
PLURALSIGHT

Data Engineering

THE HARTFORD

Tech Catalyst Bootcamp

Tarek Atwan
Instructor, Pluralsight

PLURALSIGHT

STANDUP

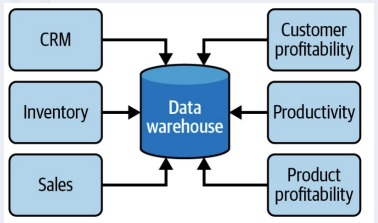
What are some of the challenges you faced yesterday in the lab.

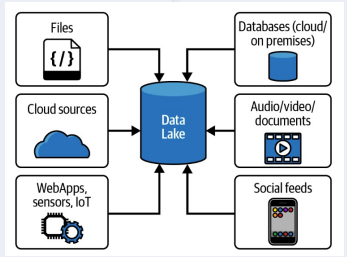
How did you resolve it?
What did you learn from it?

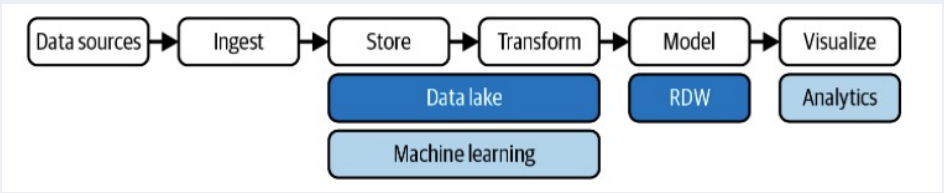
What was something “new” or interesting that you learned from the lab yesterday?

