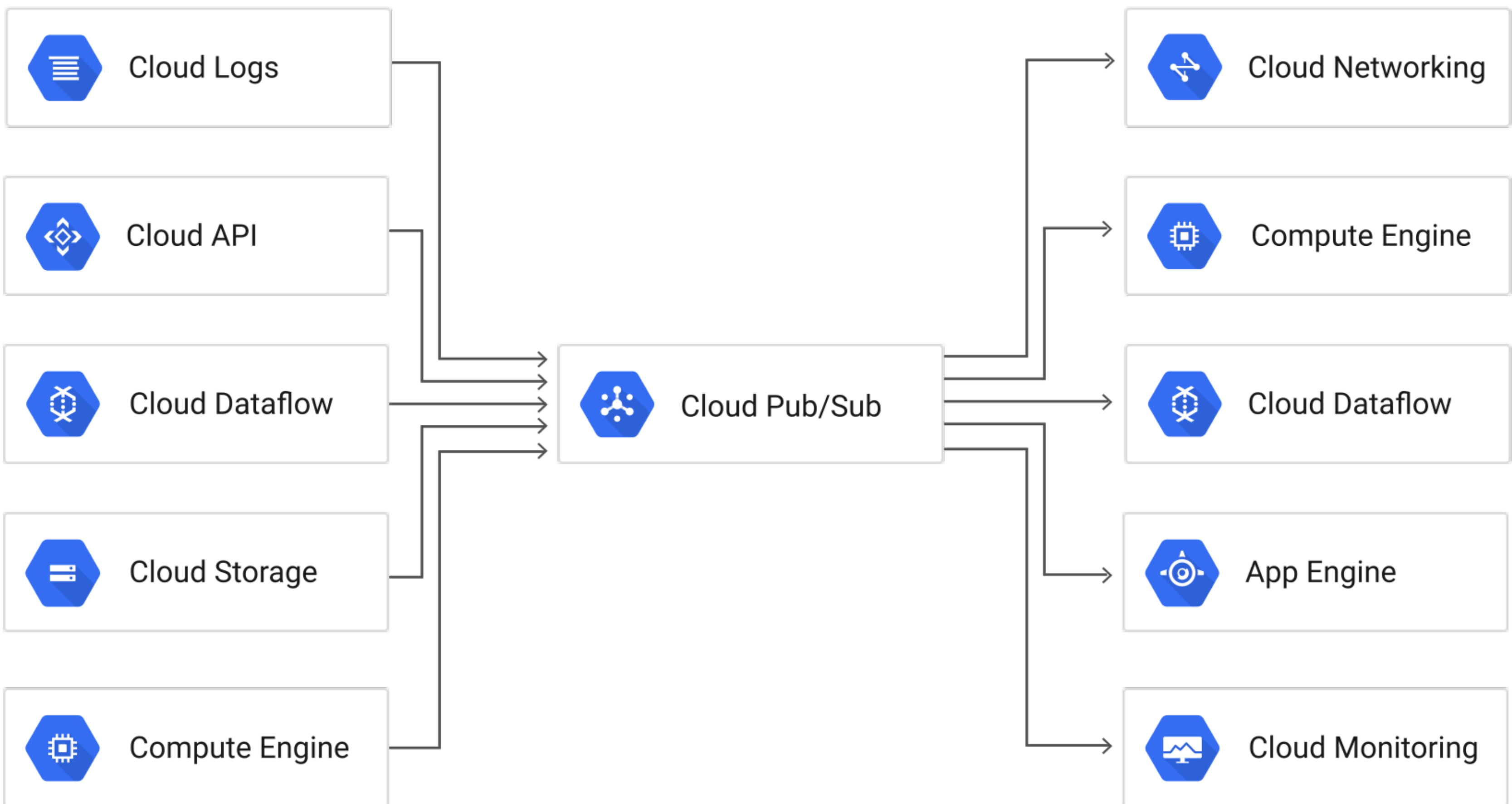
Cloud Pub/Sub Overview

Next

What is Cloud Pub/Sub?

- Global-scale messaging buffer/coupler
- NoOps, global availability, auto-scaling
- Decouples senders and receivers
- Streaming data ingest:
  - Also connects other data pipeline services
- Equivalent to Apache Kafka (open source)
- Guaranteed at-least-once delivery

Asynchronous messaging - many to many (or any other combination)



Return to Table of Contents

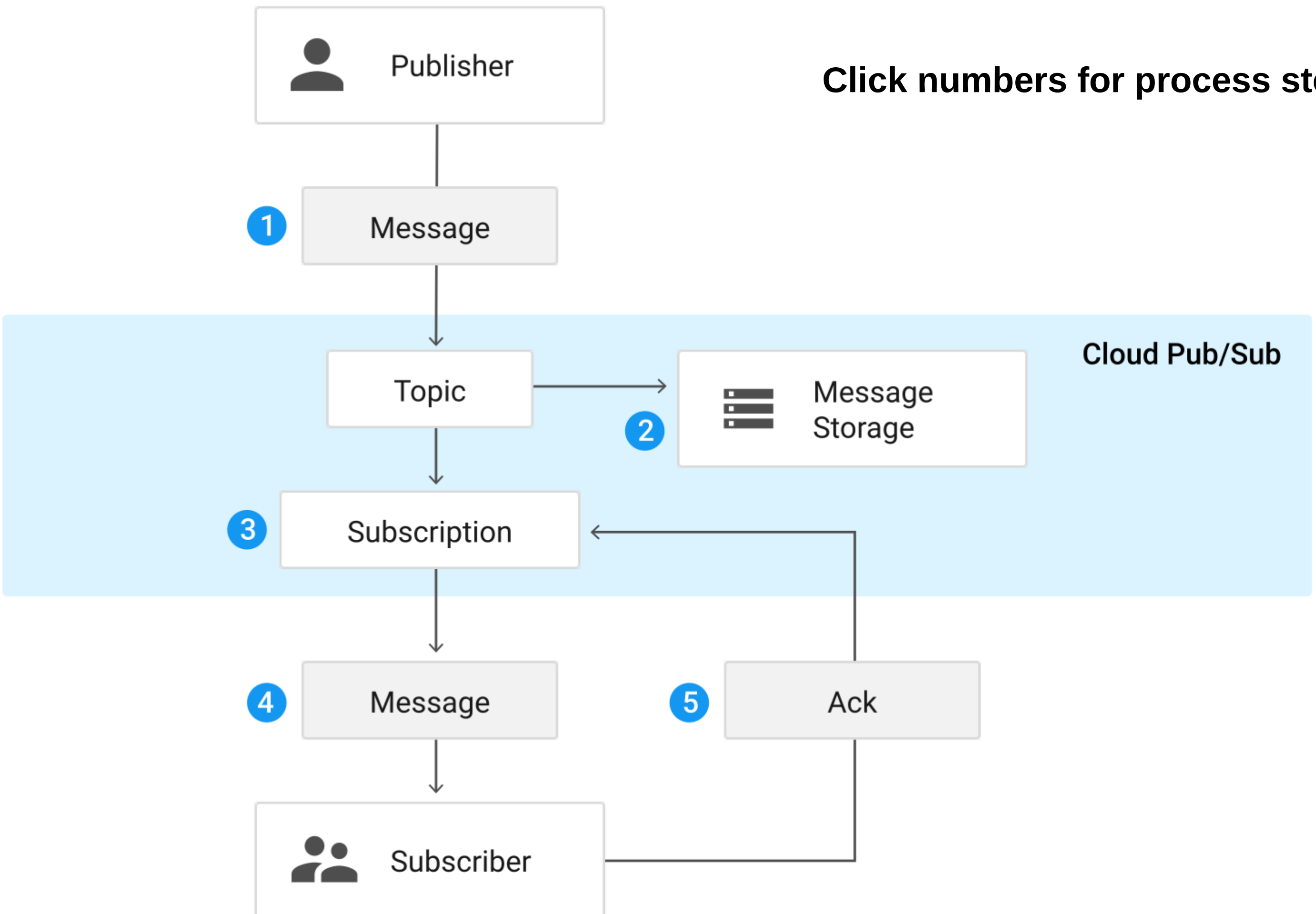
Choose a Lesson
Streaming Data Challenges
Cloud Pub/Sub Overview
Pub/Sub Hands On
Connecting Kafka to GCP
Monitoring Subscriber Health

Cloud Pub/Sub Overview

Previous
Next

How It Works: Terminology

- Topics, Messages, Publishers, Subscribers, Message Store



Click numbers for process steps

Choose a Lesson

Streaming Data Challenges

Cloud Pub/Sub Overview

Pub/Sub Hands On

Connecting Kafka to GCP

Monitoring Subscriber Health

X

Publisher application creates a *topic* in the Cloud Pub/Sub service and sends *messages* to the topic. A message contains a payload and optional *attributes* that describe the payload content.

Choose a Lesson

Streaming Data Challenges

Cloud Pub/Sub Overview

Pub/Sub Hands On

Connecting Kafka to GCP

Monitoring Subscriber Health

X

Messages are stored in a *message store* until they are delivered and acknowledged by subscribers.

Return to Table of Contents

Choose a Lesson

Streaming Data Challenges

Cloud Pub/Sub Overview

Pub/Sub Hands On

Connecting Kafka to GCP

Monitoring Subscriber Health

X

Pub/Sub forwards messages from a topic to all subscribers, individually.
Messages can be either *pushed* by Pub/Sub to subscribers, or *pulled* by subscribers from Pub/Sub.

Choose a Lesson

Streaming Data Challenges

Cloud Pub/Sub Overview

Pub/Sub Hands On

Connecting Kafka to GCP

Monitoring Subscriber Health

X

A subscriber receives pending messages from its subscription, and acknowledges each one to the Pub/Sub service.

X

The after message is acknowledged by the subscriber, then it is removed from the subscription's queue of messages.

Return to Table of Contents

Cloud Pub/Sub Overview

Previous

Next

Choose a Lesson

Streaming Data Challenges

Cloud Pub/Sub Overview

Pub/Sub Hands On

Connecting Kafka to GCP

Monitoring Subscriber Health

Push and Pull

- Pub/Sub can either *push* messages to subscribers, or subscribers can *pull* messages from Pub/Sub.
- Push = lower latency, more real-time.
- Push subscribers must be Webhook endpoints that accept POST over HTTPS.
- Pull is ideal for large volume of messages, and uses batch delivery

IAM

- Allows for controlling access at project, topic, or subscription level
- Admin, Editor, Publisher, Subscriber
- Service accounts are best practice

Pricing

- Data volume used per month (per GB)

Monthly data	Price Per GB
First 10 GB	$0.00
Next 50 TB	$0.06
Next 100 TB	$0.05
Beyond 150 TB	$0.04

Out of order messaging

- Messages may arrive from multiple sources out of order.
- Pub/Sub does not care about message ordering.
- Dataflow is where out of order messages are processed/resolved.
- It's possible to add message attributes to help with ordering.

Return to Table of Contents

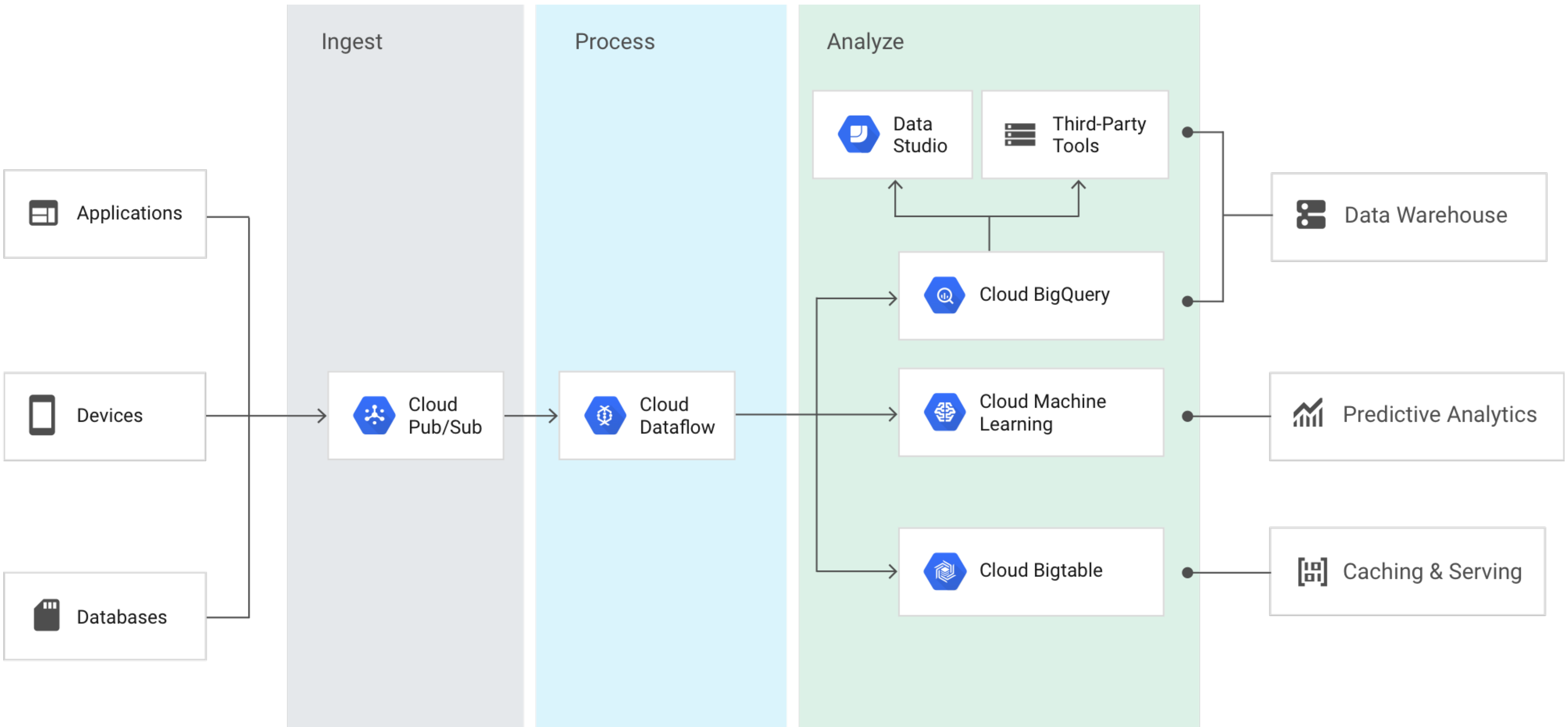
Cloud Pub/Sub Overview

Previous

Choose a Lesson

- Streaming Data Challenges
- Cloud Pub/Sub Overview
- Pub/Sub Hands On
- Connecting Kafka to GCP
- Monitoring Subscriber Health

Big Picture: Data Lifecycle for Streaming Data Ingest



Return to Table of Contents

Pub/Sub Hands On

Choose a Lesson

Streaming Data Challenges

Cloud Pub/Sub Overview

Pub/Sub Hands On

Connecting Kafka to GCP

Monitoring Subscriber Health

Next

The Steps

- Create a topic
- Create a subscription
- Publish messages
- Retrieve messages

Simple topic/subscription/publish via `gcloud`

Create a topic called *my-topic*:

- `gcloud pubsub topics create my-topic`

Create subscription to topic *my-topic*:

- `gcloud pubsub subscriptions create --topic my-topic mySub1`

Publish a message to your topic:

- `gcloud pubsub topics publish my-topic --message "hello"`

Retrieve message with your subscription, acknowledge receipt, and remove message from queue:

- `gcloud pubsub subscriptions pull --auto-ack mySub1`

Cancel subscription:

- `gcloud pubsub subscriptions delete mySub1`

Return to Table of Contents

Choose a Lesson

Streaming Data Challenges

Cloud Pub/Sub Overview

Pub/Sub Hands On

Connecting Kafka to GCP

Monitoring Subscriber Health

Pub/Sub Hands On

Previous

Traffic Data Exercise

- **Clone GitHub**
- **Copy data points**
- **Simulate traffic data**
- **Pull messages**

Clone GitHub data to Cloud Shell (or other SDK environment), and browse to publish folder:

```
cd ~
git clone https://github.com/linuxacademy/googledataengineer
cd ~/googledataengineer/courses/streaming/publish
```

Create a topic called *sandiego*:

```
gcloud pubsub topics create sandiego
```

Create subscription to topic *sandiego*:

```
gcloud pubsub subscriptions create --topic sandiego mySub1
```

Run script to download sensor data:

```
./download_data.sh
```

May need to authenticate shell to ensure we have the right permissions:

```
gcloud auth application-default login
```

View script info:

```
vim ./send_sensor_data.py or use viewer of your choice
```

Run python script to simulate one hour of data per minute:

```
./send_sensor_data.py --speedFactor=60 \
--project=YOUR-PROJECT-ID
```

If you receive error: *google.cloud.pubsub can not be found* or an *ImportError: No module named iterator*, run this `pip` command to install components, then try again:

```
sudo pip install -U google-cloud-pubsub
```

Open new Cloud Shell tab (using + symbol)

Pull message using subscription *mySub1*:

```
gcloud pubsub subscriptions pull --auto-ack mySub1
```

Create a new subscription and pull messages with it:

```
gcloud pubsub subscriptions create --topic sandiego mySub2
gcloud pubsub subscriptions pull --auto-ack mySub2
```

Return to Table of Contents

Choose a Lesson

Streaming Data Challenges

Cloud Pub/Sub Overview

Pub/Sub Hands On

Connecting Kafka to GCP

Monitoring Subscriber Health

Connecting Kafka to GCP

Next

Does Pub/Sub Replace Kafka?

- Not always
- Hybrid workloads:
  - Interact with existing tools and frameworks
  - Don't need global/scaling capabilities with pub/sub
- Can use *both*: Kafka for on-premises and pub/sub for GCP in same data pipeline

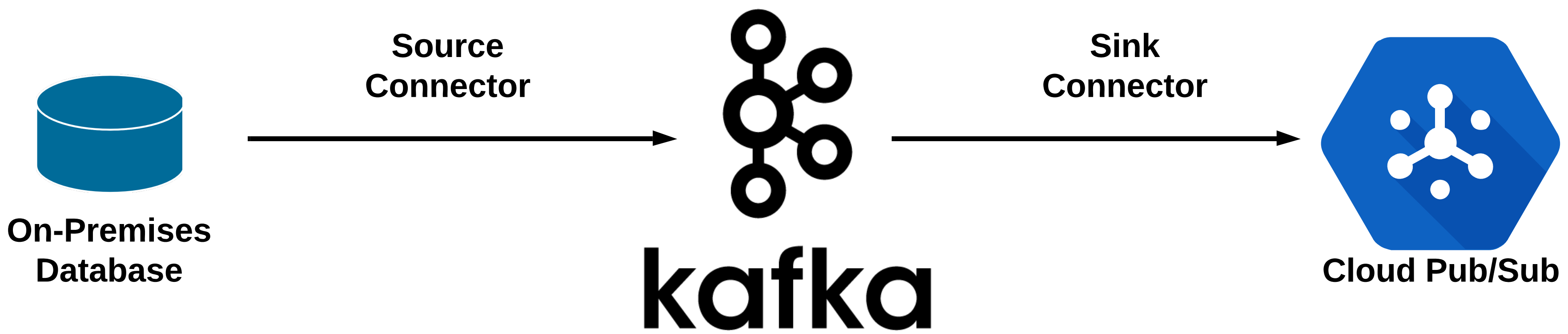
How do we connect Kafka to GCP?

Overview on Connectors:

- Open-source plugins that connect Kafka to GCP
- Kafka Connect: One optional "connector service"
- Exist to connect Kafka directly to pub/sub, Dataflow, and BigQuery (among others)

Additional Terms

- **Source connector:** An upstream connector:
  - Streams *from* something *to* Kafka
- **Sink connector:** A downstream connector:
  - Streams *from* Kafka *to* something else



Return to Table of Contents

Choose a Lesson

Streaming Data Challenges

Cloud Pub/Sub Overview

Pub/Sub Hands On

Connecting Kafka to GCP

Monitoring Subscriber Health

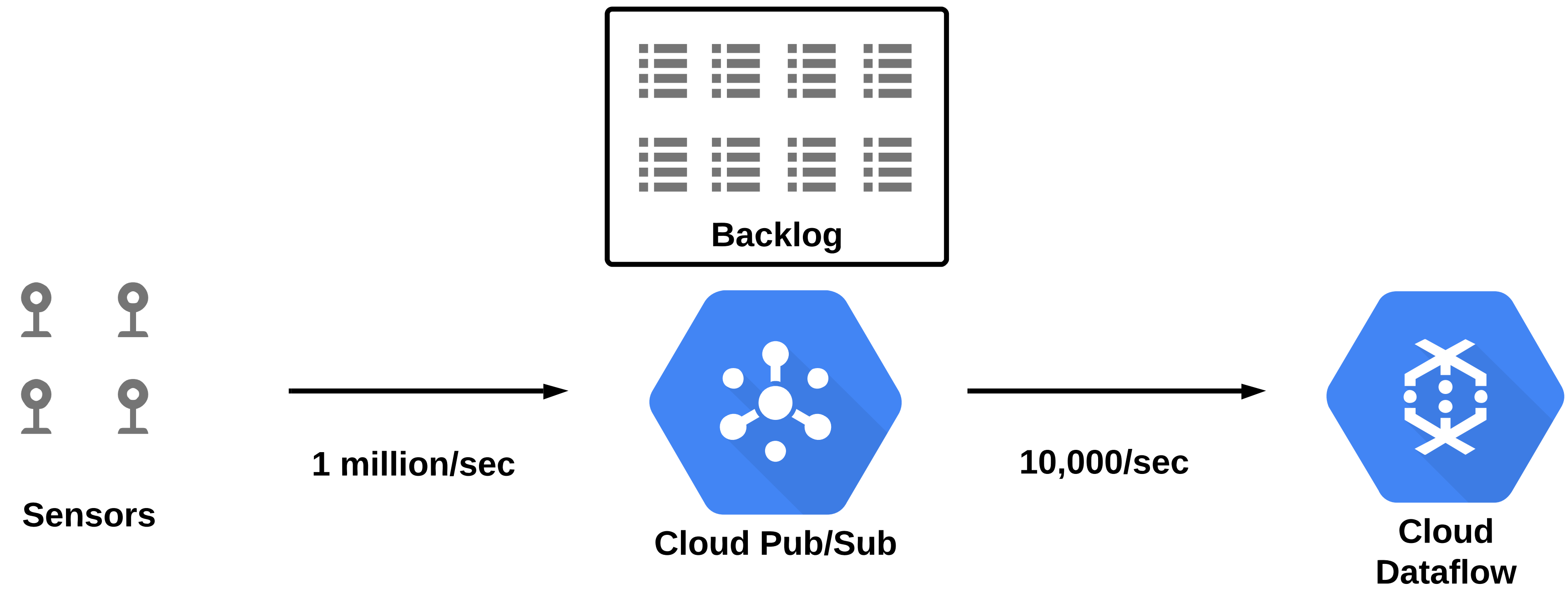
Monitoring Subscriber Health

In a Perfect World...

- Subscribers and Publishers work in perfect harmony:
  - Example:
    - 1 million messages/second published
    - 1 million messages/second successfully pulled/pushed
    - Result: No backlog in Pub/Sub queue
- But we don't live in a perfect world...
  - Subscriber cannot keep up with publish rate
  - Result: Backlog in Pub/Sub queue

Troubleshooting Subscriber Health (Backlog)

- Create alerts for (x) backlog threshold
- Subscriber not able to keep up:
  - Under-provisioned
  - Code not optimized
- Not acknowledging message receipt:
  - Pub/Sub doesn't know it's delivered, and keeps trying
  - Subscriber code not properly acknowledging pulled messages
- Check publishers for excessive re-transmits



Return to Table of Contents

Choose a Lesson

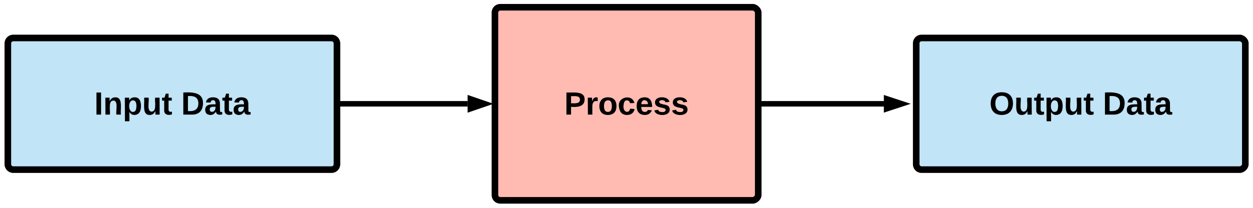
- Data Processing Challenges
- Cloud Dataflow Overview
- Key Concepts
- Template Hands On
- Streaming Ingest Pipeline Hands On
- Additional Best Practices

Data Processing Challenges

Next

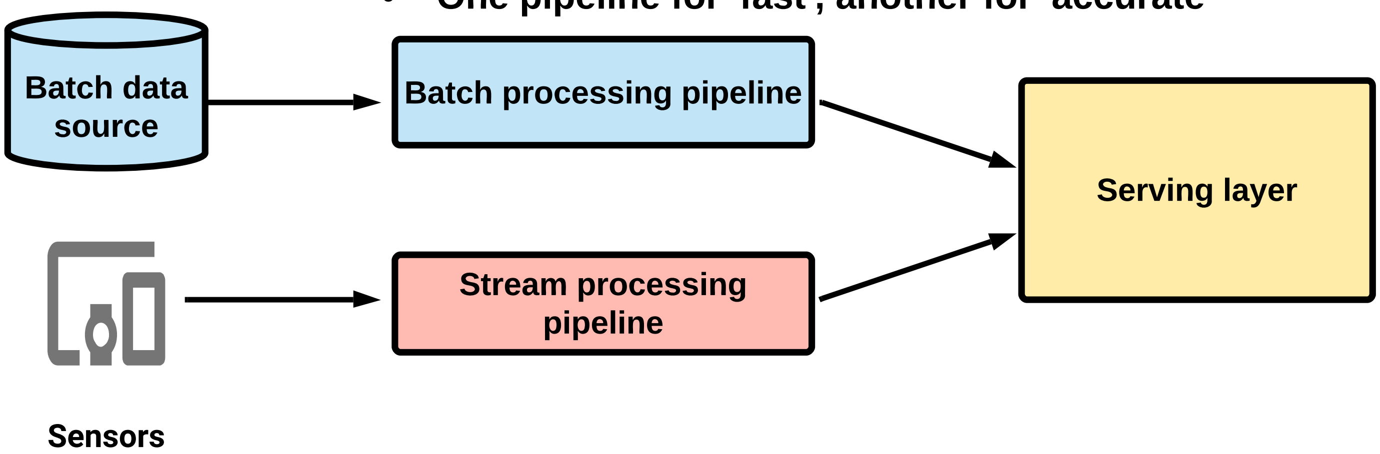
What is Data Processing?