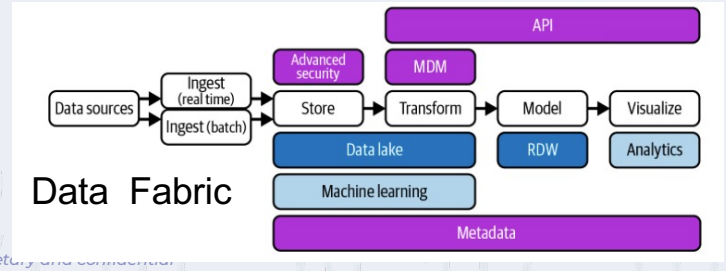
Quick Review

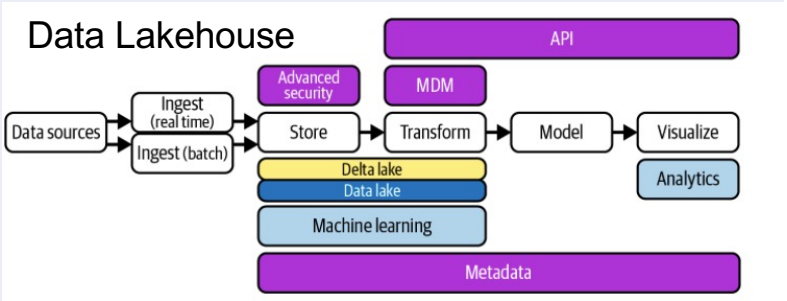
Evolution Summary











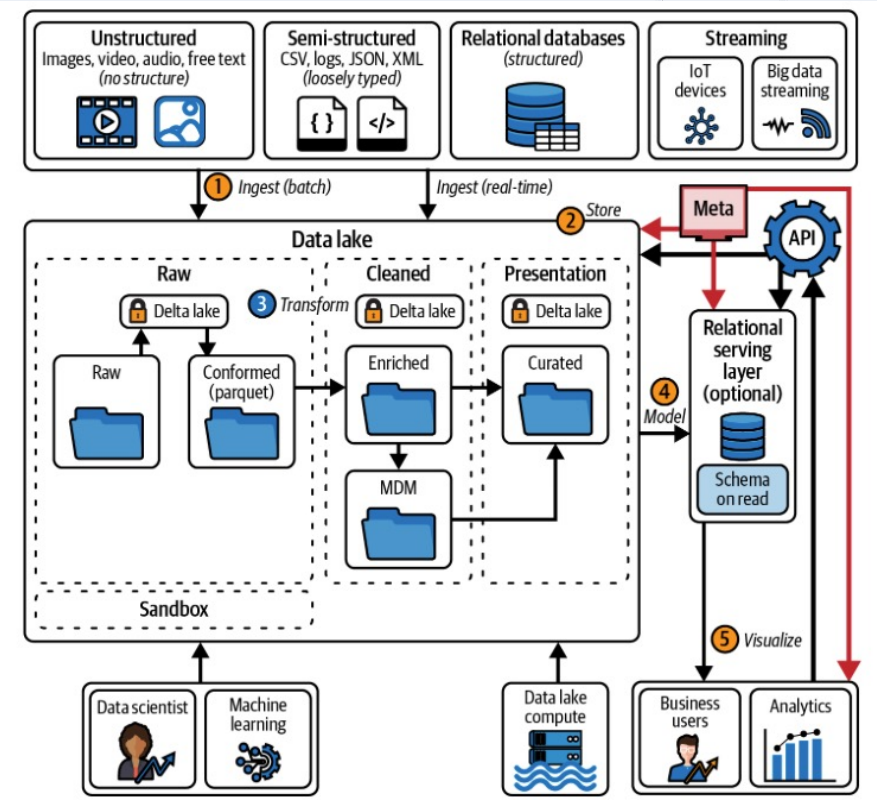
Data Lakehouse Architecture

It adds

- Transaction Support (ACID)
- Time Travel
- Caching
- Query optimization

Drawback

- Can be resource intensive to build this



Databases

https://docs.aws.amazon.com/whitepapers/latest/aws-overview/database.html

AWS Analytics Services

AWS Glue

AWS Glue

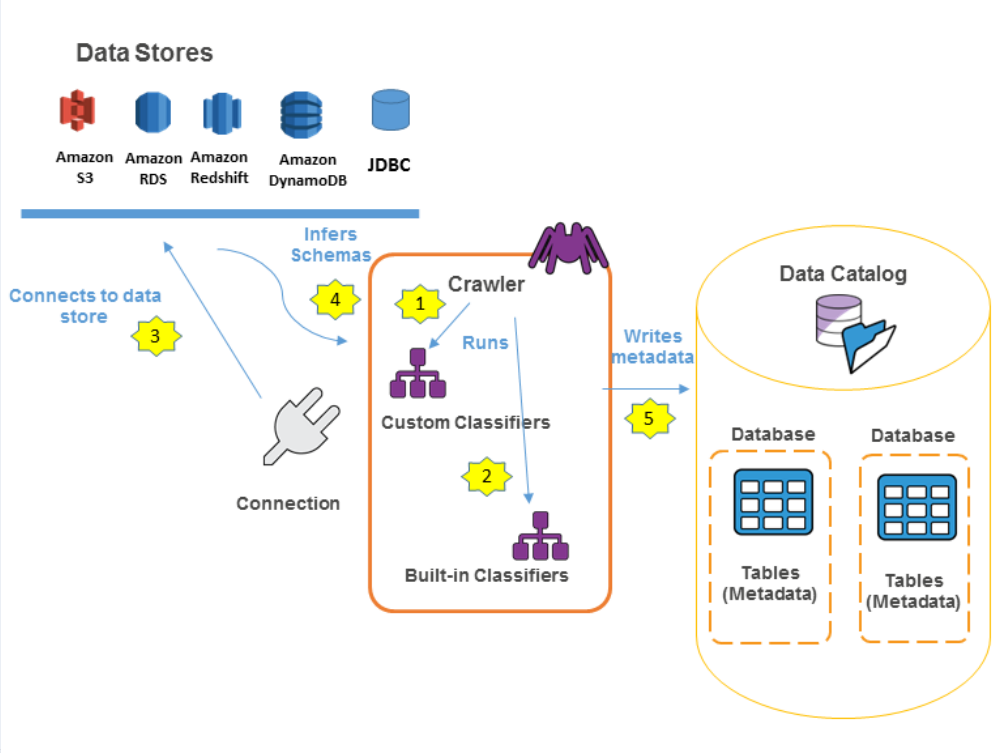
Serverless discovery and definition of table definitions and schema

- S3 “data lakes”
- RDS
- Redshift
- DynamoDB
- Most other SQL databases

Custom ETL jobs

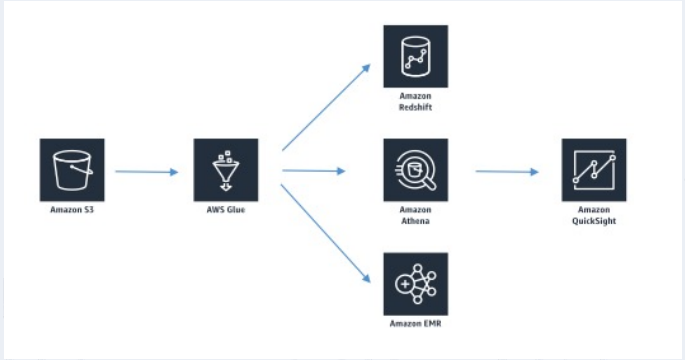
- Trigger-driven, on a schedule, or on demand
- Fully managed

Glue Crawler / Data Catalog



Glue Crawler / Data Catalog

- Glue crawler scans data in S3, creates schema
- Can run periodically
- Populates the Glue Data Catalog
  - Stores only table definition
  - Original data stays in S3
- Once cataloged, you can treat your unstructured data like it's structured
  - Redshift Spectrum
  - Athena
  - EMR
  - Quicksight



Glue ETL

- Automatic code generation (Scala or Python)
- Encryption
    - Server-side (at rest)
    - SSL (in transit)
- Can be event-driven
- Can provision additional “DPU’s” (data processing units) to increase performance of underlying Spark jobs
    - Enabling job metrics can help you understand the maximum capacity in DPU’s you need
- Errors reported to CloudWatch
    - Could tie into SNS for notification

Glue ETL

- Transform data, Clean Data, Enrich Data (before doing
- analysis)
    - Generate ETL code in Python or Scala, you can modify the code
    - Can provide your own Spark or PySpark scripts
    - Target can be S3, JDBC (RDS, Redshift), or in Glue Data Catalog
- Fully managed, cost effective, pay only for the resources consumed
- Jobs are run on a serverless Spark platform
- Glue Scheduler to schedule the jobs
- Glue Triggers to automate job runs based on “events”

Glue ETL - Transformations

- Bundled Transformations:

  DropFields, DropNullFields – remove (null) fields
  Filter – specify a function to filter records
  Join – to enrich data
  Map - add fields, delete fields, perform external lookups

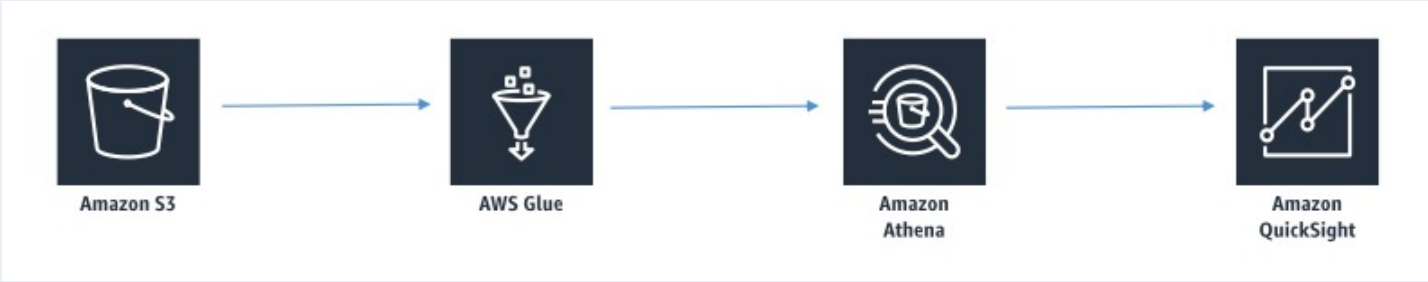
- Machine Learning Transformations:

  FindMatches ML: identify duplicate or matching records in your dataset, even when the records do not have a common unique identifier and no fields match exactly.