- Read Data (Input)
- Transform it to be relevant - Extract, Transform, and Load (ETL)
- Create output



Challenge: Streaming and Batch data pipelines:

- Until recently, separate pipelines are required for each
- Difficult to compare recent and historical data
- One pipeline for 'fast', another for 'accurate'



Why both?

- Credit card monitoring
- Compare streaming transactions to historical batch data to detect fraud

Return to Table of Contents

Data Processing Challenges

Choose a Lesson

- Data Processing Challenges
- Cloud Dataflow Overview
- Key Concepts
- Template Hands On
- Streaming Ingest Pipeline Hands On
- Additional Best Practices

Previous

Challenge: Complex element processing:

- Element = single data input
- One at a time element ingest from single source = easy
- Combining elements (aggregation) = hard
- Processing data from different sources, streaming, and out of order (composite) = REALLY hard

Solution: Apache Beam + Cloud Dataflow

Cloud Dataflow

Return to Table of Contents

Choose a Lesson
Data Processing Challenges
Cloud Dataflow Overview
Key Concepts
Template Hands On
Streaming Ingest Pipeline Hands On
Additional Best Practices

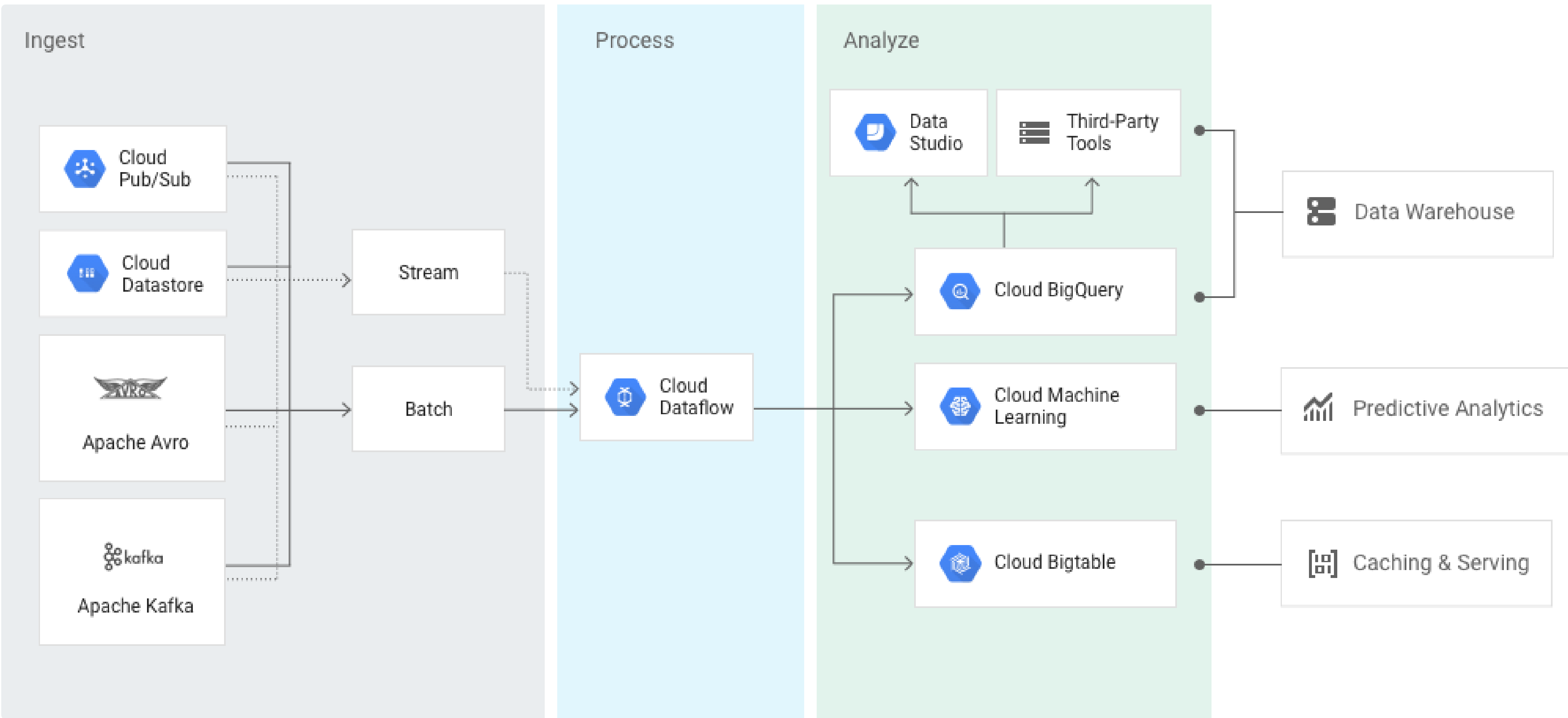
Cloud Dataflow Overview

Next

What is it?

- Auto-scaling, No-Ops, Stream, and Batch Processing
- Built on Apache Beam:
  - Documentation refers to Apache Beam site
  - Configuration is 100% code-based
- Integrates with other tools (GCP and external):
  - Natively - Pub/Sub, BigQuery, Cloud ML Engine
  - Connectors - Bigtable, Apache Kafka
- Pipelines are regional-based

Big Picture - Data Transformation



Return to Table of Contents

Cloud Dataflow Overview

Choose a Lesson

- Data Processing Challenges
- Cloud Dataflow Overview
- Key Concepts
- Template Hands On
- Streaming Ingest Pipeline Hands On
- Additional Best Practices

Previous

Next

IAM:

- Project-level only - all pipelines in the project (or none)
- Pipeline data access separate from pipeline access
- Dataflow Admin - Full pipeline access plus machine type/storage bucket config access
- Dataflow Developer - Full pipeline access, no machine type/storage bucket access
- Dataflow Viewer - view permissions only
- Dataflow Worker - Specifically for service accounts

Dataflow vs Dataproc?

Beam vs. Hadoop/Spark?

Dataproc:

- Familiar tools/packages
- Employee skill sets
- Existing pipelines

Dataflow:

- Less Overhead
- Unified batch and stream processing
- Pipeline portability across Dataflow, Spark, and Flink as runtimes

WORKLOADS	CLOUD DATAPROC	CLOUD DATAFLOW
Stream processing (ETL)		X
Batch processing (ETL)	X	X
Iterative processing and notebooks	X	
Machine learning with Spark ML	X	
Preprocessing for machine learning		X (with Cloud ML Engine)

Return to Table of Contents

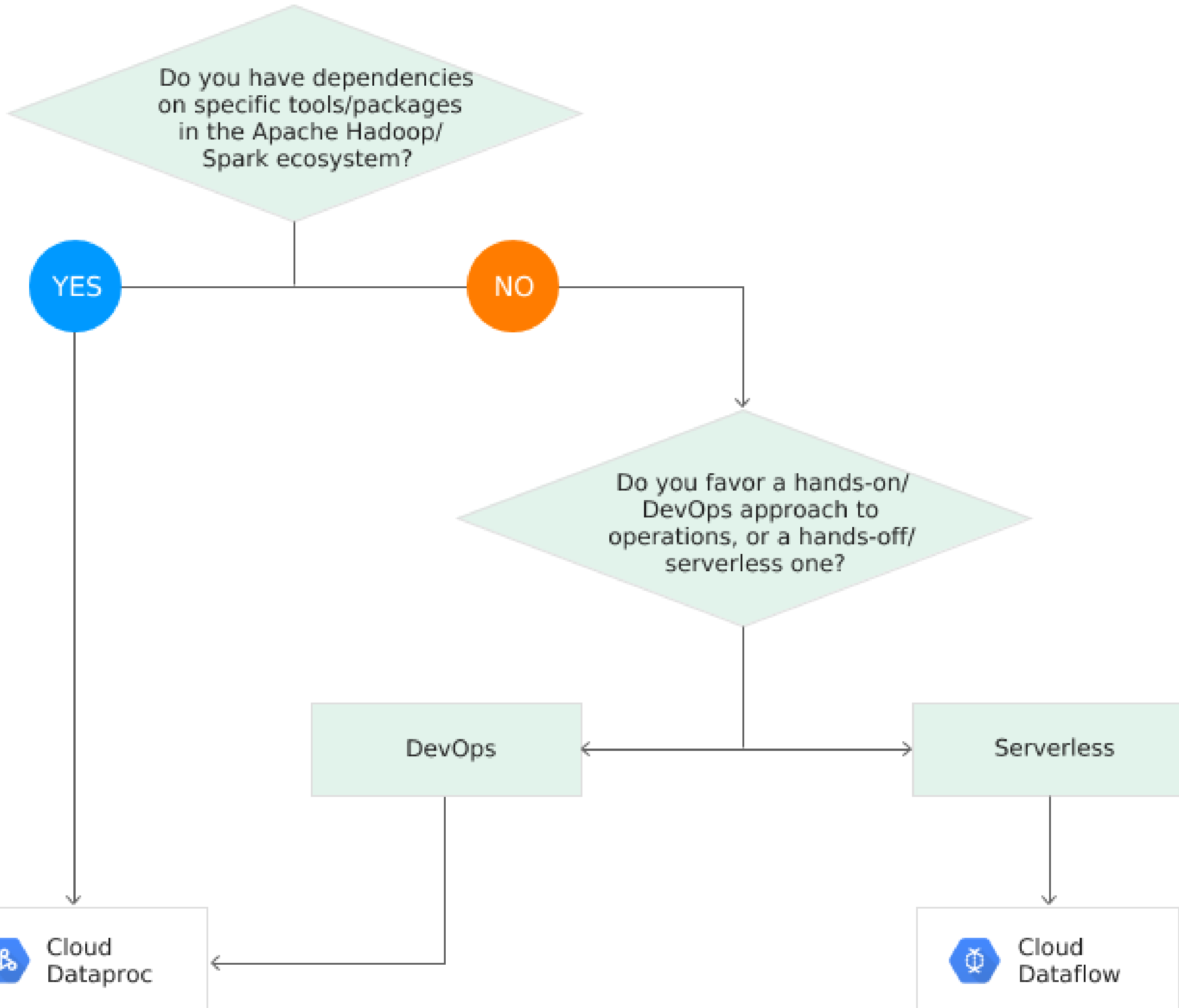
Cloud Dataflow Overview

Previous

Choose a Lesson

- Data Processing Challenges
- Cloud Dataflow Overview
- Key Concepts
- Template Hands On
- Streaming Ingest Pipeline Hands On
- Additional Best Practices

Dataflow vs. Dataproc decision tree



Return to Table of Contents

Choose a Lesson
Data Processing Challenges
Cloud Dataflow Overview
Key Concepts
Template Hands On
Streaming Ingest Pipeline Hands On
Additional Best Practices

Key Concepts

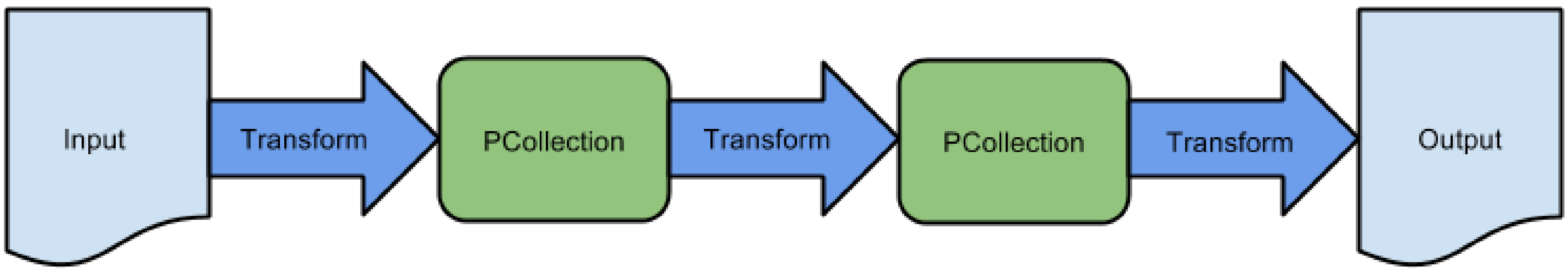
Next

Course/exam perspective:

- Dataflow is very code-heavy
- Exam does not go deep into coding questions
- Some key concepts/terminology will be tested

Key terms:

- Element - single entry of data (e.g., table row)
- PCollection - Distributed data set, data input and output
- Transform - Data processing operation (or step) in pipeline:
    - Uses programming conditionals (for/while loops, etc.)
- ParDo - Type of transform applied to individual elements:
    - Filter out/extract elements from a large group of data



PCollection and ParDo in example Java code.

One step in a multi-step transformation process.

```
PCollection<LaneInfo> currentConditions = p //
    .apply("GetMessages", PubsubIO.readStrings().fromTopic(topic)) //
    .apply("ExtractData", ParDo.of(new DoFn<String, LaneInfo>() {
      @ProcessElement
      public void processElement(ProcessContext c) throws Exception {
        String line = c.element();
        c.output(LaneInfo.newLaneInfo(line));
      }
    }));
```

Return to Table of Contents

Choose a Lesson

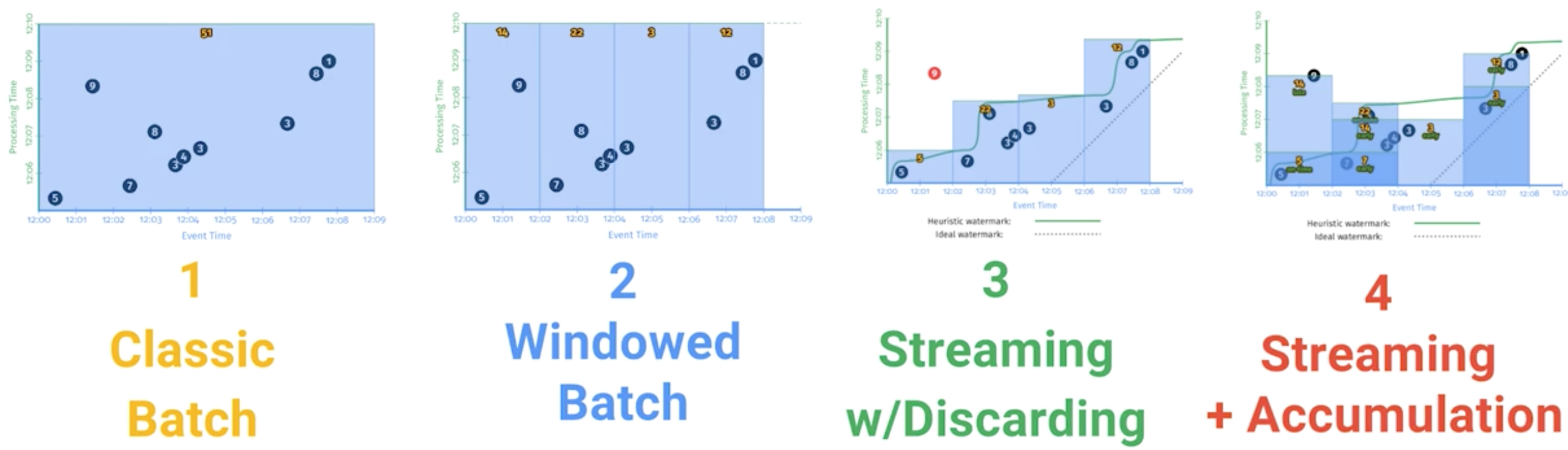
Data Processing Challenges
Cloud Dataflow Overview
Key Concepts
Template Hands On
Streaming Ingest Pipeline Hands On
Additional Best Practices

Cloud Dataflow Overview

Previous

Dealing with late/out of order data:

- Latency is to be expected (network latency, processing time, etc.)
- Pub/Sub does not care about late data, that is resolved in Dataflow
- Resolved with Windows, Watermarks, and Triggers
- Windows = logically divides element groups by time span
- Watermarks = 'timestamp':
  - Event time = when data was generated
  - Processing time = when data processed anywhere in the processing pipeline
  - Can use Pub/Sub-provided watermark or source-generated
- Trigger = determine when results in window are emitted (submitted as complete):
  - Allow late-arriving data in allowed time window to re-aggregate previously submitted results
  - Timestamps, element count, combinations of both

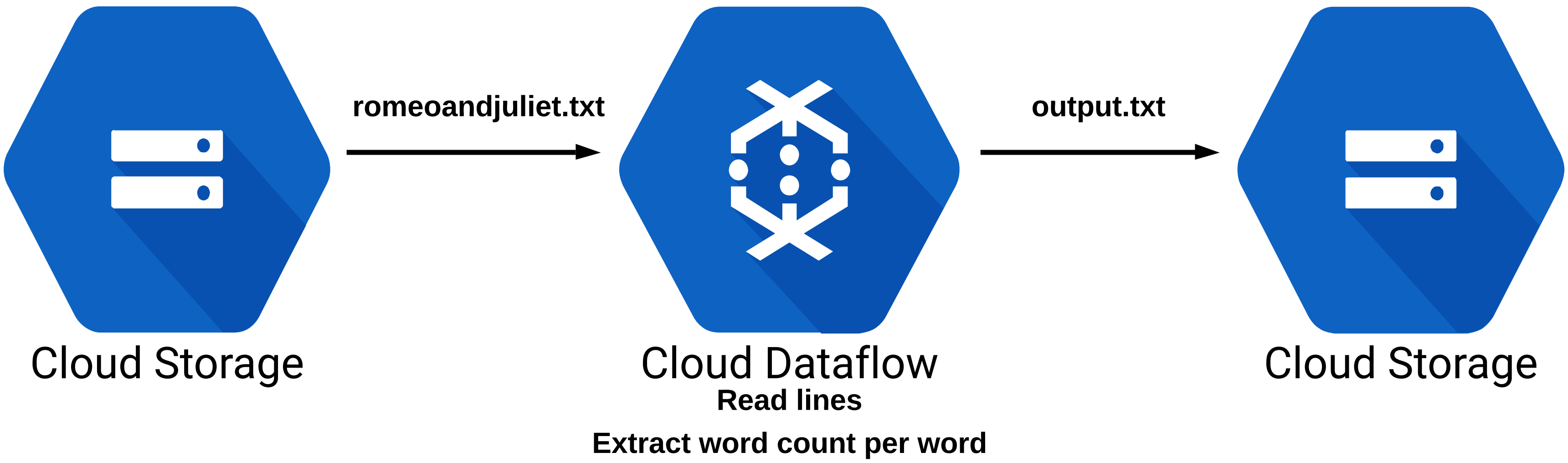


Return to Table of Contents

Template Hands On

Choose a Lesson
Data Processing Challenges
Cloud Dataflow Overview
Key Concepts
Template Hands On
Streaming Ingest Pipeline Hands On
Additional Best Practices

- **Google-provided templates**
- **Simple word count extraction**



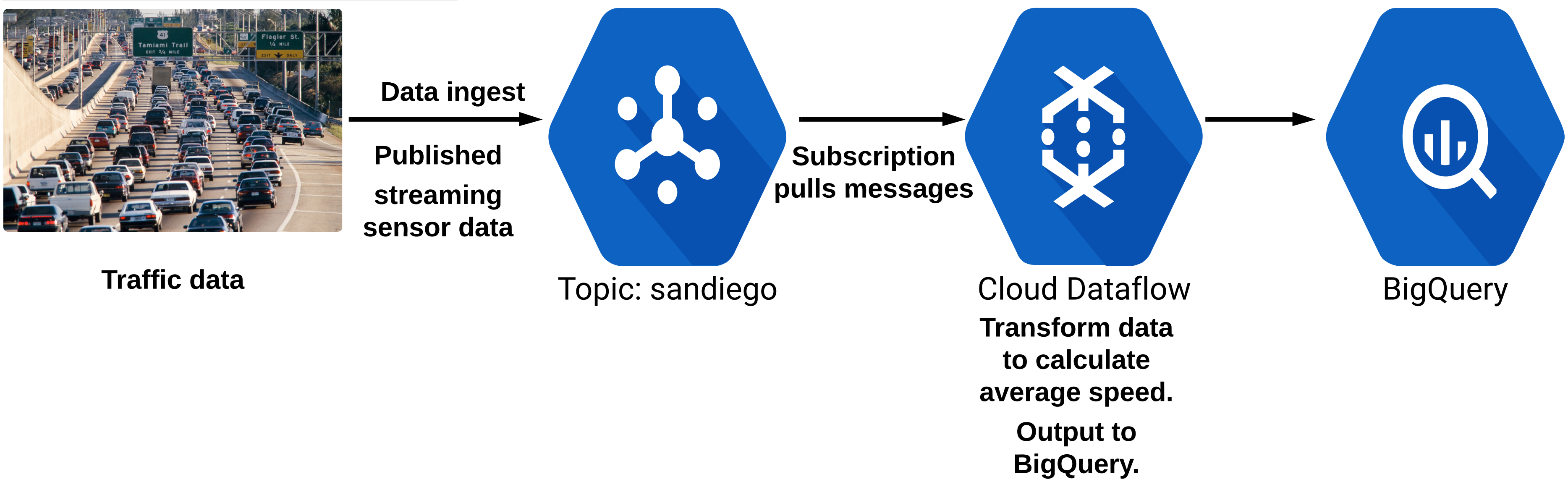
Return to Table of Contents

Choose a Lesson
Data Processing Challenges
Cloud Dataflow Overview
Key Concepts
Template Hands On
Streaming Ingest Pipeline Hands On
Additional Best Practices

Streaming Ingest Pipeline Hands On

Next

- Take San Diego traffic data
- Ingest through Pub/Sub
- Process with Dataflow
- Analyze results with BigQuery
- First: Enable Dataflow API from API's and Services



Return to Table of Contents

Choose a Lesson

Data Processing Challenges

Cloud Dataflow Overview

Key Concepts

Template Hands On

Streaming Ingest Pipeline Hands On

Additional Best Practices

Streaming Ingest Pipeline Hands On

Previous

Next

Quick command line setup (Cloud Shell)

- Create BigQuery dataset for processing pipeline output:
  - bq mk --dataset $DEVSHELL_PROJECT_ID:demos
- Create Cloud Storage bucket for Dataflow staging:
  - gsutil mb gs://$DEVSHELL_PROJECT_ID
- Create Pub/Sub topic and stream data:
  - cd ~/googledataengineer/courses/streaming/publish
  - gcloud pubsub topics create sandiego
  - ./download_data.sh
  - sudo pip install -U google-cloud-pubsub
  - ./send_sensor_data.py --speedFactor=60 --project=$DEVSHELL_PROJECT_ID

Open a new Cloud Shell tab:

- Execute Dataflow pipeline for calculating average speed:
  - cd ~/googledataengineer/courses/streaming/process/sandiego
  - ./run_oncloud.sh $DEVSHELL_PROJECT_ID $DEVSHELL_PROJECT_ID AverageSpeeds
- Error resolution:
  - Pub/Sub permission denied, re-authenticate
    - gcloud auth application-default login
  - Dataflow workflow failed - enable Dataflow API

Return to Table of Contents

Streaming Ingest Pipeline Hands On

Choose a Lesson

Data Processing Challenges

Cloud Dataflow Overview

Key Concepts

Template Hands On

Streaming Ingest Pipeline Hands On

Additional Best Practices

Previous

View results in BigQuery:

- List first 100 rows:
  - SELECT * FROM [<PROJECTID>:demos.average_speeds] ORDER BY timestamp DESC LIMIT 100
- Show last update to table:
  - SELECT MAX(timestamp) FROM [<PROJECTID>:demos.average_speeds]
- Look at results from the last minute:
  - SELECT * FROM [<PROJECTID>:demos.average_speeds@-60000] ORDER BY timestamp DESC

Shut down pipeline:

- Drain - finishing processing buffered jobs before shutting down
- Cancel - full stop, cancels existing buffered jobs

Return to Table of Contents

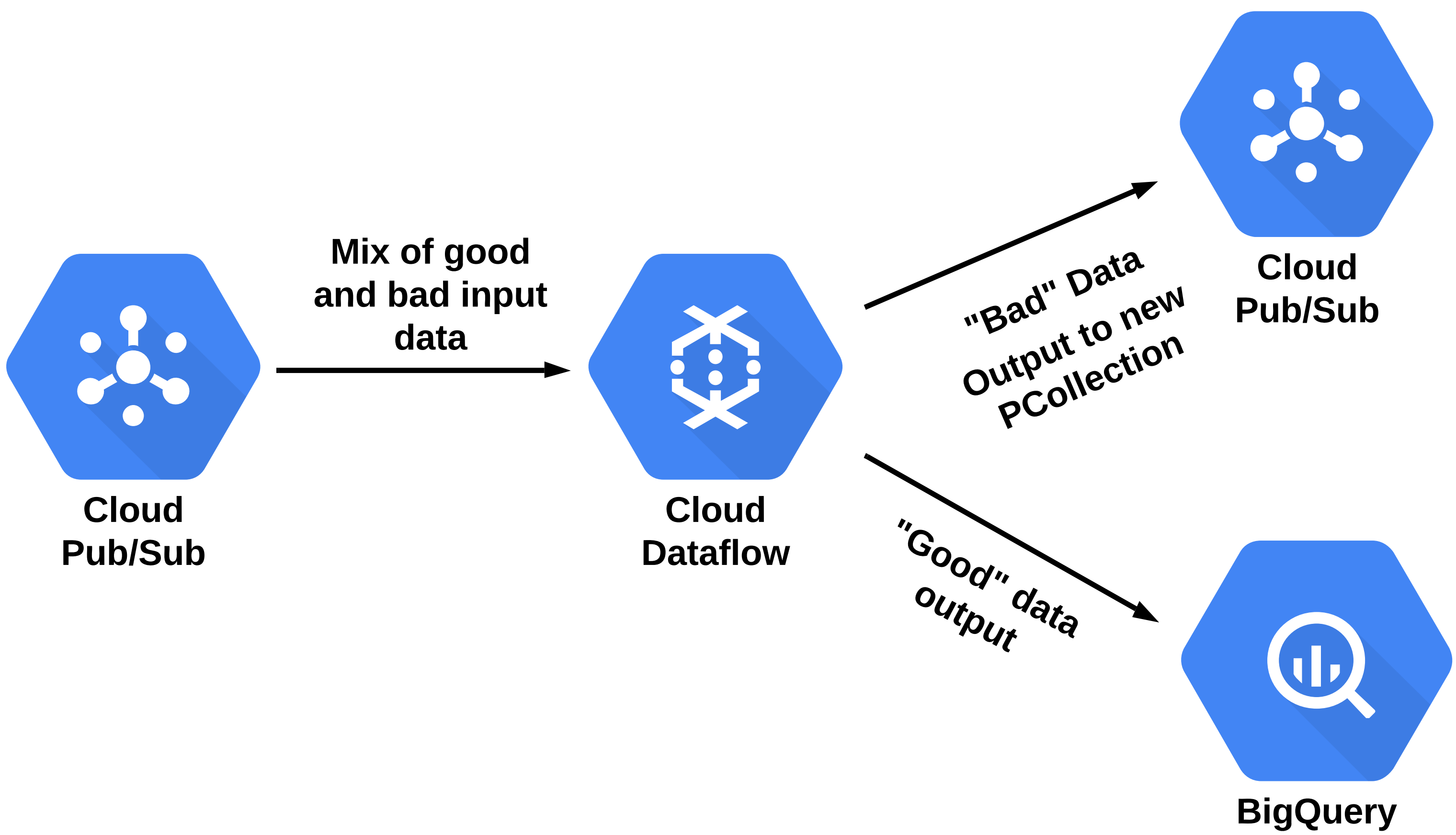
Choose a Lesson
Data Processing Challenges
Cloud Dataflow Overview
Key Concepts
Template Hands On
Streaming Ingest Pipeline Hands On
Additional Best Practices

Additional Best Practices

Handling Pipeline Errors

Next

- If you do not have a mechanism in place to handle input data errors in your pipeline, the job can fail. How can we account for this?
- Gracefully catch errors:
  - Create separate output:
    - **Try-catch** block handles errors
    - Output errors to new **PCollection** - Send to **collector** for later analysis (Pub/Sub is a good target)
    - Think of it as *recycling* the *bad* data
- Technique is also valid for troubleshooting missing messages:
  - Scenario: Streaming pipeline missing some messages
  - Solution: Run a batch of the streaming data, and check output:
    - Create additional output to capturing and processing error data.



Choose a Lesson

Data Processing Challenges

Cloud Dataflow Overview

Key Concepts

Template Hands On

Streaming Ingest Pipeline Hands On

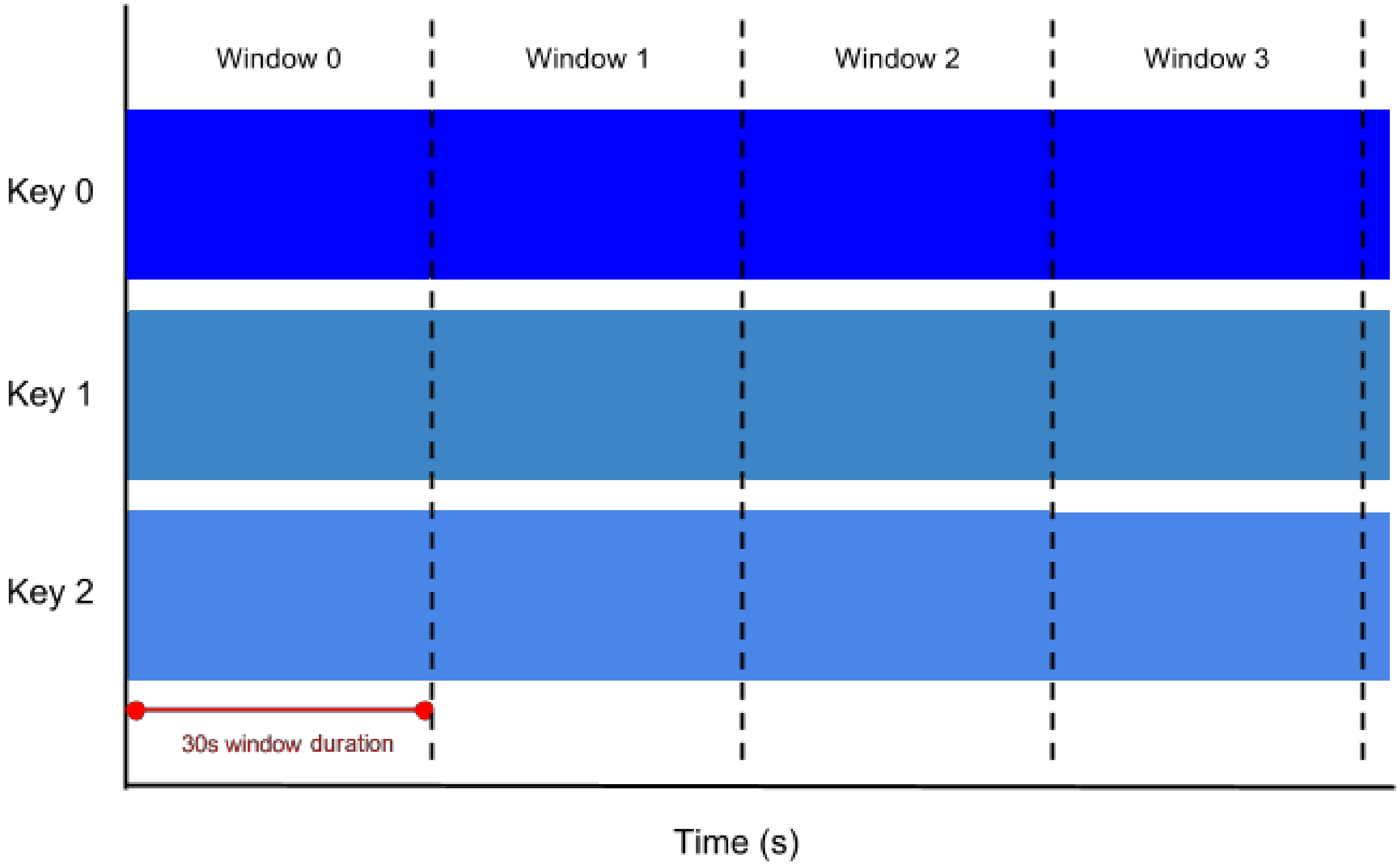
Additional Best Practices

Additional Best Practices

Know your window types

- **Global, Fixed, Sliding, Session**
- **Global** - The default, uses a single window for entire pipeline
- **Fixed time** - Every (x) period of time
    - Every 5 seconds, 10 minutes, etc.
- **Sliding time** - Overlapping time windows
- **Session** - Within certain time of certain elements:
    - For example, *Time since last user/mouse activity*

Fixed time Window



Return to Table of Contents

Choose a Lesson

Data Processing Challenges

Cloud Dataflow Overview

Key Concepts

Template Hands On

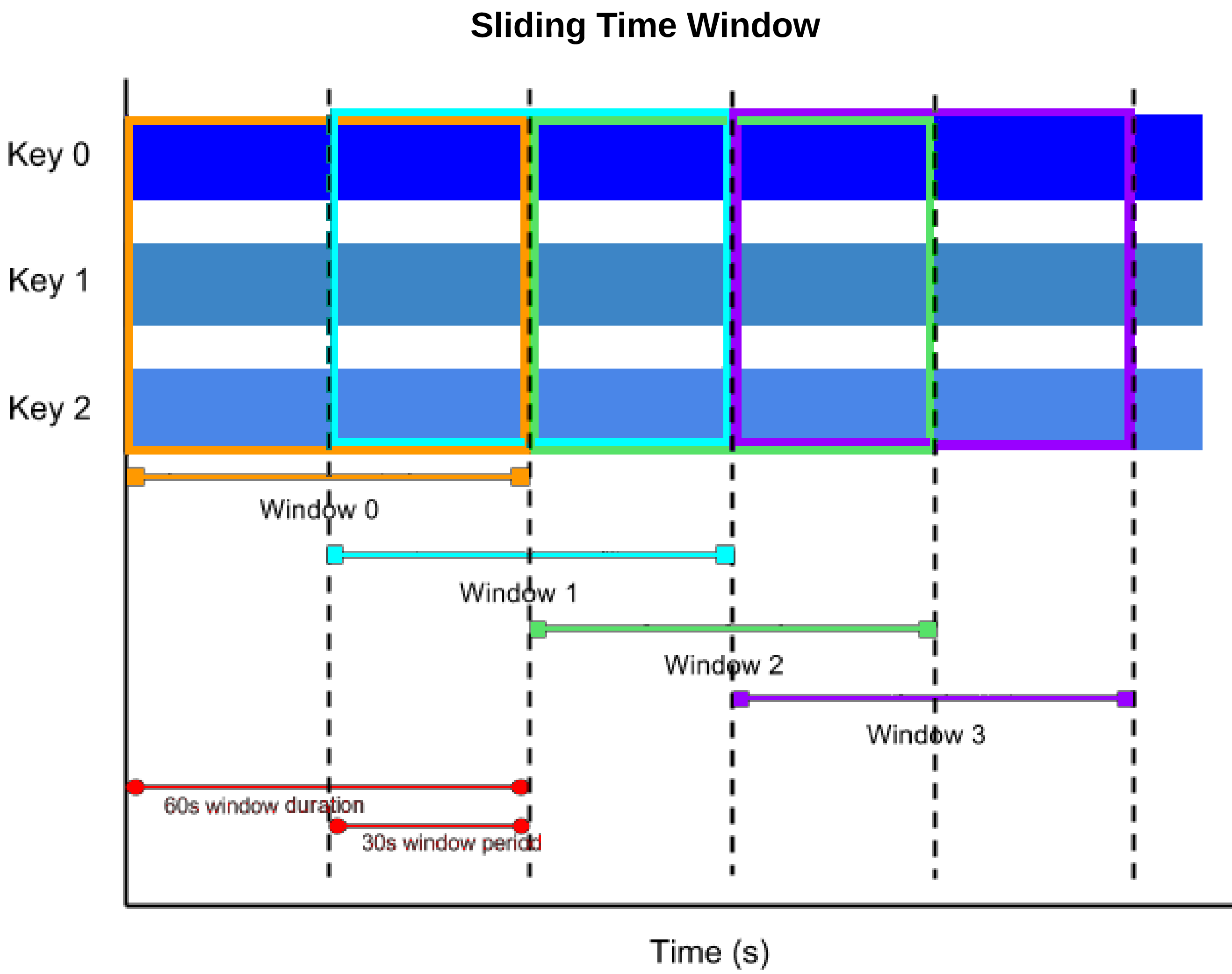
Streaming Ingest Pipeline Hands On

Additional Best Practices

Additional Best Practices

Previous

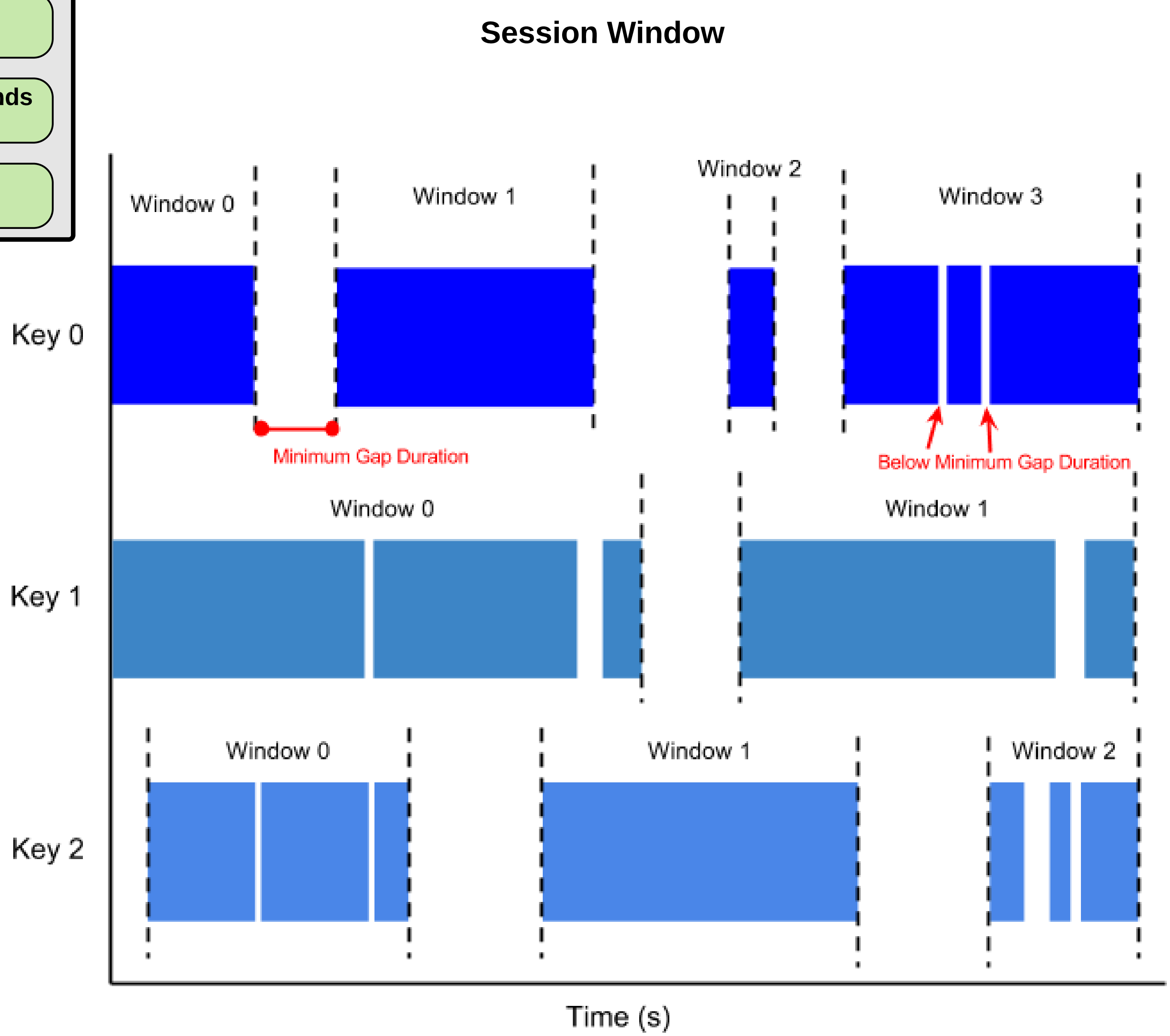
Next



Choose a Lesson
Data Processing Challenges
Cloud Dataflow Overview
Key Concepts
Template Hands On
Streaming Ingest Pipeline Hands On
Additional Best Practices

Additional Best Practices

Previous
Next



Return to Table of Contents

Choose a Lesson

Data Processing Challenges

Cloud Dataflow Overview

Key Concepts

Template Hands On

Streaming Ingest Pipeline Hands On

Additional Best Practices

Additional Best Practices

Previous

Updating Dataflow Pipelines

- **Scenario:** Update streaming Dataflow pipeline with new code:
  - New code = new pipeline not compatible with current version
  - Need data to *switch over* to new job/pipeline without losing anything in the process
- **Solution**: Update job:
  - Creates new job with same name/new *jobID*
- Compatibility between old/new jobs:
  - Map old to new job transforms with **transform mapping**
    - "Bridge" between old and new code base
  - After compatibility check:
    - Buffered data transferred to new job, using transform mapping to translate changes

Return to Table of Contents

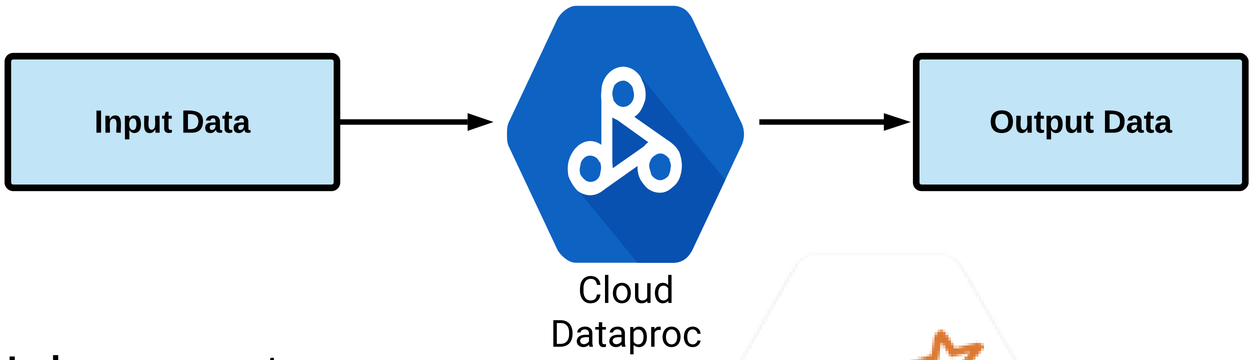
Choose a Lesson

- Dataproc Overview
- Configure Dataproc Cluster and Submit Job
- Migrating and Optimizing for Google Cloud
- Best Practices for Cluster Performance

Dataproc Overview

What is Cloud Dataproc?

Next



Hadoop ecosystem:

- **Hadoop, Spark, Pig, Hive**
- **Lift and shift to GCP**

Managed Hadoop/Spark Stack

Custom Code
Monitoring/Health
Dev Integration
Manual Scaling
Job Submission
Google Cloud Connectivity
Deployment
Creation

Dataproc facts:

- **On-demand, managed Hadoop and Spark clusters**
- **Managed, but not no-ops:**
    - **Must configure cluster, not auto-scaling**
    - **Greatly reduces administrative overhead**
- **Integrates with other Google Cloud services:**
    - **Separate data from the cluster - save costs**
- **Familiar Hadoop/Spark ecosystem environment:**
    - **Easy to move existing projects**
- **Based on Apache Bigtop distribution:**
    - **Hadoop, Spark, Hive, Pig**
- **HDFS available (but maybe not optimal)**
- **Other ecosystem tools can be installed as well via initialization actions**

Return to Table of Contents

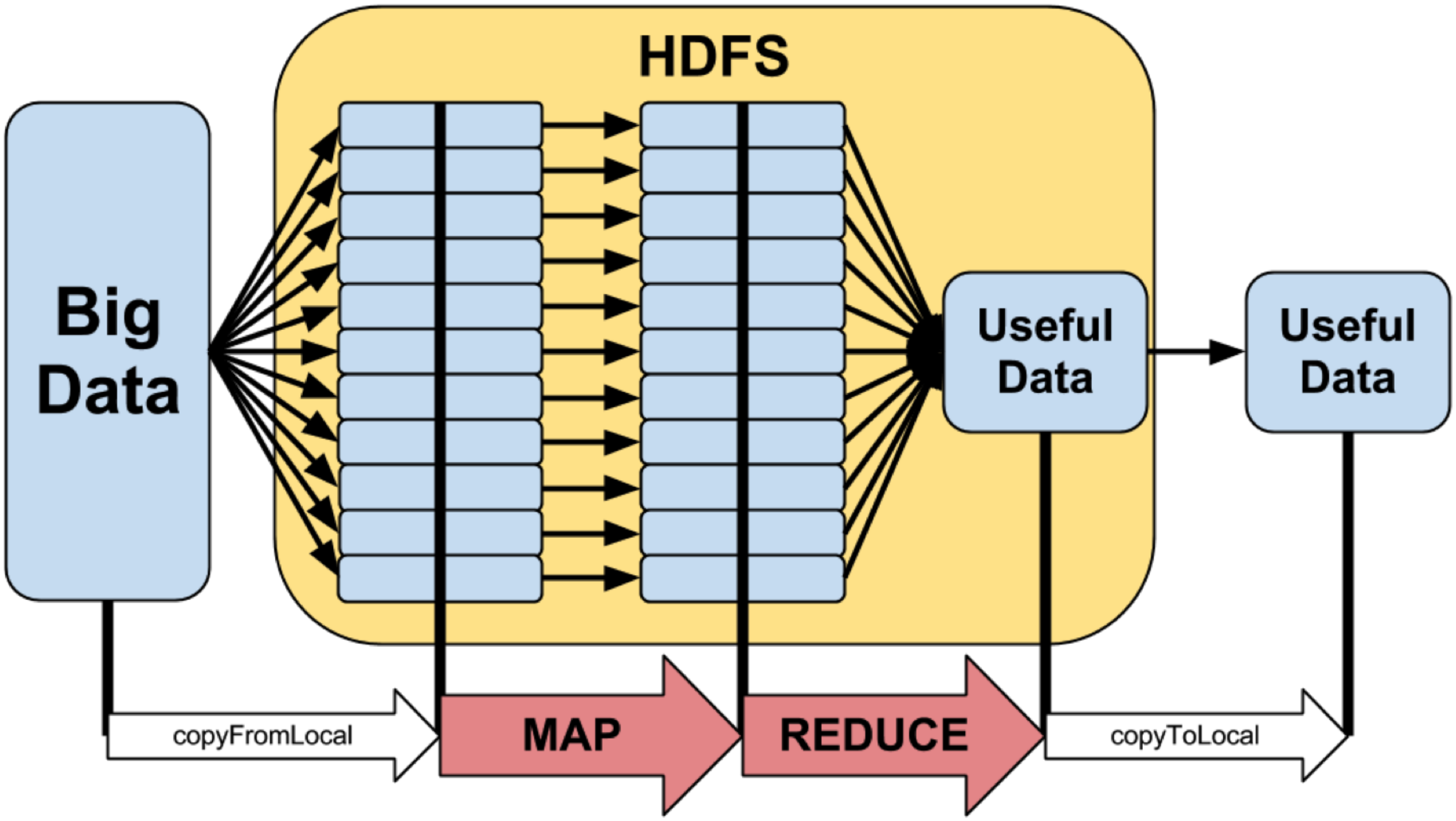
Choose a Lesson
Dataproc Overview
Configure Dataproc Cluster and Submit Job
Migrating and Optimizing for Google Cloud
Best Practices for Cluster Performance

Dataproc Overview

Previous
Next

What is MapReduce?