- Format conversions: CSV, JSON, Avro, Parquet, ORC, XML
- Apache Spark transformations (example: K-Means)

  Can convert between Spark DataFrame and Glue DynamicFrame

Amazon Athena – Typical Pattern



AWS Lake Formation

DATA LAKES AND ANALYTICS

AWS Lake Formation

Create and manage data lakes with centralized access control across Amazon Web Services

The easiest way to create and manage your data lake on Amazon S3

Get started

With AWS Lake Formation, it is easy to create and manage your data lake without having to configure and integrate each underlying AWS service.

Get started

Pricing (US)

With AWS Lake Formation, you pay minimal fees for metadata and API costs on top of your current storage, analytic, and machine learning service usage charges.

Learn more

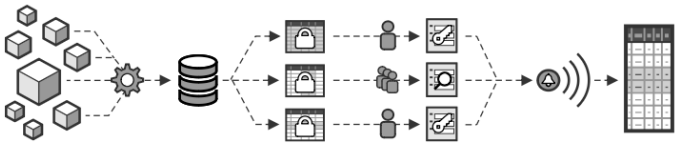
Related services

AWS S3

AWS Glue

AWS Athena

How it works



Ingest & Organize

Automatically ingest, clean, encrypt, and register existing Amazon S3 bucket content, including log data from CloudTrail, CloudFront, and Amazon

Secure & Control

Define access control that provides the right data to the right users, groups, and roles. Flexible database, table, and column permissions enable

Collaborate & Use

Search and discover using catalog metadata. All access is checked against policy, so your data is protected even if tools change or new data arrives.

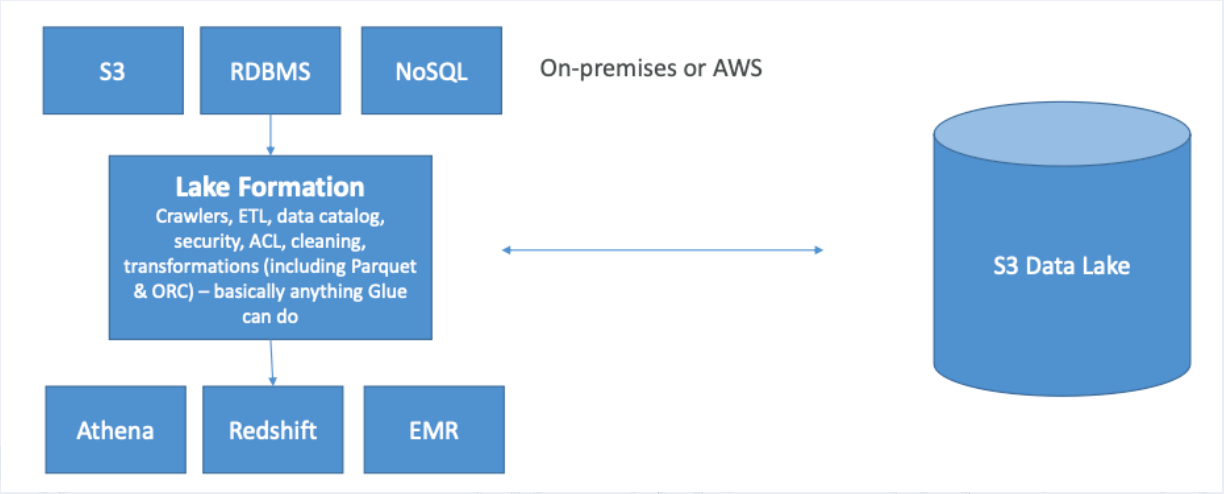
Monitor & Audit

Be alerted of access requests and policy exceptions. Review activity history with detailed change logs and data lineage.

AWS Lake Formation

AWS Lake Formation

AWS Lake Formation helps you centrally **govern**, **secure**, and globally share data for analytics and machine learning. With Lake Formation, you can manage **fine-grained access control** for your data lake data on Amazon Simple Storage Service (Amazon S3) and its metadata in AWS Glue Data Catalog.



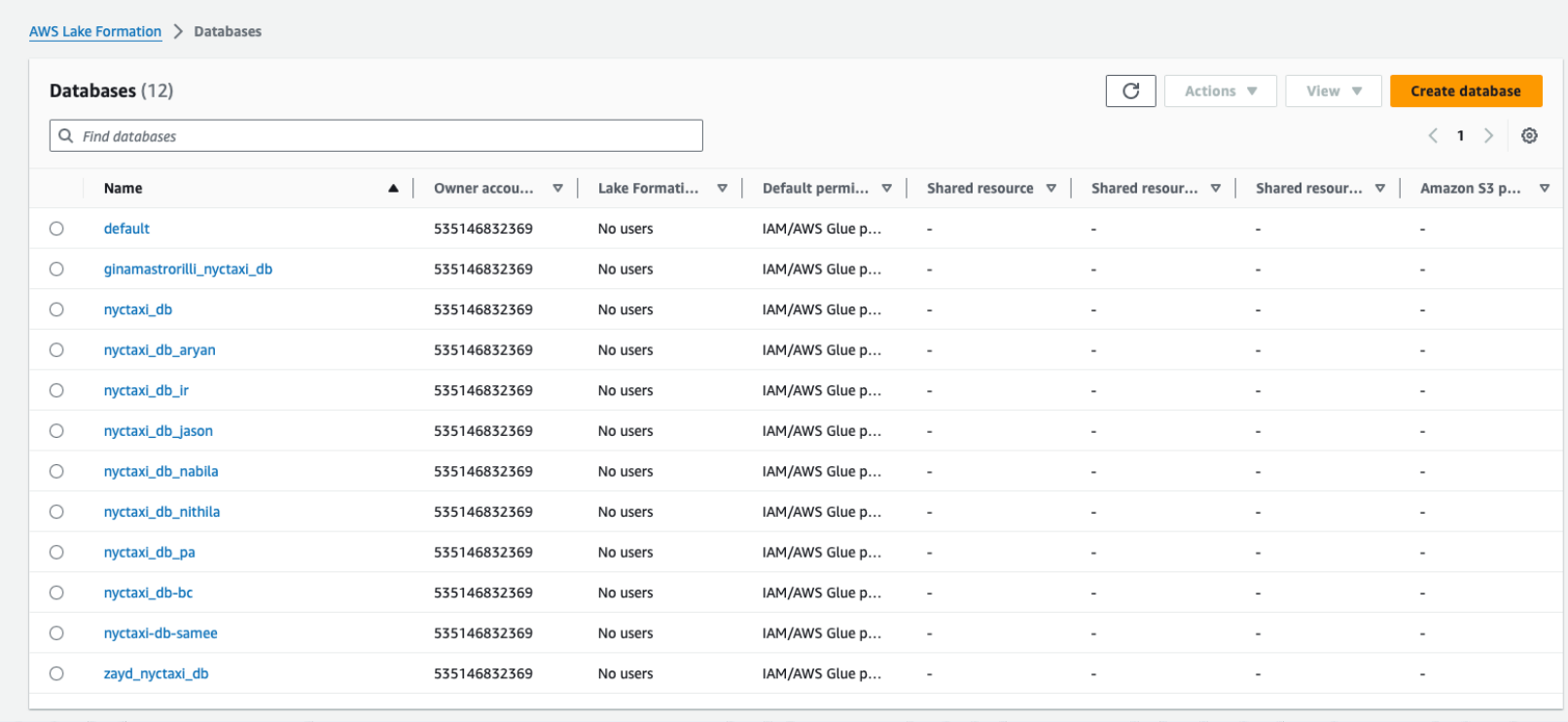
AWS Lake Formation

You can now create Apache Iceberg tables in the Data Catalog. To learn more, visit the documentation.