- Simple definition:
  - Take big data, distribute it to many workers (map)
  - Combine results of many pieces (reduce)
- Distributed/parallel computing



Return to Table of Contents

Choose a Lesson
Dataproc Overview
Configure Dataproc Cluster and Submit Job
Migrating and Optimizing for Google Cloud
Best Practices for Cluster Performance

Dataproc Overview

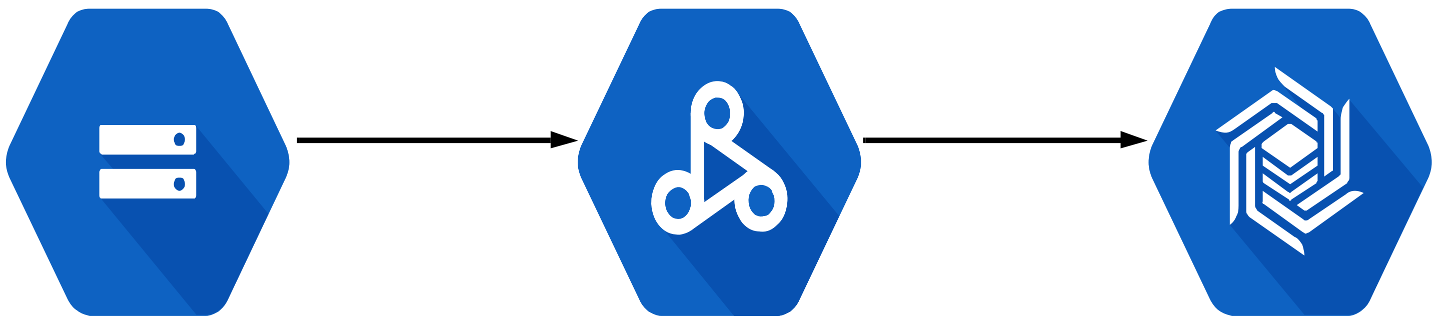
Previous
Next

Pricing:

- **Standard Compute Engine machine type pricing + managed Dataproc premium**
- **Premium = $0.01 per vCPU core/hour**

Machine type	Virtual CPUs	Memory	Dataproc
n1-highcpu-2	2	1.80GB	$0.020
n1-highcpu-4	4	3.60GB	$0.040
n1-highcpu-8	8	7.20GB	$0.080
n1-highcpu-16	16	14.40GB	$0.160
n1-highcpu-32	32	28.80GB	$0.320
n1-highcpu-64	64	57.60GB	$0.640

Data Lifecycle Scenario
Data Ingest, Transformation, and Analysis



Cloud Storage
Durable, inexpensive mass storage

Cloud Dataproc
Data Transformation

Cloud Bigtable
High speed analytics

Return to Table of Contents

Choose a Lesson

Dataproc Overview

Configure Dataproc Cluster and Submit Job

Migrating and Optimizing for Google Cloud

Best Practices for Cluster Performance

Dataproc Overview

Previous

Identity and Access Management (IAM):

- Project level only (primitive and predefined roles)
- Cloud Dataproc Editor, Viewer, Worker
- Editor - Full access to create/delete/edit clusters/jobs/workflows
- Viewer - View access only
- Worker - Assigned to service accounts:
  - Read/write GCS, write to Cloud Logging

Return to Table of Contents

Choose a Lesson

Dataproc Overview

Configure Dataproc Cluster and Submit Job

Migrating and Optimizing for Google Cloud

Best Practices for Cluster Performance

Configure Dataproc Cluster

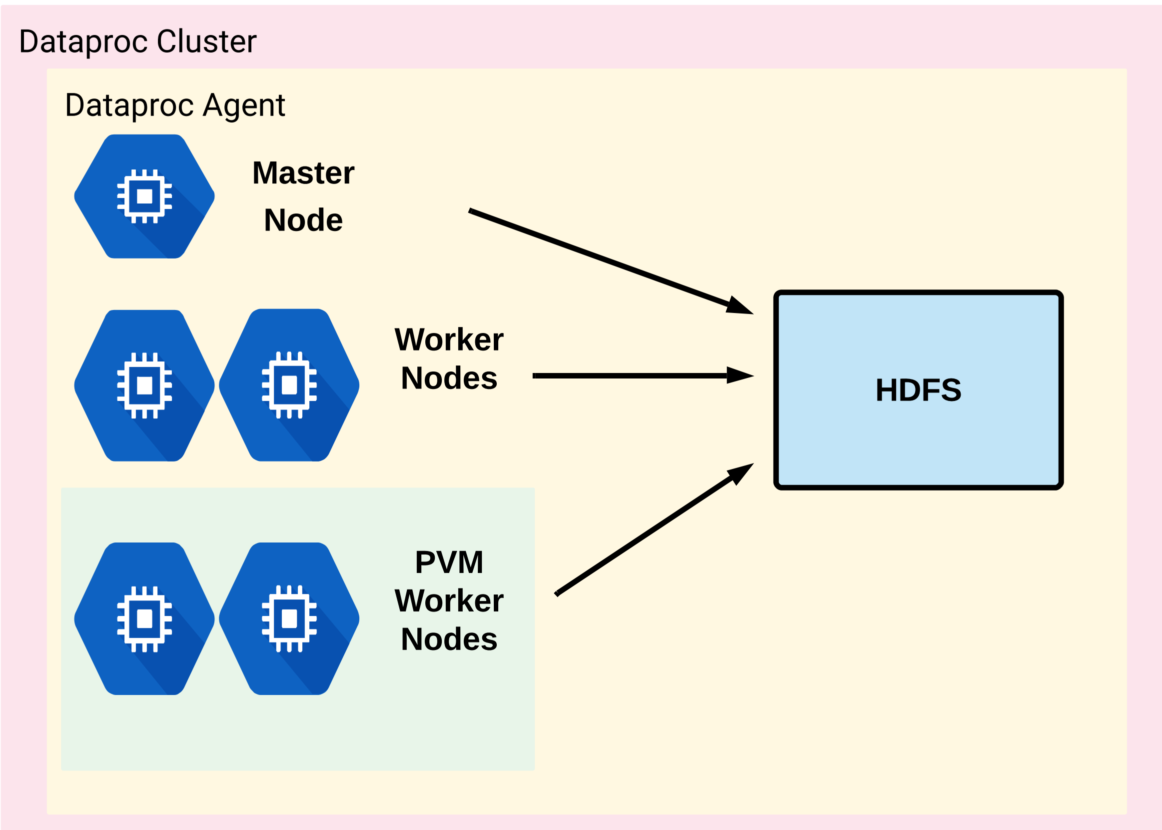
Next

Create cluster:

- gcloud dataproc clusters create [cluster_name] --zone [zone_name]
- Configure master node, worker nodes:
  - Master contains YARN resource manager
  - YARN = Yet Another Resource Negotiator

Updating clusters:

- Can only change # workers/preemptible VM's/labels/toggle graceful decommission
- Automatically reshards data for you
- gcloud dataproc clusters update [cluster_name] --num-workers [#] --num-preemptible-workers [#]



Return to Table of Contents

Configure Dataproc Cluster

Choose a Lesson

Dataproc Overview

Configure Dataproc Cluster and Submit Job

Migrating and Optimizing for Google Cloud

Best Practices for Cluster Performance

Previous

Preemptible VM's on Dataproc:

- Excellent low-cost worker nodes
- Dataproc manages the entire leave/join process:
  - No need to configure startup/shutdown scripts
  - Just add PVM's...and that's it
- No assigned disks for HDFS (only disk for caching)
- Want a mix of standard + PVM worker nodes

Access your cluster:

- SSH into master - same as any compute engine instance
- gcloud compute ssh [master_node_name]

Access via web - 2 options:

- Open firewall ports to your network (8088, 9870)
- Use SOCKS proxy - does not expose firewall ports

SOCKS proxy configuration:

- SSH to master to enable port forwarding:
  - gcloud compute ssh *master-host-name* --project=*project-id* --zone=*master-host-zone* -- -D 1080 -N
- Open new terminal window - launch web browser with parameters (varies by OS/browser):
  - "/Applications/Google Chrome.app/Contents/MacOS/Google Chrome" --proxy-server="socks5://localhost:1080" --host-resolver-rules="MAP * 0.0.0.0 , EXCLUDE localhost" --user-data-dir=/tmp/*cluster1-m*
- Browse to http://[master]:port:
  - 8088 - Hadoop
  - 9870 - HDFS

Using Cloud Shell (must use for each port):

- gcloud compute ssh *master-host-name* --project=*project-id* --zone *master-host-zone* -- -4 -N -L *port1*:*master-host-name*:*port2*
- Use Web Preview to choose port (8088/9870)

Return to Table of Contents

Choose a Lesson

Dataproc Overview

Configure Dataproc Cluster and Submit Job

Migrating and Optimizing for Google Cloud

Best Practices for Cluster Performance

Migrating and Optimizing for Google Cloud

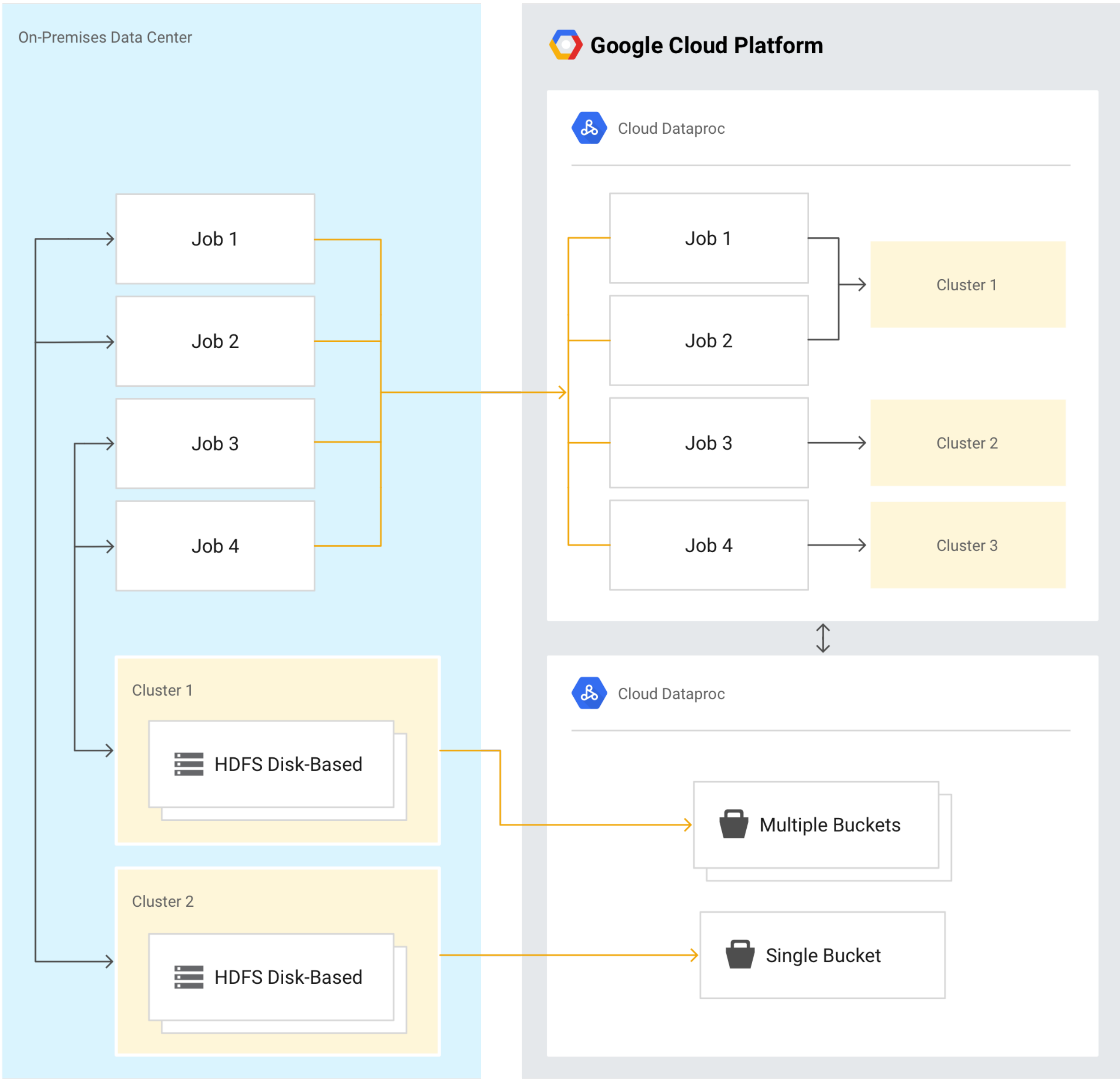
Migrating to Cloud Dataproc

Next

What are we moving/optimizing?

- **Data (from HDFS)**
- **Jobs (pointing to Google Cloud locations)**
- **Treating clusters as ephemeral (temporary) rather than permanent entities**

Install Cloud Storage connector to connect to GCS (Google Cloud Storage).



Return to Table of Contents

Choose a Lesson

Dataproc Overview

Configure Dataproc Cluster and Submit Job

Migrating and Optimizing for Google Cloud

Best Practices for Cluster Performance

Migrating and Optimizing for Google Cloud

Previous

Next

Migration Best Practices:

- Move data first (generally Cloud Storage buckets):
  - Possible exceptions:
    - Apache HBase data to Bigtable
    - Apache Impala to BigQuery
    - Can still choose to move to GCS if Bigtable/BQ features not needed
- Small-scale experimentation (proof of concept):
  - Use a subset of data to test
- Think of it in terms of ephemeral clusters
- Use GCP tools to optimize and save costs

Return to Table of Contents

Migrating and Optimizing for Google Cloud

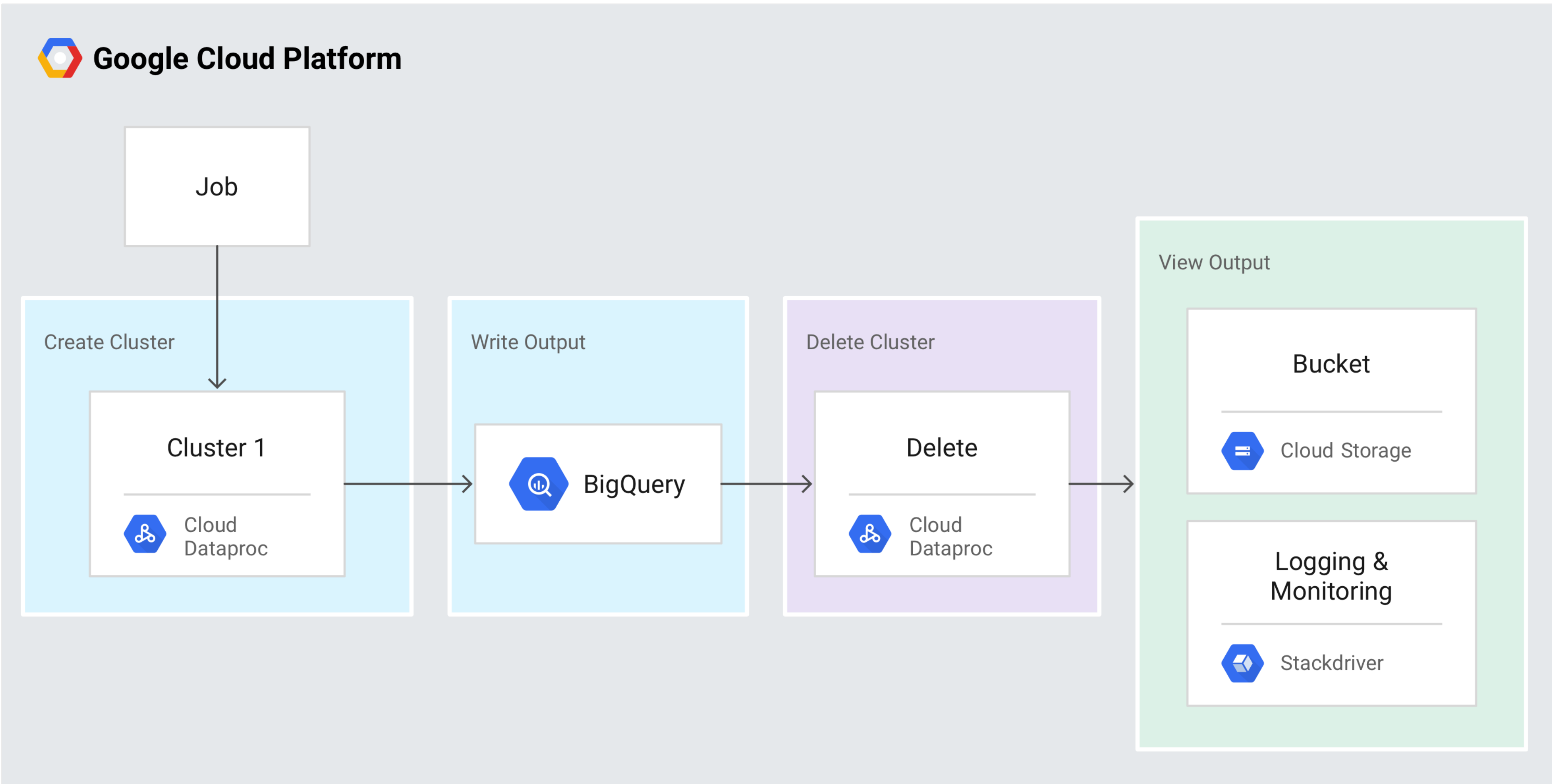
Choose a Lesson
Dataproc Overview
Configure Dataproc Cluster and Submit Job
Migrating and Optimizing for Google Cloud
Best Practices for Cluster Performance

Previous
Next

Optimize for the Cloud ("Lift and Leverage")

Separate storage and compute (cluster):

- **Save on costs:**
  - **No need to keep clusters to keep/access data**
- **Simplify workloads:**
  - **No shaping workloads to fit hardware**
  - **Simplify storage capacity**
- **HDFS --> Google Cloud Storage**
- **Hive --> BigQuery**
- **HBase --> Bigtable**



Return to Table of Contents

Choose a Lesson

Dataproc Overview

Configure Dataproc Cluster and Submit Job

Migrating and Optimizing for Google Cloud

Best Practices for Cluster Performance

Migrating and Optimizing for Google Cloud

Previous

Converting from HDFS to Google Cloud Storage:

1. Copy data to GCS:

- **Install connector or copy manually**

2. Update file prefix in scripts:

- **From hdfs:// to gs://**

3. Use Dataproc, and run against/output to GCS

The end goal should be to eventually move toward a cloud-native and serverless architecture (Dataflow, BigQuery, etc.).

Return to Table of Contents

Choose a Lesson

Dataproc Overview

Configure Dataproc Cluster and Submit Job

Migrating and Optimizing for Google Cloud

Best Practices for Cluster Performance

Best Practices for Cluster Performance

Dataproc Performance Optimization

(GCP-specific)

- **Keep data close to your cluster**
    - **Place Dataproc cluster in the same region as storage bucket**
- **Larger persistent disk = better performance**
    - **Consider using SSD over HDD – slightly higher cost**
- **Allocate more VM's**
    - **Use preemptible VM's to save on costs**
    - **More VM's will come at a higher cost than larger disks if more disk throughput is needed**

Return to Table of Contents

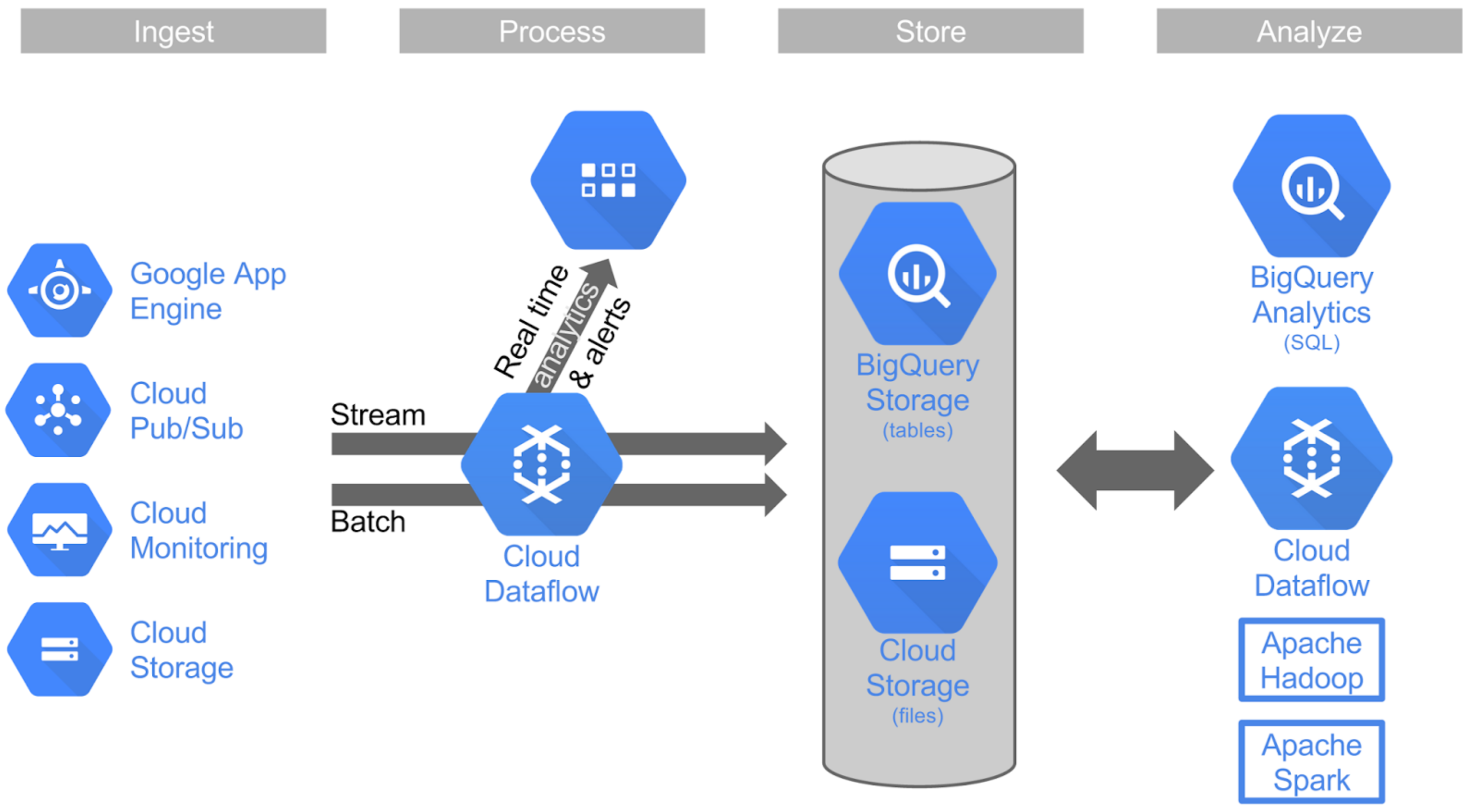
Choose a Lesson
BigQuery Overview
Interacting with BigQuery
Load and Export Data
Optimize for Performance and Costs
Streaming Insert Example
BigQuery Logging and Monitoring
BigQuery Best Practices

BigQuery Overview

Next

What is BigQuery?

- Fully Managed Data warehousing
    - Near-real time analysis of petabyte scale databases
- Serverless (no-ops)
- Auto-scaling to petabyte range
- Both storage and analysis
- Accepts batch and streaming loads
- Locations = multi-regional (US, EU), Regional (asia-northeast1)
- Replicated, durable
- Interact primarily with standard SQL (also Legacy SQL)
    - SQL Primer course



Choose a Lesson

BigQuery Overview

Interacting with BigQuery

Load and Export Data

Optimize for Performance and Costs

Streaming Insert Example

BigQuery Logging and Monitoring

BigQuery Best Practices

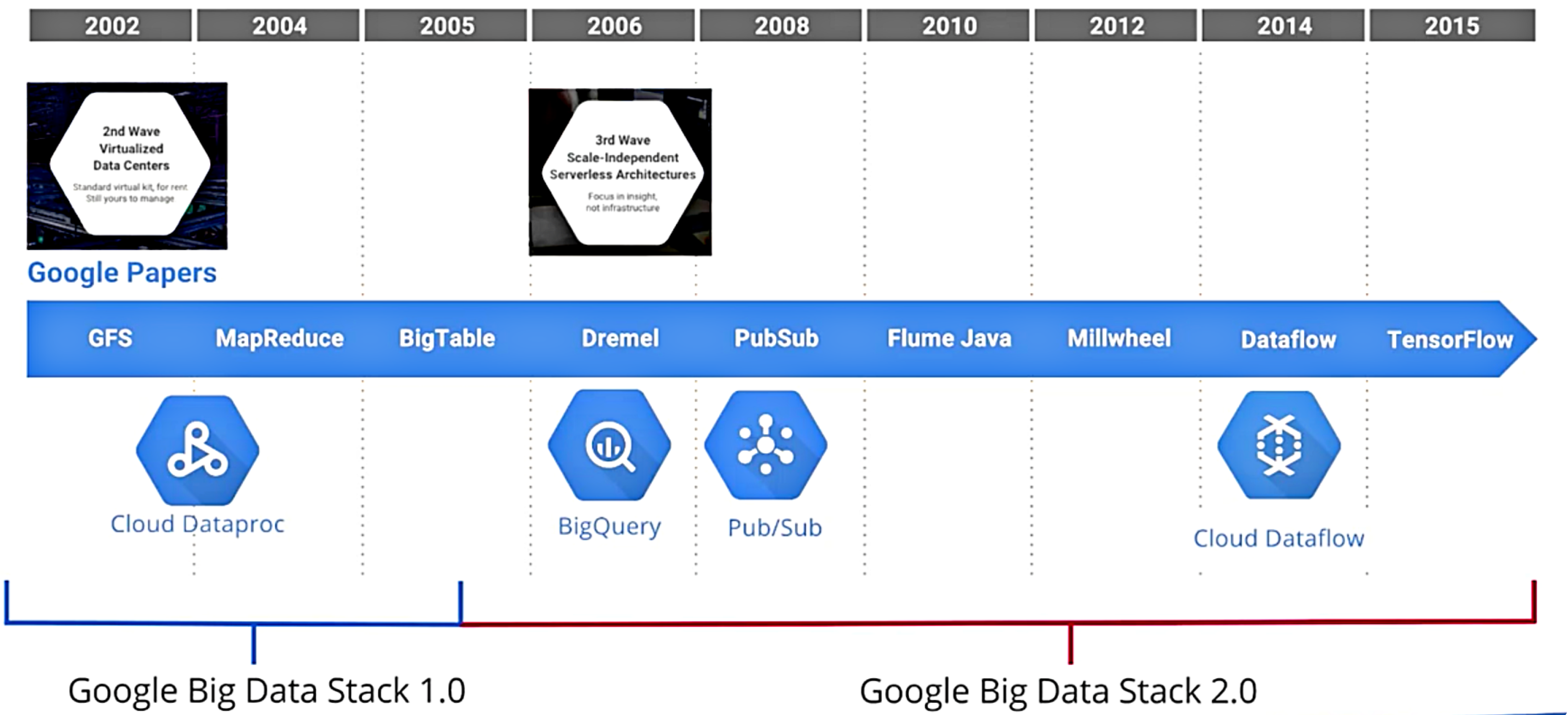
BigQuery Overview

Previous

Next

How BigQuery works

- Part of the "3rd wave" of cloud computing
  - Google Big Data Stack 2.0
- Focus on serverless compute, real time insights, machine learning...
  - ...instead of data placement, cluster configuration
  - No managing of infrastructure, nodes, clusters, etc



Return to Table of Contents

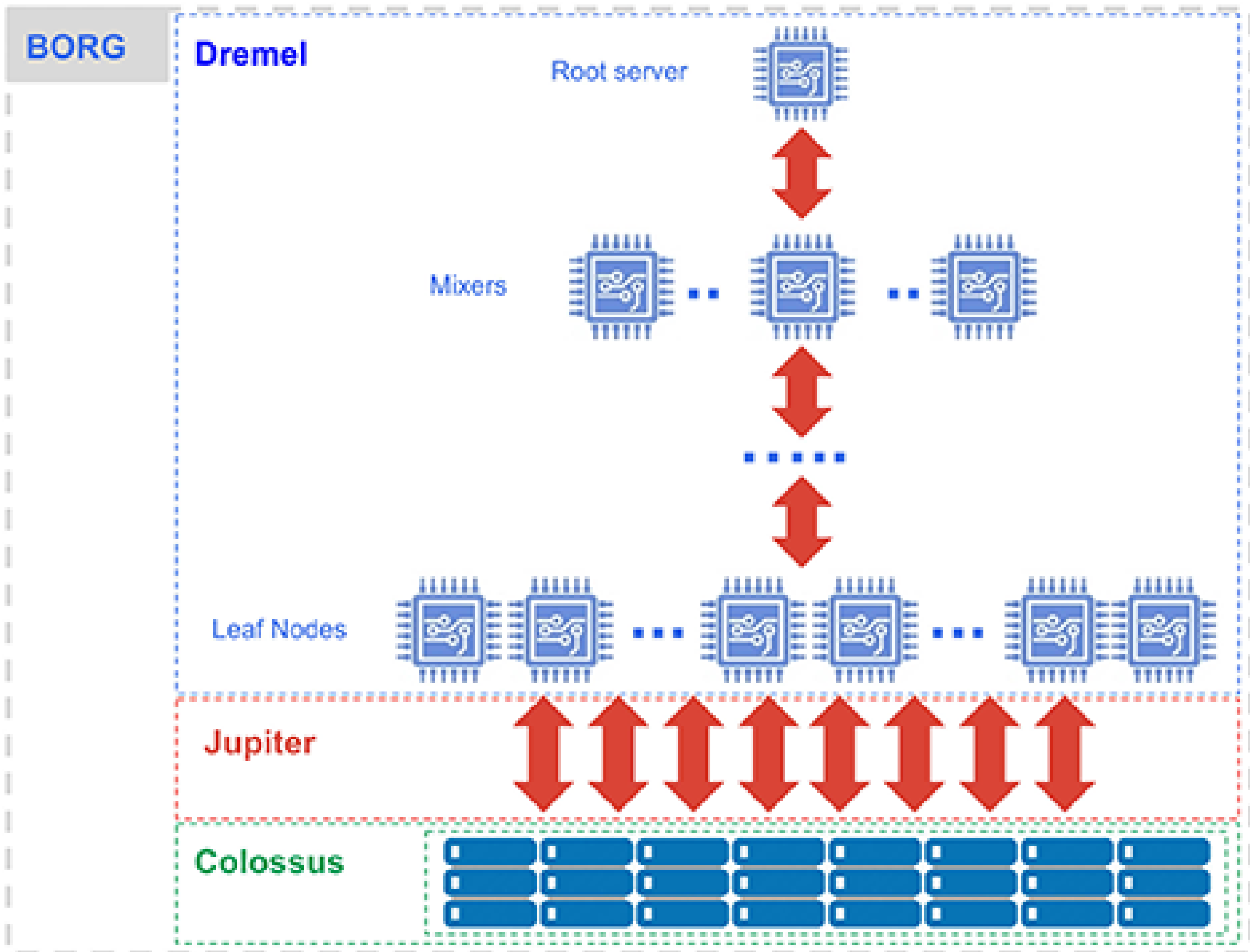
BigQuery Overview

Previous

Next

How BigQuery works (cont)

- Jobs (queries) can scale up to thousands of CPU's across many nodes, but the process is completely invisible to end user
- Storage and compute are separated, connected by petabit network



Choose a Lesson

BigQuery Overview

Interacting with BigQuery

Load and Export Data

Optimize for Performance and Costs

Streaming Insert Example

BigQuery Logging and Monitoring

BigQuery Best Practices

Return to Table of Contents

BigQuery Overview

Choose a Lesson

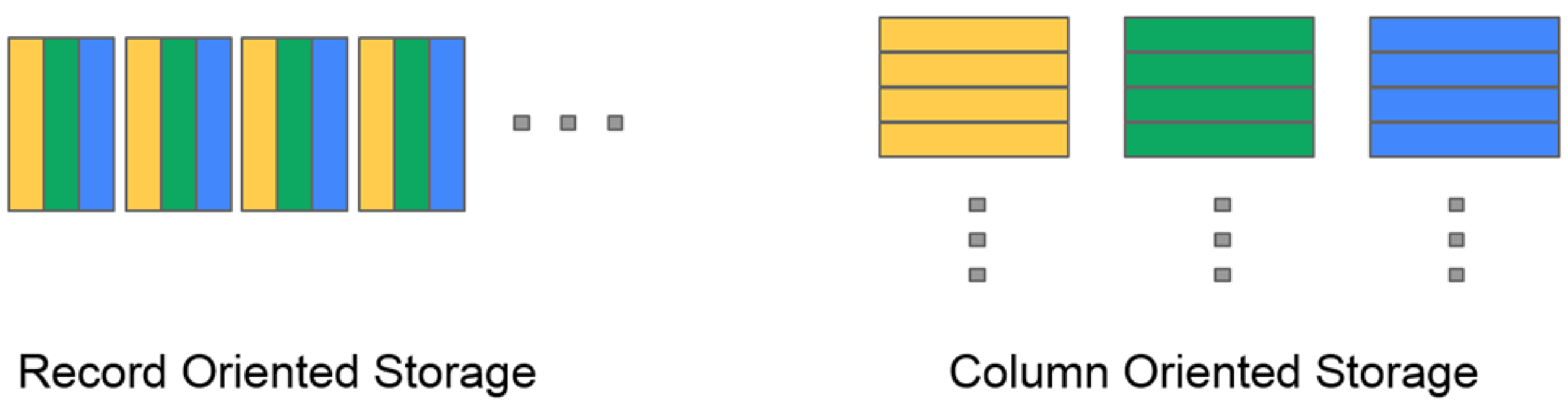
- BigQuery Overview
- Interacting with BigQuery
- Load and Export Data
- Optimize for Performance and Costs
- Streaming Insert Example
- BigQuery Logging and Monitoring
- BigQuery Best Practices

Previous

Next

How BigQuery works (cont)

- Columnar data store
  - Separates records into column values, stores each value on different storage volume
  - Traditional RDBMS stores whole record on one volume
  - Extremely fast read performance, poor write (update) performance - BigQuery does not update existing records
  - Not transactional



Choose a Lesson

- BigQuery Overview
- Interacting with BigQuery
- Load and Export Data
- Optimize for Performance and Costs
- Streaming Insert Example
- BigQuery Logging and Monitoring
- BigQuery Best Practices

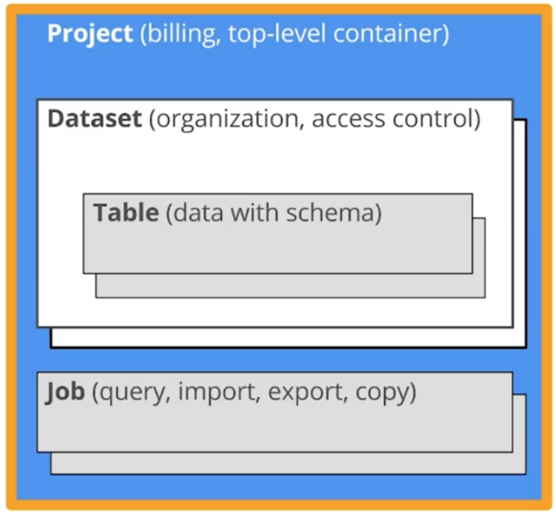
BigQuery Overview

Previous

Next

BigQuery structure

- Dataset - contains tables/views
- Table = collection of columns
- Job = long running action/query



Identity and Access Management (IAM)

- Control by project, dataset, view
- Cannot control at table level
  - But can control by views via datasets as alternative (virtual table defined by SQL query)
- Predefined roles - BigQuery...
  - Admin - full access
  - Data Owner - full dataset access
  - Data Editor - edit dataset tables
  - Data Viewer - view datasets and tables
  - Job User - run jobs
  - User - run queries and create datasets (but not tables)
- [Roles comparison matrix]
- Sharing datasets
  - Make public with All Authenticated Users

Return to Table of Contents

Choose a Lesson

BigQuery Overview

Interacting with BigQuery

Load and Export Data

Optimize for Performance and Costs

Streaming Insert Example

BigQuery Logging and Monitoring

BigQuery Best Practices

BigQuery Overview

Previous

Pricing

- Storage, Queries, Streaming insert
- Storage = $0.02/GB/mo (first 10GB/mo free)
  - Long term storage (not edited for 90 days) = $0.01/GB/mo
- Queries = $5/TB (first TB/mo free)
- Streaming = $0.01/200 MB
- Pay as you go, with high end flat-rate query pricing
- Flat rate - starts at $40K per month with 2000 slots

Return to Table of Contents

Choose a Lesson

- BigQuery Overview
- Interacting with BigQuery
- Load and Export Data
- Optimize for Performance and Costs
- Streaming Insert Example
- BigQuery Logging and Monitoring
- BigQuery Best Practices

Interacting with BigQuery

Next

Interaction methods

- Web UI
- Command line (bq commands)
    - bq query --arguments 'QUERY'
- Programmatic (REST API, client libraries)
- Interact via queries

Querying tables

- FROM `project.dataset.table` (Standard SQL)
- FROM [project:dataset.table] (Legacy SQL)

Searching multiple tables with wildcards

Query across multiple, similarly named tables

- FROM `project.dataset.table_prefix*`

Filter further in WHERE clause

- AND _TABLE_SUFFIX BETWEEN 'table003' and 'table050'

Advanced SQL queries are allowed

- JOINS, sub queries, CONCAT

Return to Table of Contents

Interacting with BigQuery

Choose a Lesson
BigQuery Overview
Interacting with BigQuery
Load and Export Data
Optimize for Performance and Costs
Streaming Insert Example
BigQuery Logging and Monitoring
BigQuery Best Practices

Previous

Views

- Virtual table defined by query
- 'Querying a query'
- Contains data only from query that contains view
- Useful for limiting table data to others

Cached queries

- Queries cost money
- Previous queries are cached to avoid charges if ran again
- command line to disable cached results
  - bq query --nouse_cache '(QUERY)'
- Caching is per user only

User Defined Functions (UDF)

- Combine SQL code with JavaScript/SQL functions
- Combine SQL queries with programming logic
- Allow much more complex operations (loops, complex conditionals)
- WebUI only usable with Legacy SQL

Return to Table of Contents

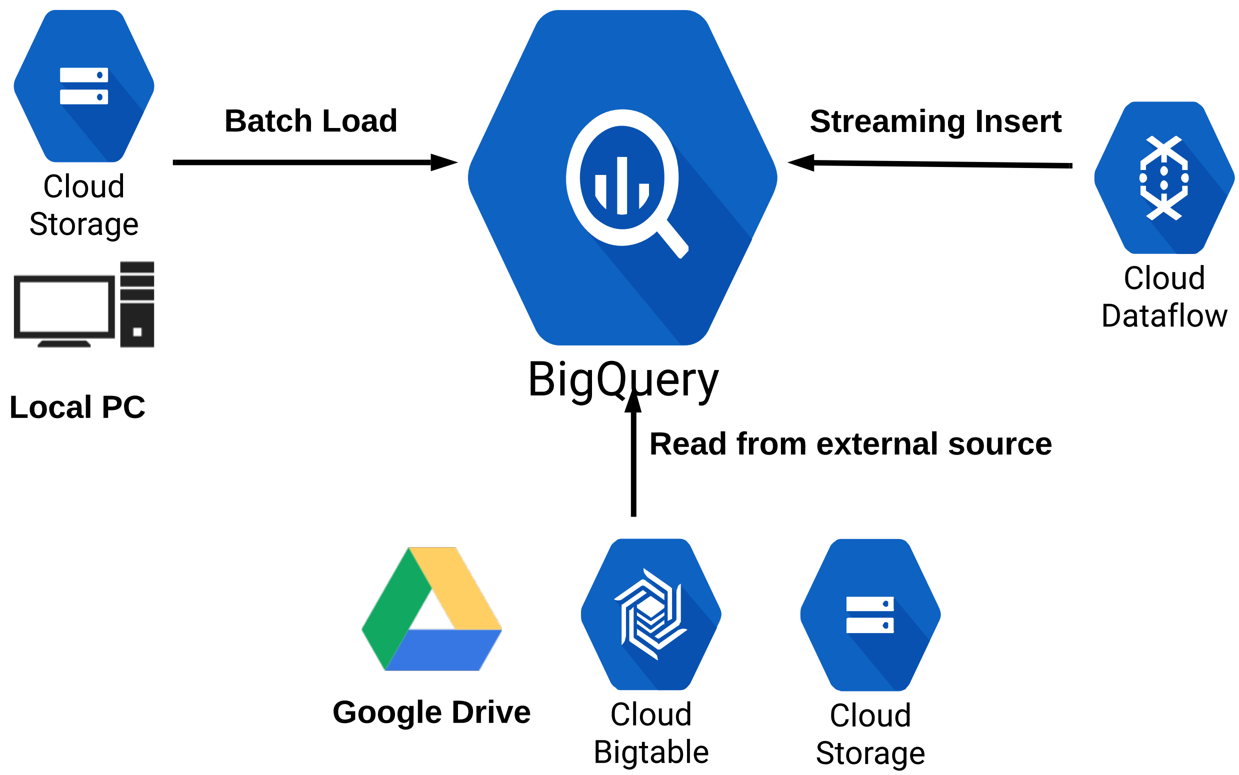
Load and Export Data

Choose a Lesson

- BigQuery Overview
- Interacting with BigQuery
- Load and Export Data
- Optimize for Performance and Costs
- Streaming Insert Example
- BigQuery Logging and Monitoring
- BigQuery Best Practices

Loading and reading sources

Next



Data formats:

Load

- CSV
- JSON (Newline delimited)
- Avro - best for compressed files
- Parquet
- Datastore backups

Read

- CSV
- JSON (Newline delimited)
- Avro
- Parquet

Why use external sources?

- Load and clean data in one pass from external, then write to BigQuery
- Small amount of frequently changing data to join to other tables

Loading data with command line

- bq load --source_format=[format] [dataset].[table] [source_path] [schema]
- Can load multiple files with command line (not WebUI)

Return to Table of Contents

Load and Export Data

Choose a Lesson

BigQuery Overview

Interacting with BigQuery

Load and Export Data

Optimize for Performance and Costs

Streaming Insert Example

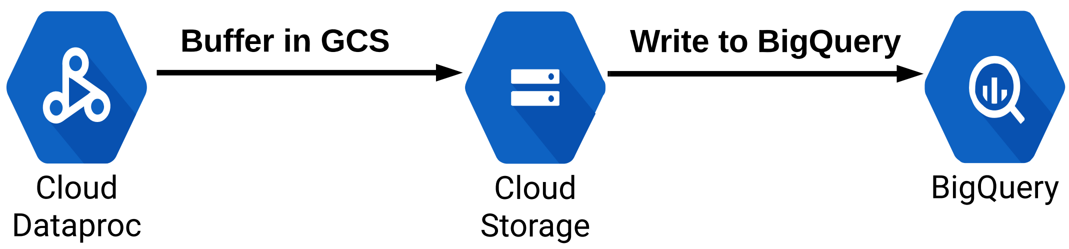
BigQuery Logging and Monitoring

BigQuery Best Practices

Previous

Connecting to/from other Google Cloud services

- Dataproc - Use BigQuery connector (installed by default), job uses Cloud Storage for staging



Exporting tables

- Can only export to Cloud Storage
- Can copy table to another BigQuery dataset
- Export formats: CSV, JSON, Avro
- Can export multiple tables with command line
- Can only export up to 1GB per file, but can split into multiple files with wildcards
- Command line
  - bq extract 'projectid:dataset.table' gs://bucket_name/folder/object_name
  - Can drop 'project' if exporting from same project
  - Default is CSV, specify other format with --destination_format
  - --destination_format=NEWLINE_DELIMITED_JSON

BigQuery Transfer Service

- Import data to BigQuery from other Google advertising SaaS applications
- Google AdWords
- DoubleClick
- YouTube reports

Return to Table of Contents

Choose a Lesson

BigQuery Overview

Interacting with BigQuery

Load and Export Data

Optimize for Performance and Costs

Streaming Insert Example

BigQuery Logging and Monitoring

BigQuery Best Practices

Optimize for Performance and Costs

Performance and costs are complementary

Next

- Less work = faster query = less costs
- What is 'work'?
  - I/O - how many bytes read?
  - Shuffle - how much passed to next stage
  - How many bytes written?
  - CPU work in functions

General best practices

- Avoid using SELECT *
- Denormalize data when possible
  - Grouping data into single table
  - Often with nested/repeated data
  - Good for read performance, not for write (transactional) performance
- Filter early and big with WHERE clause
- Do biggest joins first, and filter pre-JOIN
- LIMIT does not affect cost
- Partition data by date
  - Partition by ingest time
  - Parition by specified data columns

Return to Table of Contents

Choose a Lesson

BigQuery Overview

Interacting with BigQuery

Load and Export Data

Optimize for Performance and Costs

Streaming Insert Example

BigQuery Logging and Monitoring

BigQuery Best Practices

Optimize for Performance and Costs

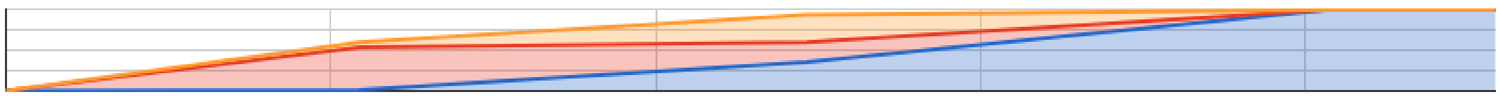
Previous

Monitoring query performance

- Understand color codes
- Understand 'skew' in difference between average and max time

Timeline ?

Expand chart



Execution Plan

	Stage timing: Wait	Read	Compute	Write	Parallel Inputs	Rows: Input	Output
S00: Input					105	122 M	5.34 K (78.2 KB)
S02: Coalesce					100	5.34 K	5.34 K (78.2 KB)
S03: Join+					74	22.1 M	37 (925 B)
S04: Aggregate+					17	37	19 (646 B)
S05: Output					1	19	19 (532 B)

Return to Table of Contents

Streaming Insert Example

Choose a Lesson

BigQuery Overview

Interacting with BigQuery

Load and Export Data

Optimize for Performance and Costs

Streaming Insert Example

BigQuery Logging and Monitoring

BigQuery Best Practices

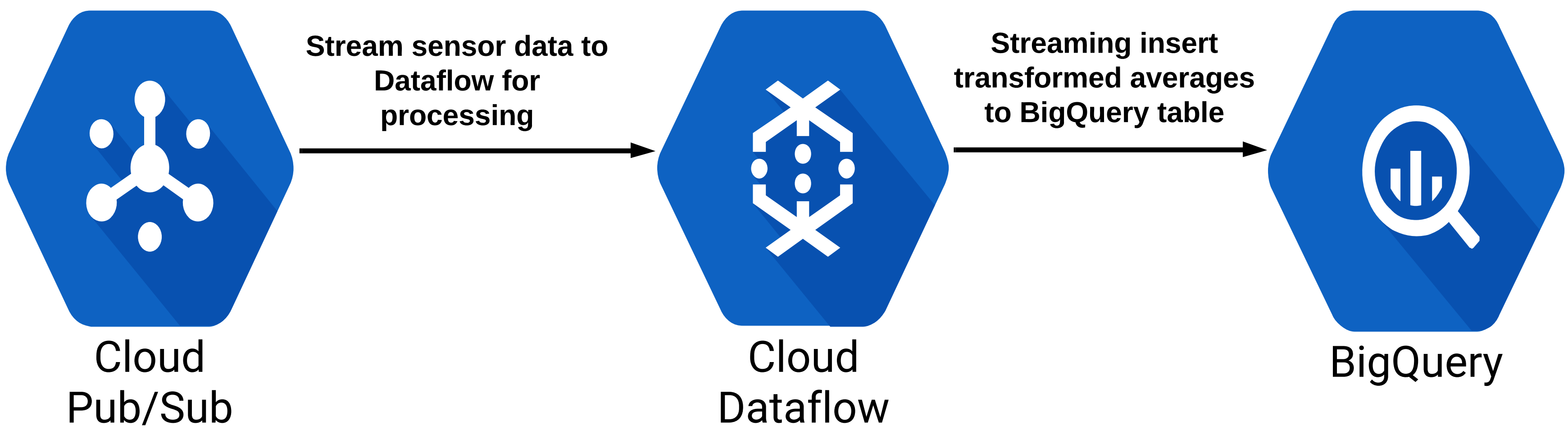
Quick setup

```
cd
gsutil cp -r gs://gcp-course-exercise-scripts/data-engineer/* .
bash streaming-insert.sh
```

Clean up

```
bash streaming-cleanup.sh
```

Manually stop Dataflow job



Return to Table of Contents

Choose a Lesson

BigQuery Overview

Interacting with BigQuery

Load and Export Data

Optimize for Performance and Costs

Streaming Insert Example

BigQuery Logging and Monitoring

BigQuery Best Practices

BigQuery Logging and Monitoring

Stackdriver Monitoring and Logging Differences

- Monitoring = performance/resources
- Logging = who is doing what
  - History of actions

Monitoring BigQuery Performance/Resources

- Monitoring = metrics, performance, resource capacity/usage (slots)
  - Query count, query times, slot utilization
  - Number of tables, stored and uploaded bytes over time
  - Alerts on metrics e.g., long query times
    - Example: Alerts when queries take more than one minute
- No data on **who** is doing what, or query details

Stackdriver Logging: "A Paper Trail"

- Logging = who is doing what
- Record of jobs and queries associated with accounts

Return to Table of Contents

Choose a Lesson

BigQuery Overview

Interacting with BigQuery

Load and Export Data

Optimize for Performance and Costs

Streaming Insert Example

BigQuery Logging and Monitoring

BigQuery Best Practices

BigQuery Best Practices

Data Format for Import

Next

- Best performance = Avro format
- Scenario: Import multi-TB databases with millions of rows

Faster
Avro - Compressed
Avro - Uncompressed
Parquet
CSV
JSON
CSV - Compressed
JSON - Compressed
Slower

Return to Table of Contents

Choose a Lesson

BigQuery Overview

Interacting with BigQuery

Load and Export Data

Optimize for Performance and Costs

Streaming Insert Example

BigQuery Logging and Monitoring

BigQuery Best Practices

BigQuery Best Practices

Previous

Next

Partitioned Tables

What is a partitioned table?

- Special single table
  - Divided into segments known as “partitions”

Why is this important?

- Query only certain rows (partitions) instead of entire table
  - Limits amount of read data
  - Improves performance
  - Reduces costs
- Partition types
  - Ingests time — when the data/row is created
  - Includes **TIMESTAMP** or **DATE** column
- **Scenario**: A large amount of data gets generated every day, and we need to query for only certain time periods within the same table.

Why not use multiple tables (one for each day) plus wildcards?

- Limited to 1000 tables per dataset
- Substantial performance drop vs. a single table

Return to Table of Contents

BigQuery Best Practices

Previous

Next

Choose a Lesson

- BigQuery Overview
- Interacting with BigQuery
- Load and Export Data
- Optimize for Performance and Costs
- Streaming Insert Example
- BigQuery Logging and Monitoring
- BigQuery Best Practices

Clustered Tables

- Taking partitioned tables "to the next level"
- Similar to partitioning, divides table reads by a specified column field
  - Instead of dividing by date/time, divides by field
- **Scenario**: Logistics company needs to query by tracking ID
  - Cluster by tracking ID column = only reading table rows with specified tracking ID's
- Restriction: only (currently) available for partitioned tables

Slots

- Computational capacity required to run a SQL query
  - Bigger/more complex queries need more slots
- Default, on-demand pricing allocates 2000 slots
  - Only an issue for extremely complex queries, or high number of simultaneous users
  - If more than 2000 slots required, switch to **flat-rate pricing**

Return to Table of Contents

Choose a Lesson

BigQuery Overview

Interacting with BigQuery

Load and Export Data

Optimize for Performance and Costs

Streaming Insert Example

BigQuery Logging and Monitoring

BigQuery Best Practices

BigQuery Best Practices

Previous

Backup and Recovery

- Highly available = multi-regional dataset vs. regional
- Backup/recovery = BigQuery automatically takes continuous snapshots of tables
  - 7 day history, but 2 days if purposely deleted
- Restore to previous point in time using `@(time)`, in milliseconds
- Example: Get snapshot from one hour ago

```
#legacySQL
SELECT * FROM [PROJECT_ID:DATASET.TABLE@-3600000]
```

- Alternatively, export table data to GCS, though not as cost effective

Choose a Lesson

What is Machine Learning?

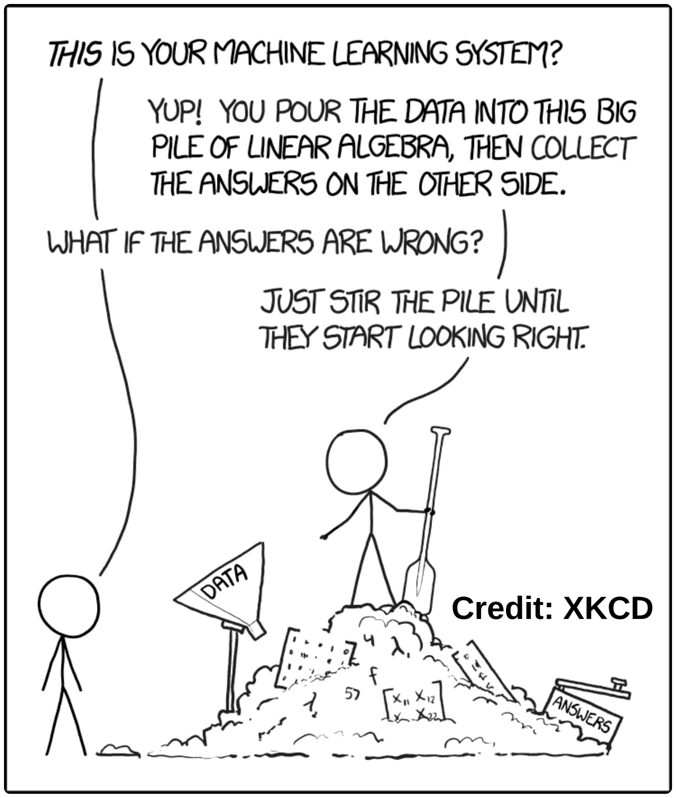
Working with Neural Networks

Preventing Overfitted Training Models

What is Machine Learning?

Next

Popular view of machine learning...

DATA →  → MAGIC!

Credit: XKCD

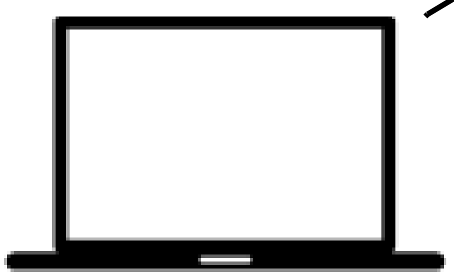
For Data Engineer:
Know the training and inference stages of ML

So what is machine learning?

Process of combining inputs to produce useful predictions on never-before-seen data

Makes a machine learn from data to make predictions on future data, instead of programming every scenario

New, unlabeled image



"I have never seen this image before, but I'm pretty sure that this is a cat!"

Return to Table of Contents

Choose a Lesson

What is Machine Learning?
Working with Neural Networks
Preventing Overfitted Training Models

What is Machine Learning?

Previous
Next

How it works

- Train a model with examples
- Example = input + label
- Training = adjust model to learn relationship between features and label - minimize error:
  - Optimize weights and biases (parameters) to different input features
- Feature = input variable(s)
- Inference = apply trained model to unlabeled examples
- Separate test and training data ensures model is generalized for additional data:
  - Otherwise, leads to overfitting (only models to training data, not new data)

Input + Label

"Cat"

Train on many examples

Training dataset

Train on ML model

TensorFlow

Match labels by adjusting weights to input features

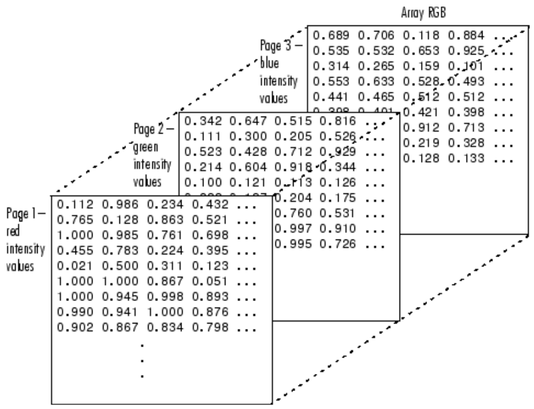
"I think this is a cat"

Predict with trained model

No label

Test dataset

Everything is numbers!



n-dimensional arrays called 'tensor', hence TensorFlow

Return to Table of Contents

Choose a Lesson

What is Machine Learning?

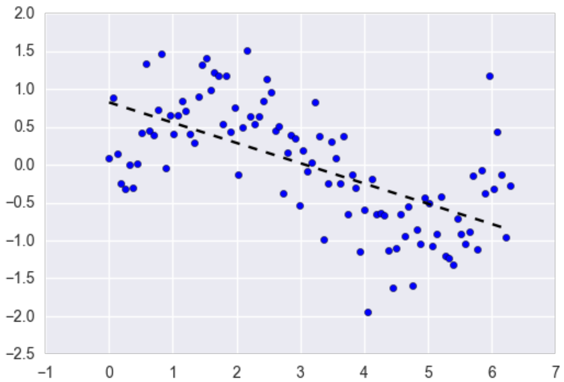
Working with Neural Networks

Preventing Overfitted Training Models

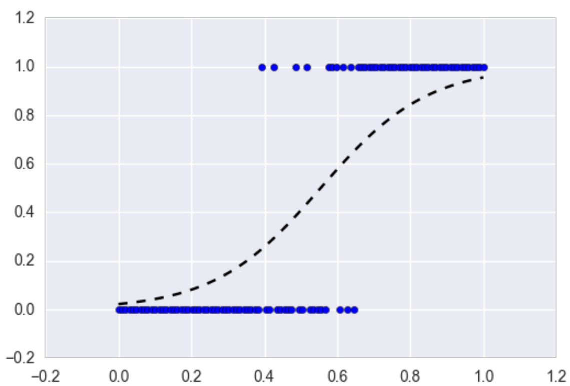
What is Machine Learning?

Previous

Regression



Classification



Learning types

- Supervised learning
  - Apply labels to data ("cat", "spam")
  - Regression - Continuous, numeric variables:
    - Predict stock price, student test scores
  - Classification - categorical variables:
    - yes/no, decision tree
    - "is this email spam?" "is this picture a cat?"
  - Same types for dataset columns:
    - continuous (regression) and categorical (classification)
    - income, birth year = continuous
    - gender, country = categorical
- Unsupervised learning
  - Clustering - finding patterns
  - Not labeled or categorized
  - "Given the location of a purchase, what is the likely amount purchased?"
  - Heavily tied to statistics
- Reinforcement Learning
  - Use positive/negative reinforcement to complete a task
    - Complete a maze, learn chess

Return to Table of Contents

Choose a Lesson

What is Machine Learning?

Working with Neural Networks

Preventing Overfitted Training Models

Working with Neural Networks

Next

Hands on learning tool

playground.tensorflow.org

Key terminology

- Neural network - model composed of layers, consisting of connected units (neurons):
    - Learns from training datasets
- Neuron - node, combines input values and creates one output value
- Input - what you feed into a neuron (e.g. cat pic)
- Feature - input variable used to make predictions
    - Detecting email spam (subject, key words, sender address)
    - Identify animals (ears, eyes, colors, shapes)
- Hidden layer - set of neurons operating from same input set
- Feature engineering - deciding which features to use in a model
- Epoch - single pass through training dataset
    - Speed up training by training on a subset of data vs. all data

Making Adjustments with Parameters

$$w_1x_1 + w_2x_2 > b$$

- Weights - multiplication of input values
- Bias - value of output given a weight of 0
- ML adjusts these parameters automatically
- Parameters = variables adjusted by training with data

Choose a Lesson

What is Machine Learning?

Working with Neural Networks

Preventing Overfitted Training Models

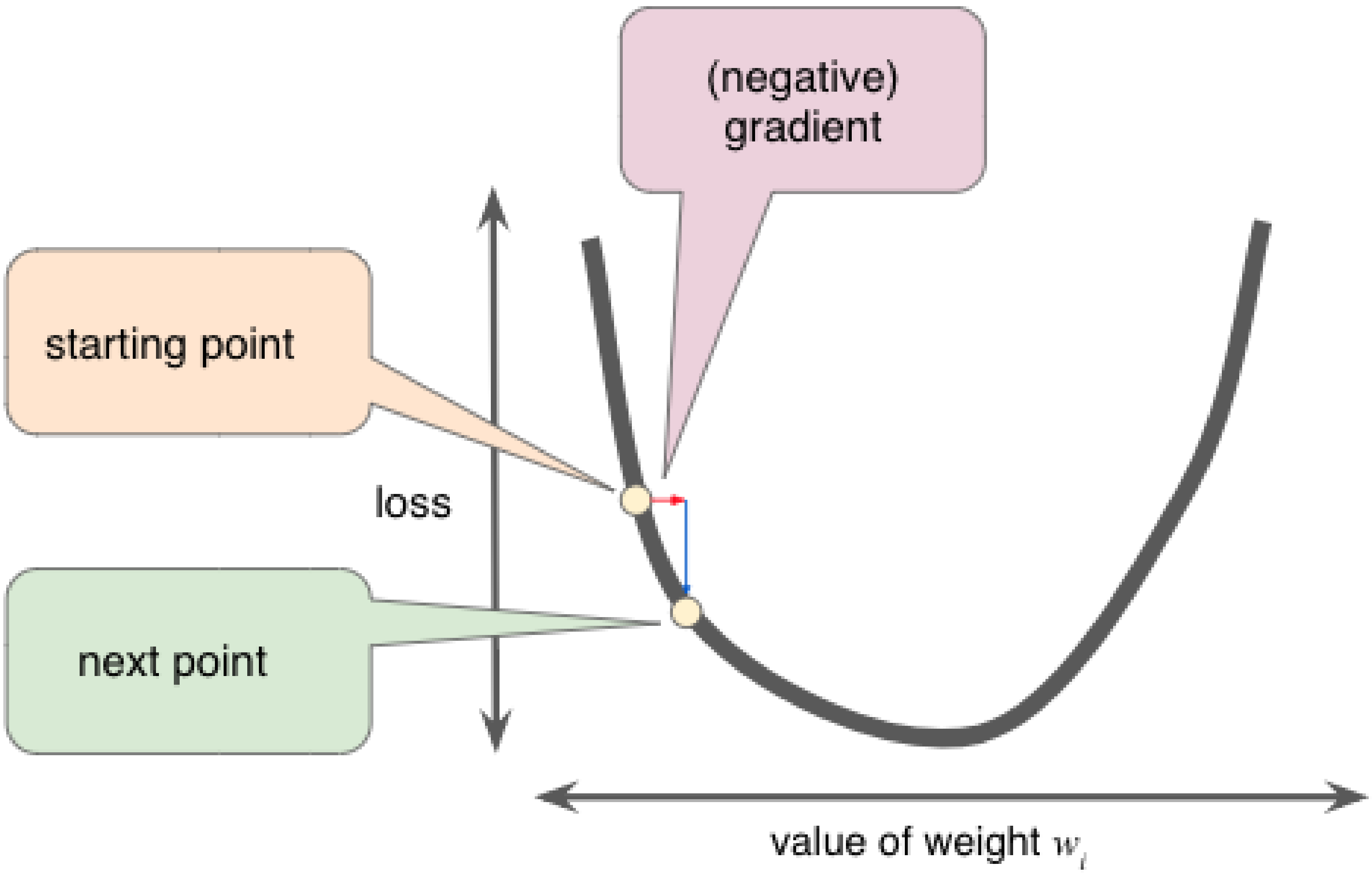
Working with Neural Networks

Previous

Next

Rate of adjustments with Learning Rate

- Magnitude of adjustments of weights and biases
- Hyperparameter = variables about the training process itself:
  - Also includes hidden layers
  - Not related to training data
- Gradient descent - technique to minimize loss (error rate)
- Challenge is to find the correct learning rate:
  - Too small - takes forever
  - Too large - overshoots



Choose a Lesson

What is Machine Learning?

Working with Neural Networks

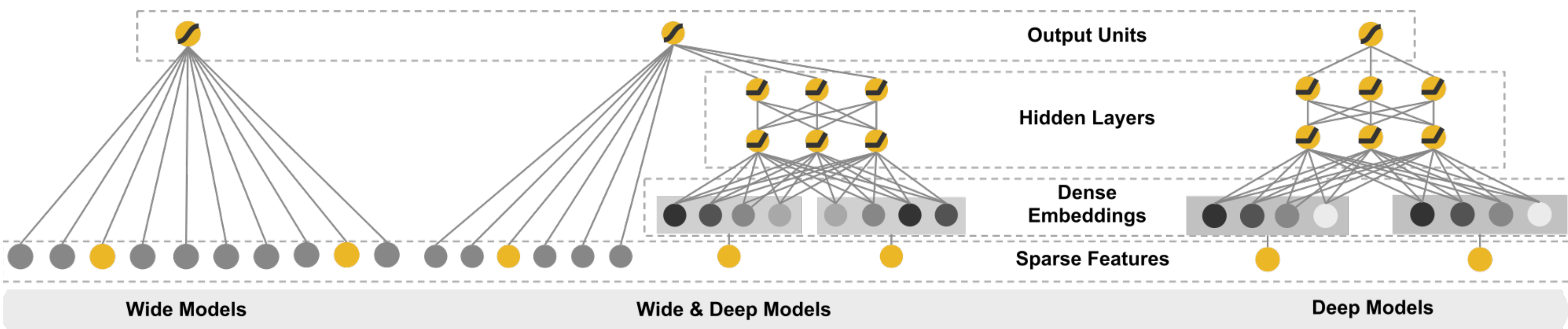
Preventing Overfitted Training Models

Working with Neural Networks

Previous

Deep and wide neural networks

- Wide - memorization:
  - Many features
- Deep - generalization:
  - Many hidden layers
- Deep and wide = both:
  - Good for recommendation engines



Return to Table of Contents

Choose a Lesson

What is Machine Learning?

Working with Neural Networks

Preventing Overfitted Training Models

Preventing Overfitted Training Models

Next

What is Overfitting?

- Training model *overfitted* to training data: Unable to **generalize** with new data
- Training model *fails to generalize*: Accounting for slightly different but close enough data

Causes of Overfitting:

- Not enough training data
  - Need more variety of samples
- Too many features
  - Too complex
- Model fitted to unnecessary features unique to training data, a.k.a. “Noise”

Solving for Overfitted Model:

- Use more data:
  - Add more training data.
  - More varied data allows for better generalization.
- Make the model less complex:
  - Use less (but more relevant) features.
  - Combine multiple co-dependant/redundant features into a single representative feature:
    - This also helps reduce model training time.
- Remove *noise*:
  - Increase **regularization** parameters

Return to Table of Contents

Choose a Lesson

What is Machine Learning?

Working with Neural Networks

Preventing Overfitted Training Models

Preventing Overfitted Training Models

Previous

Regularization?

- Adds a penalty to a model as it becomes more complex
- Penalizing **parameters** = better generalization
- Cuts out *noise* and unimportant data, to avoid overfitting

Regularization types:

- **L1 and L2 regularization** - Different approaches to tuning out noise. Each has different use case and purpose.
- **L1** - Lasso Regression: Assigns greater importance to **more influential features**
    - Shrinks less important features influence to zero
    - Good for models with many features, some more important than others
    - Example: Choosing features to predict likelihood of home selling:
        - House price more influential feature than carpet color
- **L2** - Ridge Regression: Performs better when all the input features influence the output, and with all weights being of **roughly equal size**

Return to Table of Contents

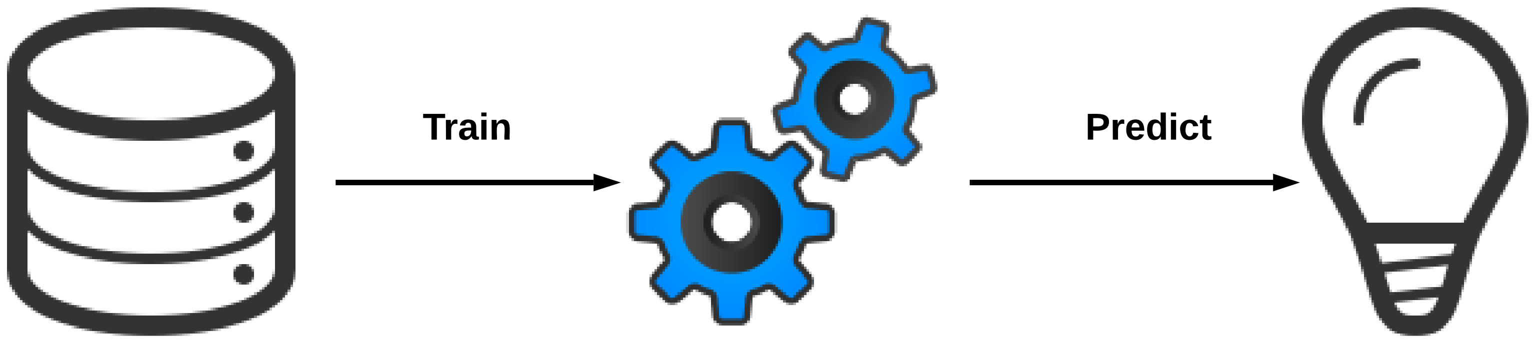
Choose a Lesson
GCP Machine Learning Services
AI Platform Overview
AI Platform Hands On

GCP Machine Learning Services

Next

Machine Learning - In a nutshell

- Algorithm that is able to learn from data



Achieving this requires:
Lots of data (and data storage)
Lots of Compute
How can GCP help?

Return to Table of Contents

Choose a Lesson

GCP Machine Learning Services

AI Platform Overview

AI Platform Hands On

GCP Machine Learning Services

Previous

Next

Different Roles = Different Priorities

- **Data Scientist/Machine Learning Engineer**
- **Application Developer**

Data Scientist/ML Engineer

- Works directly with ML libraries (e.g. Tensorflow)
- Creates, trains, and adjusts ML models
- "Does the math" for ML algorithms
- Gets into the ML details:
  - Parameters, biases, features, etc
- Values customization over simplicity

Application Developer

- Wants to 'plug in' ML capabilities to their app
- Avoids the mathematical details
- Values 'plug and play' solution

Return to Table of Contents

Choose a Lesson

Pre-trained ML API's
Vision API demo

Pre-trained ML API's

Next

AI Platform (Formerly Cloud ML Engine)

- Train, deploy, and manage custom ML models on managed infrastructure resources.
- You create the model, then Google provides managed infrastructure for testing it.

Pre-trained ML models

- Pre-trained models
- Common use cases (not customizable)
- Simply 'plug' into your application
- "Make Google do it"

Return to Table of Contents

AI Platform Overview

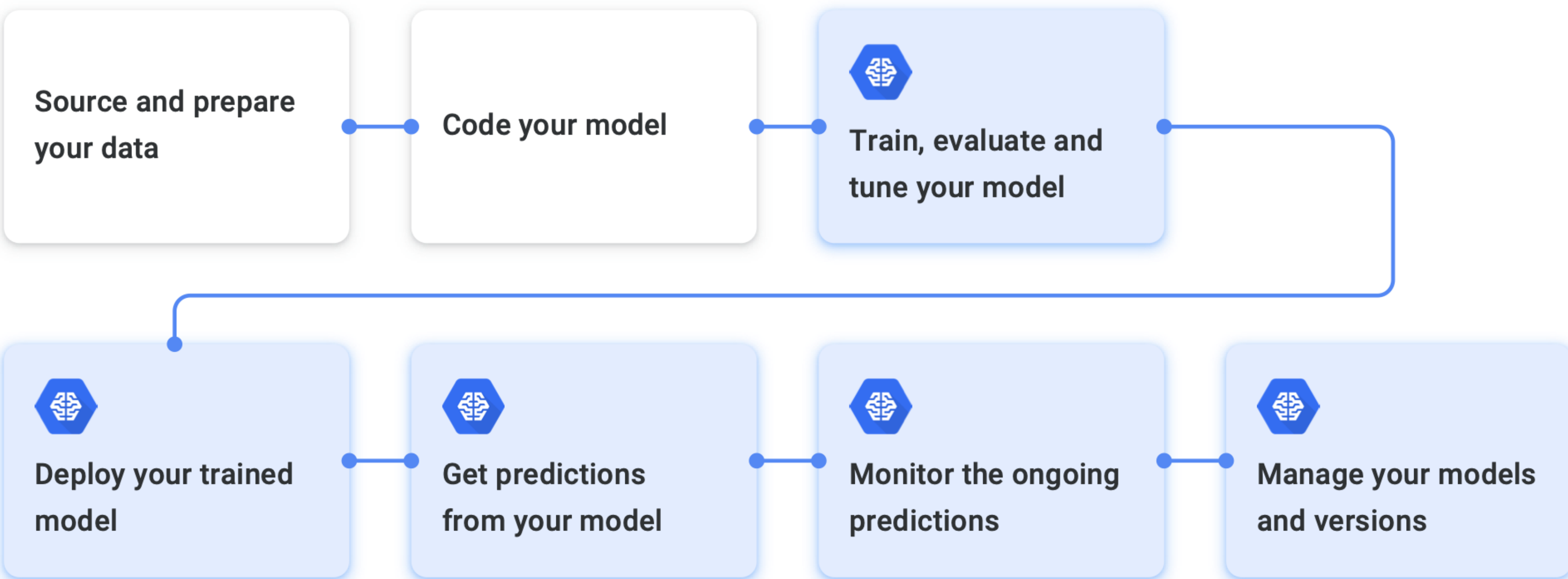
Next

Choose a Lesson
GCP Machine Learning Services
AI Platform Overview
AI Platform Hands On

AI Platform (formerly Cloud ML Engine)

- Fully managed Tensorflow (and other ML libraries) platform
- Distributed training and prediction:
    - Breaks jobs down into pieces, distributes to multiple workers
- Scales to tens of CPUs/GPUs/TPUs
- Hyperparameter tuning with Hypertune
- Automate the "annoying bits" of machine learning
- "I want to train my own model, but automate it."

High Level Overview



Return to Table of Contents

Choose a Lesson

GCP Machine Learning Services

AI Platform Overview

AI Platform Hands On

AI Platform Overview

Previous
Next

Tensorflow? ML Libraries?

- Software library for high performance numerical computation
- Released as open source by Google in 2015
- Often the default ML library of choice
- Pre-processing, feature creation, model training
- "I want to work with all of the detailed pieces."

Return to Table of Contents

Choose a Lesson
GCP Machine Learning Services
AI Platform Overview
AI Platform Hands On

AI Platform Overview

Previous
Next

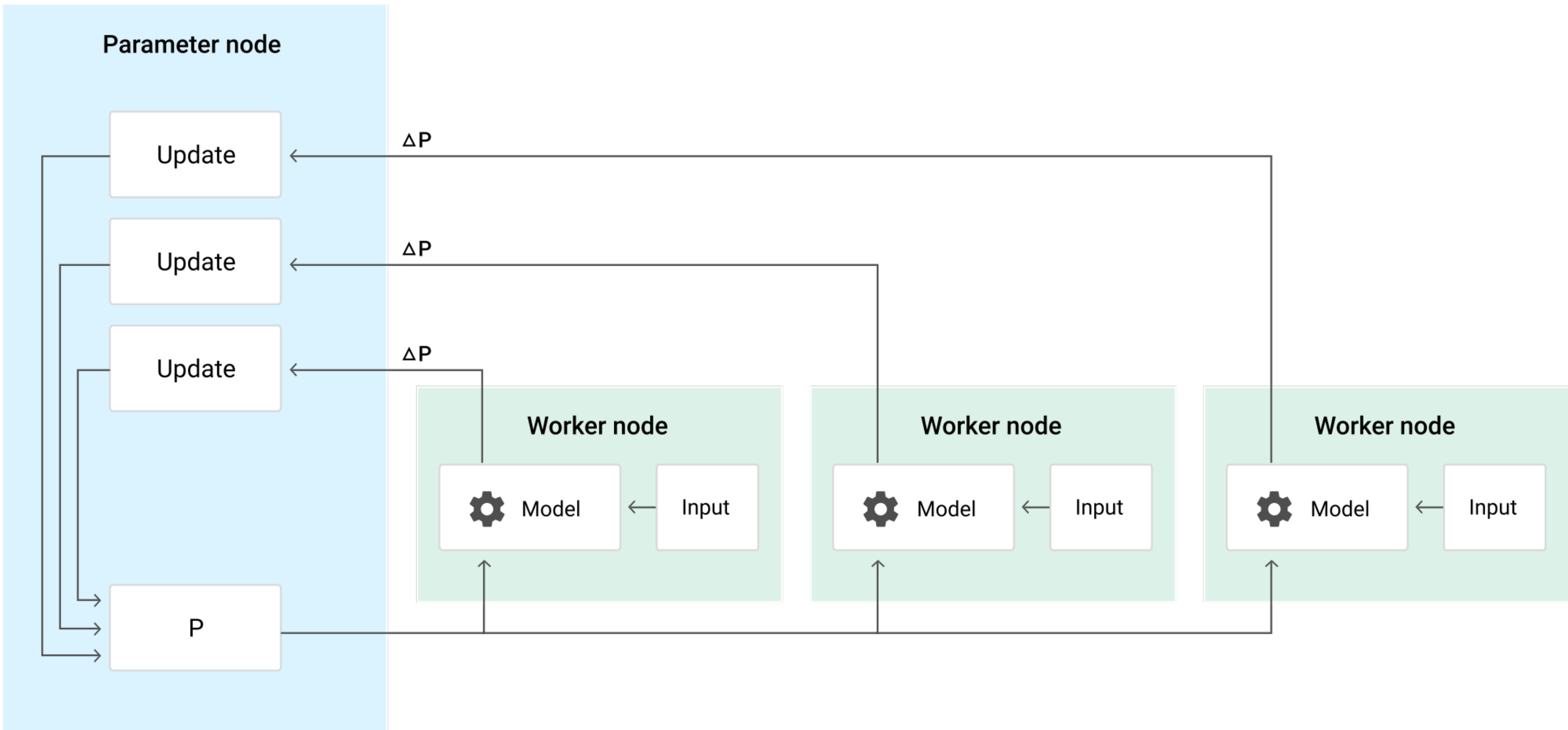
How AI Platform Works

Prepare trainer and data for the cloud:

- Write training application in Tensorflow (or other ML library)
- Python is language of choice

Train your model with AI Platform:

- **Master** - Manages other nodes
- **Workers** - Works on portion of training job
- **Parameter servers** - Coordinates shared model states between workers



Choose a Lesson

GCP Machine Learning Services

AI Platform Overview

AI Platform Hands On

AI Platform Overview

Get Predictions - two types:

- **Online:**
  - High rate of requests with minimal latency
  - Give job data in JSON request string, predictions returned in its response message
- **Batch:**
  - Get inference (predictions) on large collections of data with minimal job duration
  - Input and output in Cloud Storage

Key Terminology

- **Model** - Logical container of individual solutions to a problem:
  - Can deploy multiple versions
  - e.g. Sale price of houses given data on previous sales
- **Version** - Instance of model:
  - e.g. version 1/2/3 of how to predict above sale prices
- **Job** - interactions with AI Platform:
  - Train models:
    - Command = 'submit job train model' on AI Platform
  - Deploy trained models:
    - Command = 'submit job deploy trained model' on AI Platform
  - 'Failed' jobs can be monitored for troubleshooting

Return to Table of Contents

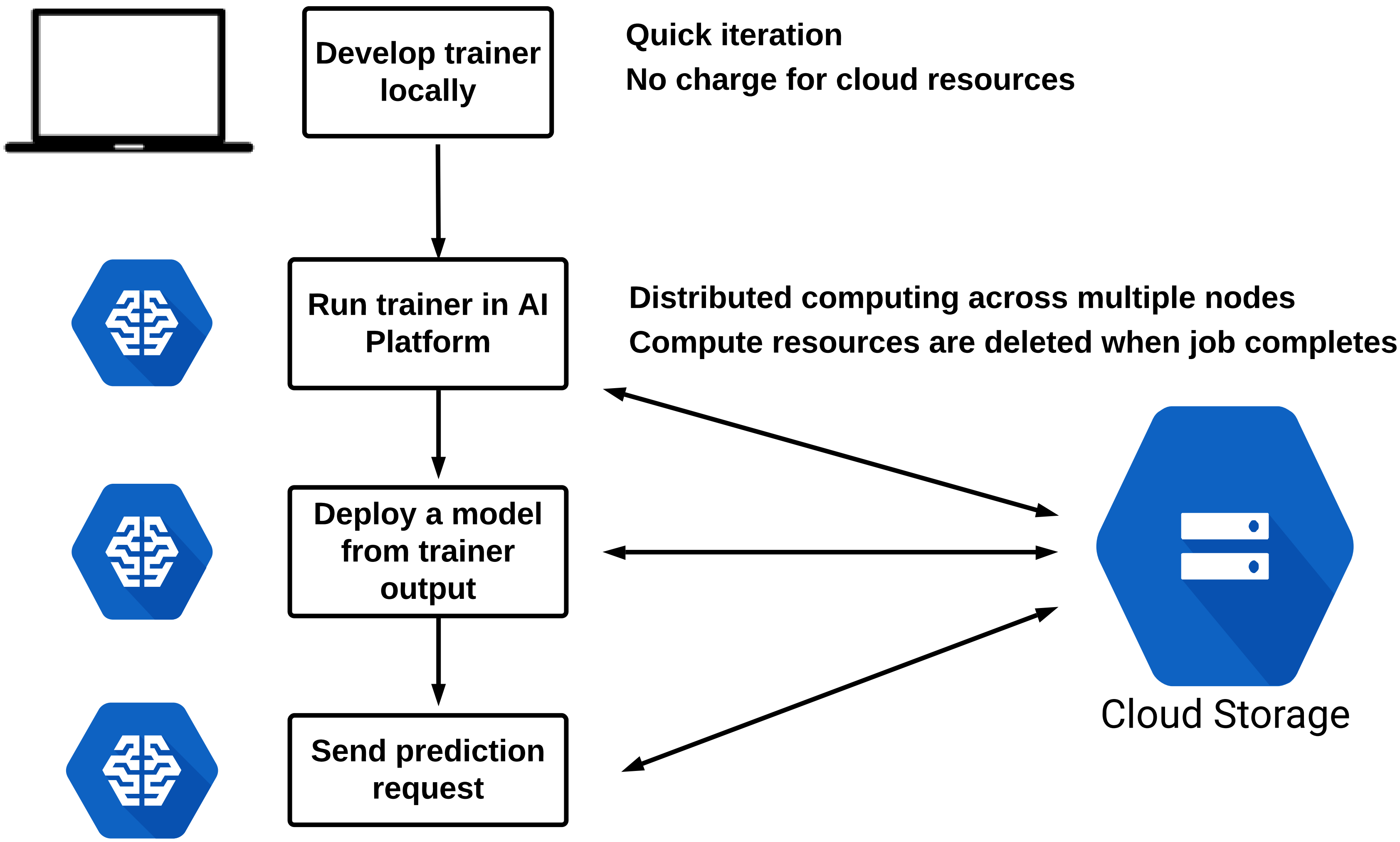
AI Platform Overview

Previous
Next

Choose a Lesson

GCP Machine Learning Services
AI Platform Overview
AI Platform Hands On

Typical process



Return to Table of Contents

Choose a Lesson

GCP Machine Learning Services

AI Platform Overview

AI Platform Hands On

AI Platform Overview

Previous

Next

Must-Know Info

- Currently supports Tensorflow, scikit-learn, and XGBoost frameworks

  Note: This list is subject to change over time
-

IAM roles:

- **Project and Models:**
  - **Admin** - Full control
  - **Developer** - Create training/prediction jobs, models/versions, and send prediction requests
  - **Viewer** - Read-only access to above
- **Models only:**
  - **Model Owner:**
    - Full access to model and versions
  - **Model User:**
    - Read models and use for prediction
    - Easy to share specific models

Using BigQuery for data source:

- Can read directly from BigQuery via training application
- Recommended to pre-process into Cloud Storage
- Using `gcloud` commands, only works with Cloud Storage

BigQuery

Cloud Storage

AI Platform

Return to Table of Contents

Choose a Lesson
GCP Machine Learning Services
AI Platform Overview
AI Platform Hands On

AI Platform Overview

Previous
Next

Machine Scale Tiers and Pricing

- BASIC: single worker instance
- STANDARD_1: 1 master, 4 workers, 3 parameter servers
- PREMIUM_1: 1 master, 19 workers, 11 parameter servers
- BASIC_GPU: 1 worker with GPU
- CUSTOM

GPU/TPU:

- Much faster processing performance

Pricing:

- Priced per hour
- Higher cost for TPU/GPU's

Training - Predefined scale tiers - price per hour	
BASIC	$0.1900
STANDARD_1	$1.9880
PREMIUM_1	$16.5536
BASIC_GPU	$0.8300
BASIC_TPU	$4.6900
CUSTOM	See the tables of machine types.

Training - AI Platform machine types - price per hour	
standard	$0.1900
large_model	$0.4736
complex_model_s	$0.2836
complex_model_m	$0.5672
complex_model_l	$1.1344
standard_gpu	$0.8300
complex_model_m_gpu	$2.5600
complex_model_l_gpu	$3.3200
standard_p100	$1.8400
complex_model_m_p100	$6.6000
standard_v100	$2.8600
large_model_v100	$2.9536
complex_model_m_v100	$10.6800
complex_model_l_v100	$21.3600
cloud_tpu*	$4.5000

Training - Compute Engine machine types - price per hour	
n1-standard-4	$0.1900
n1-standard-8	$0.3800
n1-standard-16	$0.7600
n1-standard-32	$1.5200
n1-standard-64	$3.0400
n1-standard-96	$4.5600
n1-highmem-2	$0.1184
n1-highmem-4	$0.2368
n1-highmem-8	$0.4736
n1-highmem-16	$0.9472
n1-highmem-32	$1.8944
n1-highmem-64	$3.7888
n1-highmem-96	$5.6832
n1-highcpu-16	$0.5672
n1-highcpu-32	$1.1344
n1-highcpu-64	$2.2688
n1-highcpu-96	$3.4020

Training - Accelerators - price per hour	
NVIDIA_TESLA_K80	$0.4500
NVIDIA_TESLA_P4 (Beta)	$0.6000
NVIDIA_TESLA_P100	$1.4600
NVIDIA_TESLA_T4 (Beta)	$0.9500
NVIDIA_TESLA_V100	$2.4800
Eight TPU_V2 cores*	$4.5000
Batch prediction - price per node hour	
$0.0791	
Online prediction - Machine types - price per node hour.	
mls1-c1-m2 (default)	$0.0401
mls1-c4-m2 (Beta)	$0.1349

Return to Table of Contents

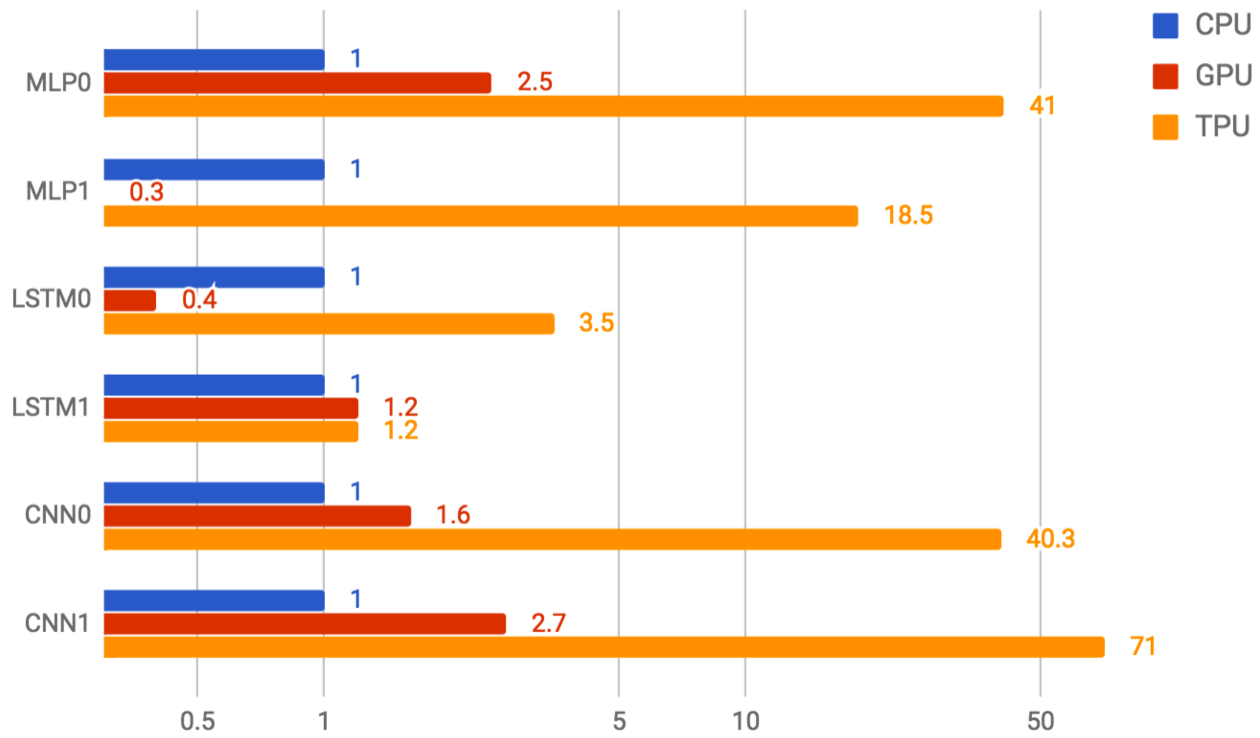
AI Platform Overview

Choose a Lesson
GCP Machine Learning Services
AI Platform Overview
AI Platform Hands On

Previous
Next

Tensor Processing Unit (TPU)

- Hardware processing specifically designed for machine learning
    - Like a GPU, but even more optimized for ML
    - Faster and more efficient



Return to Table of Contents

Choose a Lesson

GCP Machine Learning Services

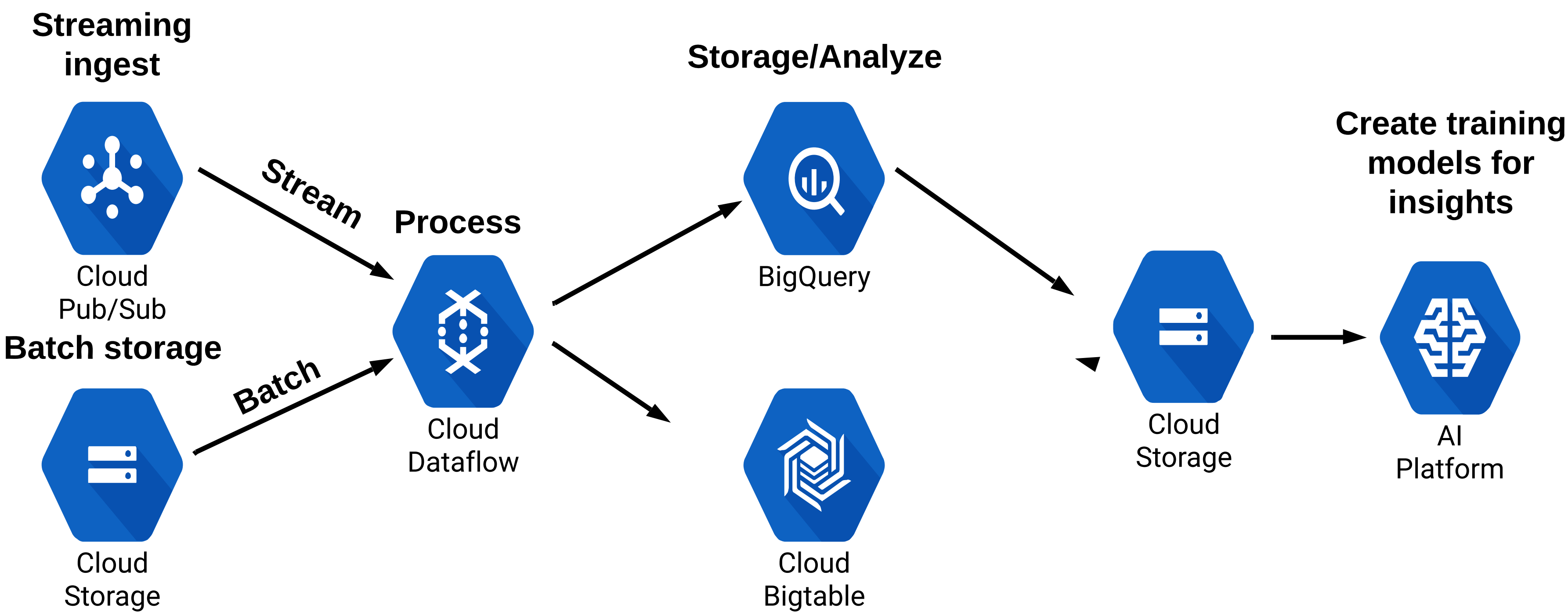
AI Platform Overview

AI Platform Hands On

AI Platform Overview

Previous

Big Picture



Return to Table of Contents

AI Platform Hands On

Choose a Lesson

GCP Machine Learning Services

AI Platform Overview

AI Platform Hands On

What We Are Doing:

- Working with pre-packaged training model:
    - Focusing on the AI Platform aspect, not TensorFlow
- Heavy command line/`gcloud` focus, using Cloud Shell

Main steps: The big picture

- Submit training job locally using `ai-platform` commands
- Submit training job on AI Platform, both single and distributed
- Deploy trained model, and submit predictions

Instructions for Hands On

Download scripts to Cloud Shell to follow along:

```
gsutil -m cp gs://gcp-course-exercise-scripts/data-engineer/ai-platform/* .
```

Return to Table of Contents

ML Engine Hands On

Choose a Lesson

GCP Machine Learning Services

AI Platform Overview

AI Platform Hands On

Previous

Next

Current ML API's (page 1 of 2)

Cloud Vision

Image recognition/analysis

Cloud Translation

Detect and translate languages

Cloud Natural Language

Text analysis
Information extraction
Understanding sentiment

Cloud Job Discovery

More relevant job searches:
Power recruitment, job boards

Cloud Speech to Text

Convert audio to text
Multi-lingual support
Understanding sentence structure

Cloud Text to Speech (Beta)

Convert text to audio
Multiple languages/voices
Natural sounding synthesis

Return to Table of Contents

ML Engine Hands On

Choose a Lesson

GCP Machine Learning Services

AI Platform Overview

AI Platform Hands On

Previous

Next

Current ML API's (page 2 of 2)

Cloud Video Intelligence

Video analysis

Labels, shot changes, explicit content

Dialogflow

Dialogflow for Enterprise

Conversational experiences

Virtual assistants

Return to Table of Contents

Pre-trained ML API's

Choose a Lesson

Pre-trained ML API's

Vision API demo

Previous

Next

Current ML APIs (new ones being added)

Cloud Vision
Image recognition/analysis

Cloud Translation
Detect and translate languages

Cloud Natural Language
Text analysis
Extract information
Understand sentiment

Cloud Job Discovery
More relevant job searches:
Power recruitment, job boards

Cloud Speech to Text
Convert audio to text
Multi-lingual support
Understand sentence structure

Cloud Text to Speech
Convert text to audio
Multiple languages/voices
Natural sounding synthesis

Cloud Video Intelligence
Video analysis
Labels, shot changes, explicit content

Dialogflow for Enterprise
Conversational experiences
Virtual assistants

Return to Table of Contents

Choose a Lesson

GCP Machine Learning Services

AI Platform Overview

AI Platform Hands On

GCP Machine Learning Services

Previous

ML Options on Google Cloud Platform

- Products for ML Engineer to Developer roles, and everything in between
- Rapid expansion of solutions: Two primary ones to focus on for exam

AI Platform (Formerly Cloud ML Engine)

- Train, deploy, and manage custom ML models on managed infrastructure resources
- You create the model, Google provides managed infrastructure for testing it

Pre-trained ML models

- Pre-trained models
- Common use cases (not customizable)
- Simply 'plug' into your application
- "Make Google do it"

Return to Table of Contents

Pre-trained ML API's

Choose a Lesson
Pre-trained ML API's
Vision API demo
Previous
Next

Current ML APIs (new ones being added)

Data Loss Prevention API

Detect, Manage, and Redact Sensitive data

- **Credit card numbers, SSN, birthdates, credentials**

Return to Table of Contents

Choose a Lesson

Pre-trained ML API's

Vision API demo

Pre-trained ML API's

Previous

Next

Cloud Vision: A Closer Look

Label Detection	Extract info in image across categories: Plane, sports, cat, night, recreation
Text Detection (OCR)	Detect and extract text from images
Safe Search	Recognize explicit content: Adult, spoof, medical, violent
Landmark Detection	Identify landmarks
Logo Detection	Recognize logos
Image Properties	Dominant colors, pixel count
Crop Hints	Crop coordinates of dominant object/face
Web Detection	Find matching web entries

Return to Table of Contents

Pre-trained ML API's

Choose a Lesson

Pre-trained ML API's

Vision API demo

Previous

Next

Newer ML options

Auto ML

- Pre-trained APIs, but for custom models!
  - Example: Identify specific geographical features
- Supply your own data to train on
- Currently available for:
  - Vision
  - Video Intelligence
  - Natural Language
  - Translation
  - Structured Data

BigQuery ML

- Create and train ML models inside BigQuery
- Use SQL syntax to create models

Return to Table of Contents

Choose a Lesson
Pre-trained ML API's
Vision API demo

Pre-trained ML API's

Previous

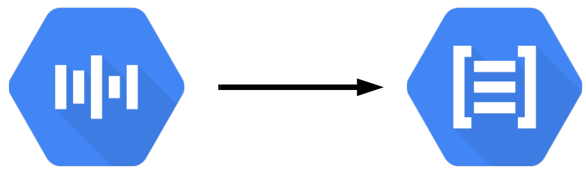
Exam Perspectives

How to covert images, video, etc. for use with API?

- Can use Cloud Storage URI for GCS stored objects
- Encodes in Base64 format

How to combine API's for scenarios?

- Search customer service calls and analyze for sentiment



Convert call audio to text
Make searchable

Analyze text
for sentiment

Return to Table of Contents

Choose a Lesson

Pre-trained ML API's

Vision API demo

Vision API Demo

Basic steps for most APIs:

- Enable the API
- Create API key
- Authenticate with API key
- Encode in Base64 (optional)
- Make an API request
- Requests and outputs via JSON

Commands will be in lesson description.

Return to Table of Contents

Choose a Lesson

Datalab Overview

Datalab Overview

Next

What is it?

- Interactive tool for exploring and visualizing data:
  - Notebook format
  - Great for data engineering, machine learning
- Built on Jupyter (formerly iPython):
  - Open source - Jupyter ecosystem
  - Create documents with live code and visualizations
- Visual analysis of data in BigQuery, ML Engine, Compute Engine, Cloud Storage, and Stackdriver
- Supports Python, SQL, and JavaScript
- Runs on GCE instance, dedicated VPC and Cloud Source Repository
- Cost: free - only pay for GCE resources Datalab runs on and other Google Cloud services you interact with

Return to Table of Contents

Choose a Lesson
Datalab Overview

Datalab Overview

Previous
Next

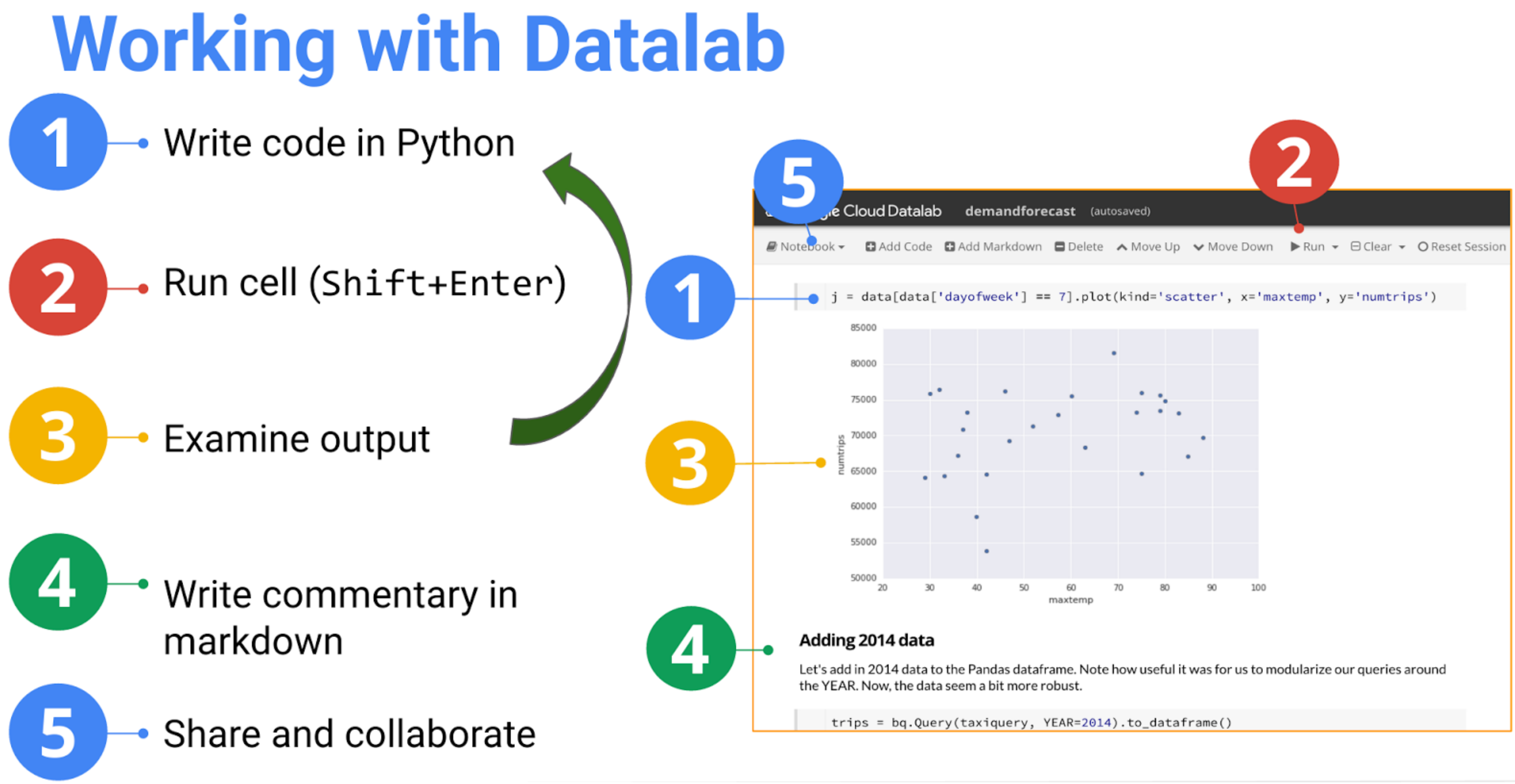
How It Works

Create and connect to a Datalab instance

datalab create (instance-name) →

- Connect via SSH and open web preview
- datalab connect (instance-name)
- Open web preview - port 8081

datalab-network | datalab-instance | datalab-notebooks Source repository



Return to Table of Contents

Choose a Lesson

Datalab Overview

Datalab Overview

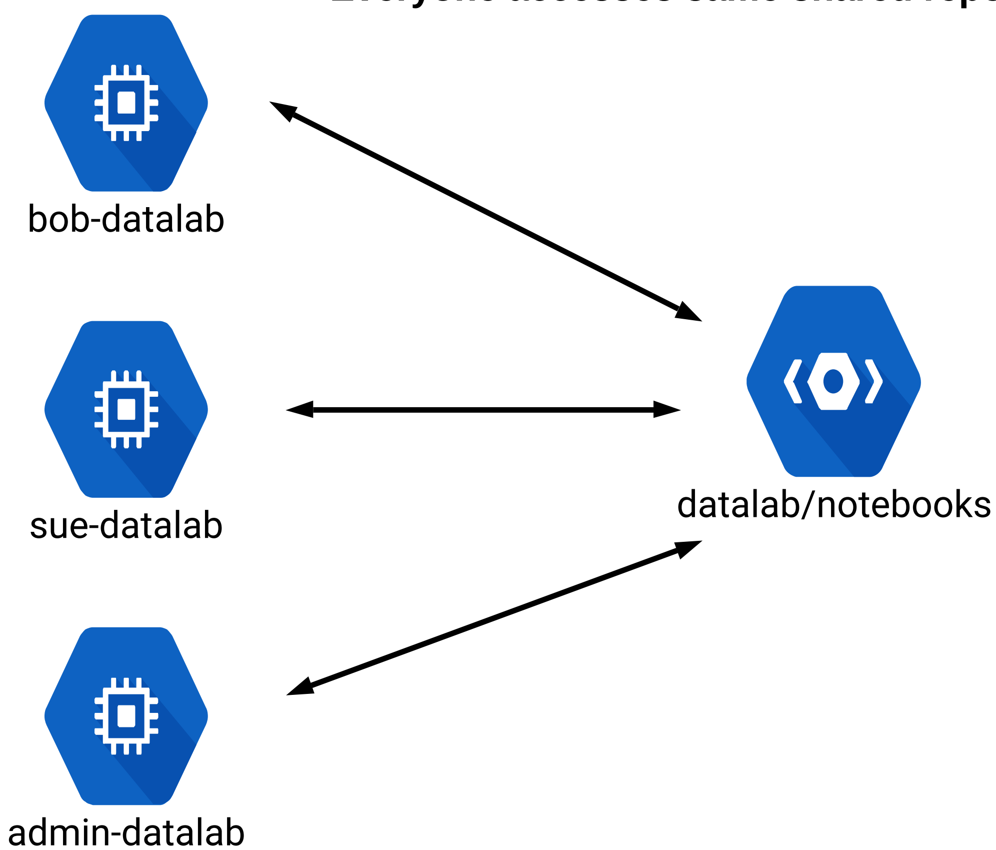
Previous

Sharing notebook data:

- GCE access based on GCE IAM roles:
  - Must have Compute Instance Admin and Service Account Actor roles
- Notebook access per user only
- Sharing data performed via shared Cloud Source Repository
- Sharing is at the project level

Creating team notebooks - two options:

- Team lead creates notebooks for users using --for user option:
  - datalab create [instance] --for-user bob@professionalwireless.net
- Each user creates their own datalab instance/notebook
- Everyone accesses same shared repository of datalab/notebooks



Return to Table of Contents

Choose a Lesson

What is Dataprep?

What is Dataprep?

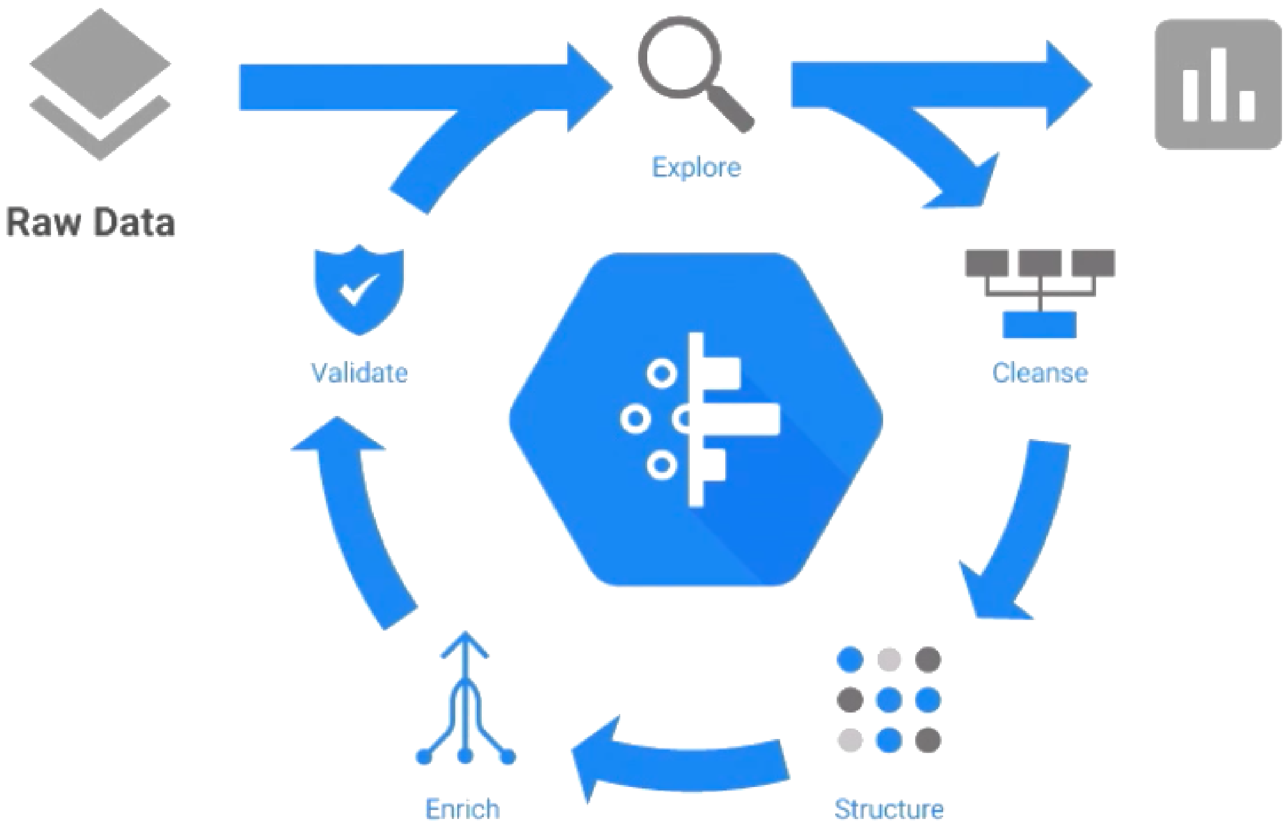
Next

What is it?

- **Intelligent data preparation**
- **Partnered with Trifacta for data cleaning/processing service**
- **Fully managed, serverless, and web-based**
- **User-friendly interface:**
    - **Clean data by clicking on it**
- **Supported file types:**
    - **Input - CSV, JSON (including nested), Plain text, Excel, LOG, TSV, and Avro**
    - **Output - CSV, JSON, Avro, BigQuery table:**
        - **CSV/JSON can be compressed or uncompressed**

Why is this important?

- **Data Engineering requires high quality, cleaned, and prepared data**
- **80% - time spent in data preparation**
- **76% - view data preparation as the least enjoyable part of work**
- **Dataprep democratizes the data preparation process**



Return to Table of Contents

Choose a Lesson

What is Dataprep?

What is Dataprep?

Previous

How It Works

Backed by Cloud Dataflow:

- **After preparing, Dataflow processes via Apache Beam pipeline**
- **"User-friendly Dataflow pipeline"**

Dataprep process:

- **Import data**
- **Transform sampled data with recipes**
- **Run Dataflow job on transformed dataset**
- **Export results (GCS, BigQuery)**

Intelligent suggestions:

- **Selecting data will often automatically give the best suggestion**
- **Can manually create recipes, however simple tasks (remove outliers, de-duplicate) should use auto-suggestions**

IAM:

- **Dataprep User - Run Dataprep in a project**
- **Dataprep Service Agent - Gives Trifecta necessary access to project resources:**
  - **Access GCS buckets, Dataflow Developer, BigQuery user/data editor**
  - **Necessary for cross-project access + GCE service account**

Pricing:

- **1.16 * cost of Dataflow job**

Return to Table of Contents

Choose a Lesson
Data Studio Introduction

Data Studio Introduction

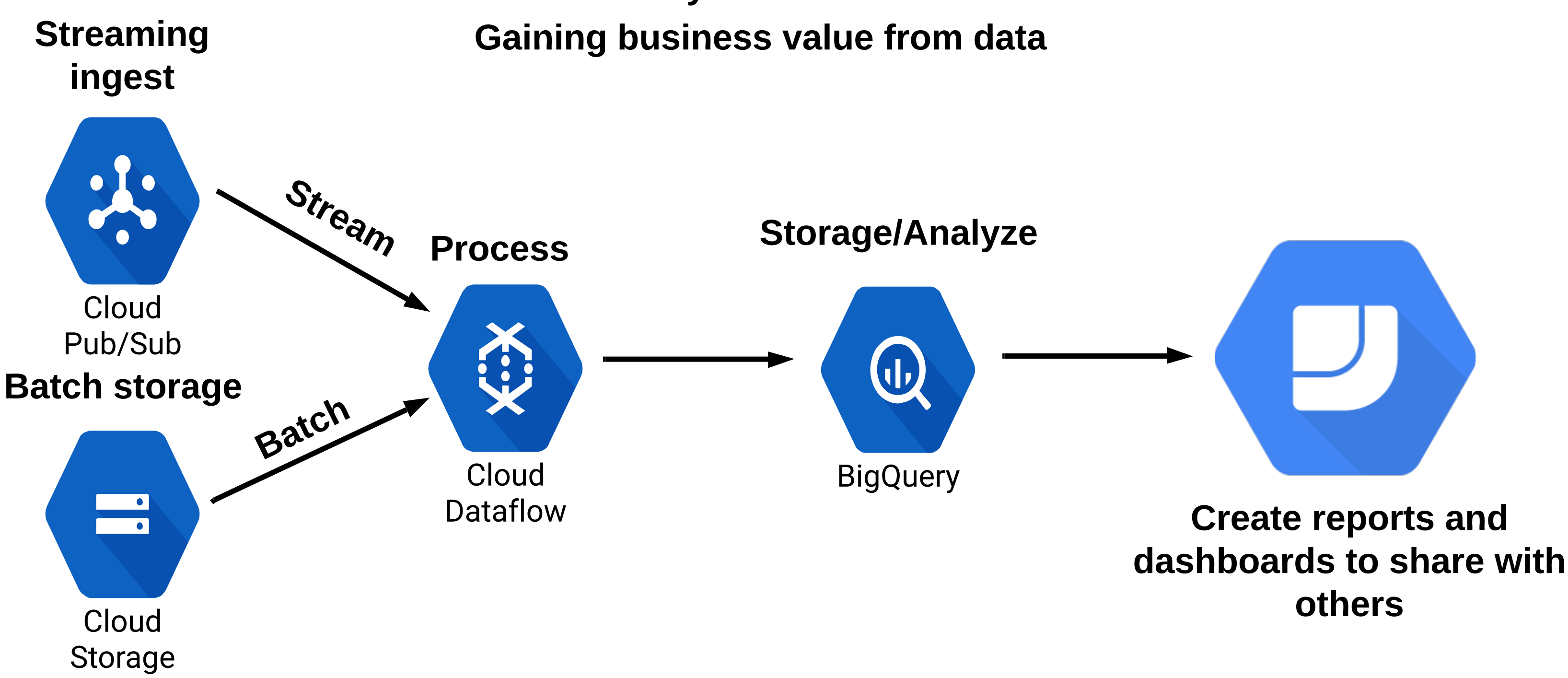
Next

What is Data Studio?

- Easy to use data visualization and dashboards:
    - Drag and drop report builder
- Part of G Suite, not Google Cloud:
    - Uses G Suite access/sharing permissions, not Google Cloud (no IAM)
    - Google account permissions in GCP will determine data source access
    - Files saved in Google Drive
- Connect to many Google, Google Cloud, and other services:
    - BigQuery, Cloud SQL, GCS, Spanner
    - YouTube Analytics, Sheets, AdWords, local upload
    - Many third party integrations
- Price - *Free*:
    - BigQuery access run normal query costs

Data Lifecycle - Visualization

Gaining business value from data



Return to Table of Contents

Data Studio Introduction

Choose a Lesson
Data Studio Introduction
Previous

Basic process

- Connect to data source
- Visualize data
- Share with others

Creating charts

- Use combinations of dimensions and metrics
- Create custom fields if needed
- Add date range filters with ease

Caching - options for using cached data performance/costs

Two cache types, query cache and prefetch cache

Query cache:

- Remembers queries issues by reports components (i.e. charts)
- When performing same query, pulls from cache
- If query cache cannot help, goes to prefetch cache
- Cannot be turned off

Prefetch cache:

- 'Smart cache' - predicts what 'might' be requested
- If prefetch cache cannot serve data, pulls from live data set
- Only active for data sources that use owner's credentials for data access
- Can be turned off

When to turn caching off:

- Need to view 'fresh data' from rapidly changing data set

Return to Table of Contents

Choose a Lesson

Cloud Composer Overview

Hands On - Cloud Composer

Cloud Composer Overview

Next

What is Cloud Composer?

- Fully managed **Apache Airflow** implementation:
  - Infrastructure/OS handled for you

What is Apache Airflow?

- Programatically create, schedule, and monitor data workflows

Why is this important?

- Automation and monitoring
- Big data pipelines are often a multi-step, complex process:
  - Create resources in multiple services
  - Process and move data from one service to another
  - Remove resources when they complete a task
- Collaborate workflow process with other team members

How Airflow/Composer helps

- Automates the above steps, including scheduling
- Built on open source, using Python as common language
- Easy to work with, and share workflow with others
- Works with non-GCP providers (on-premises, other clouds)

Return to Table of Contents

Choose a Lesson

Cloud Composer Overview

Hands On - Cloud Composer

Cloud Composer Overview

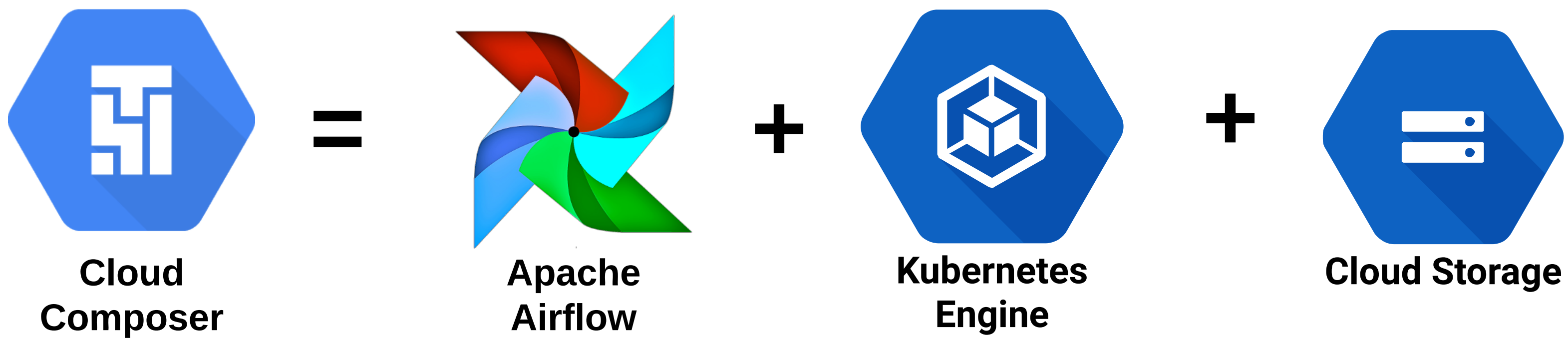
Previous

Next

How It Works

Behind the scenes:

- GKE cluster with Airflow implemented
- Cloud Storage bucket for workflow files (and other application files)



Workflows?

- Orchestrate data pipelines:
  - Like a walkthrough of tasks to run
- Format = Direct Acyclic Graph (DAG):
  - Written in Python
  - Collection of organized tasks that you want to schedule and run
- **Cloud Composer** creates **workflows** using **DAG** files

The Process

- Create Composer Environment
- Set Composer variables (i.e. project ID, GCS bucket, region)
- Add Workflows (DAG files), which Composer will execute

Return to Table of Contents

Choose a Lesson

Cloud Composer Overview

Hands On - Cloud Composer

Cloud Composer Overview

Previous

Examples and Exam Perspective

- Create a Dataproc cluster, submit a job, and then delete the cluster.
- Execute a Cloud Dataflow pipeline from data in GCS, and write output to BigQuery.
- Ingest third party data into Cloud Dataflow, process, then upload to GCS.
- **Exam perspective:** Know what DAGs are, and why you'd want to use workflows.

Return to Table of Contents

Choose a Lesson

Cloud Composer Overview

Hands On - Cloud Composer

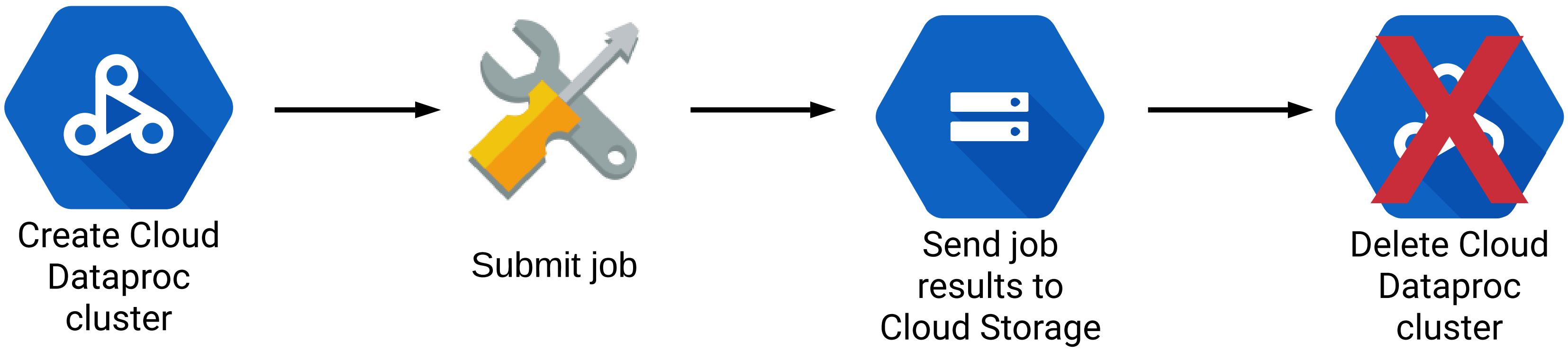
Hands On - Cloud Composer

Next

The Process:

- Create the Composer environment.
- Then create the GCS bucket for Dataproc output.
- Assign Cloud Composer variables.
- Upload the workflow file to DAG folder.
- View the results.

Automatic processes -- <u>Workflow</u>



Create Composer Environment

- Enable Composer/Dataproc API
- Create environment in closest region:
  - What's happening?
  - Creating GKE cluster + GCS bucket

Create GCS bucket to output Dataproc results

- `gsutil mb -l us-central1 gs://output-$DEVSHELL_PROJECT_ID`

Return to Table of Contents

Hands On - Cloud Composer

Previous

Choose a Lesson
Cloud Composer Overview
Hands On - Cloud Composer

Configure Cloud Composer Variables

- **Format**
  - **`gcloud composer environments run (ENVIRONMENT_NAME) --location (LOCATION) variables -- --set (KEY VALUE)`**
- `gcloud composer environments run my-environment --location us-central1 variables -- --set gcp_project (PROJECT-ID)`
- `gcloud composer environments run my-environment --location us-central1 variables -- --set gcs_bucket gs://output-(PROJECT-ID)`
- `gcloud composer environments run my-environment --location us-central1 variables -- --set gce_zone us-central1-c`

Add workflow file (Python) to Composer DAG folder:

- **github link**

Next step? There is none! Cloud Composer will take it from here...

Return to Table of Contents

Additional Study Resources

SQL deep dive

- **Course - SQL Primer**
- **https://linuxacademy.com/cp/modules/view/id/52**

Machine Learning

- **Google Machine Learning Crash Course (free)**
- **https://developers.google.com/machine-learning/crash-course/**

Hadoop

- **Hadoop Quick Start**
- **https://linuxacademy.com/cp/modules/view/id/294**

Apache Beam (Dataflow)

- **Google's guide to designing your pipeline with Apache Beam (using Java)**
- **https://cloud.google.com/dataflow/docs/guides/beam-creating-a-pipeline**