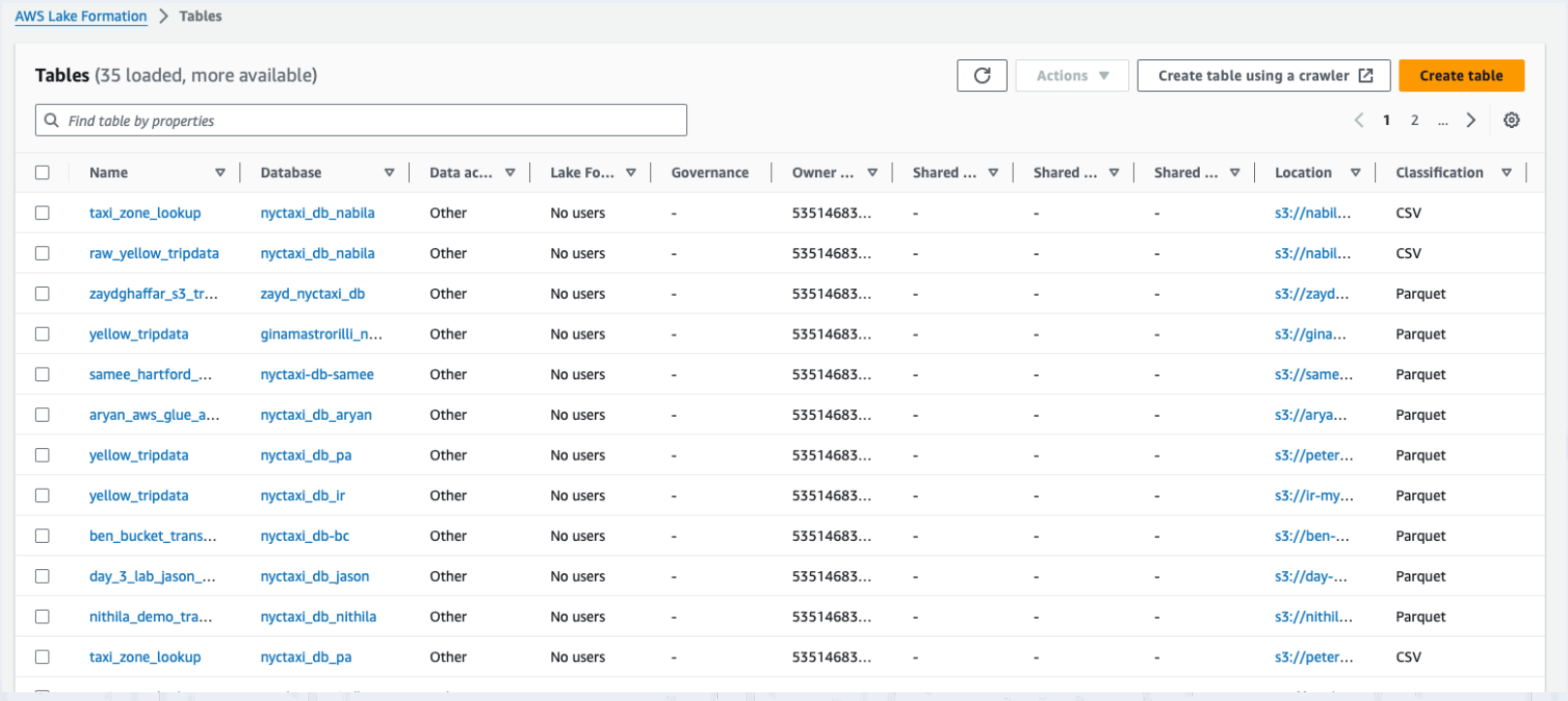
You can now enable auto-compaction for managed tables in Data Catalog. To learn more, visit the documentation.

You can now manage views in Data Catalog. To create a new view, visit the documentation.

AWS Lake Formation – Databases

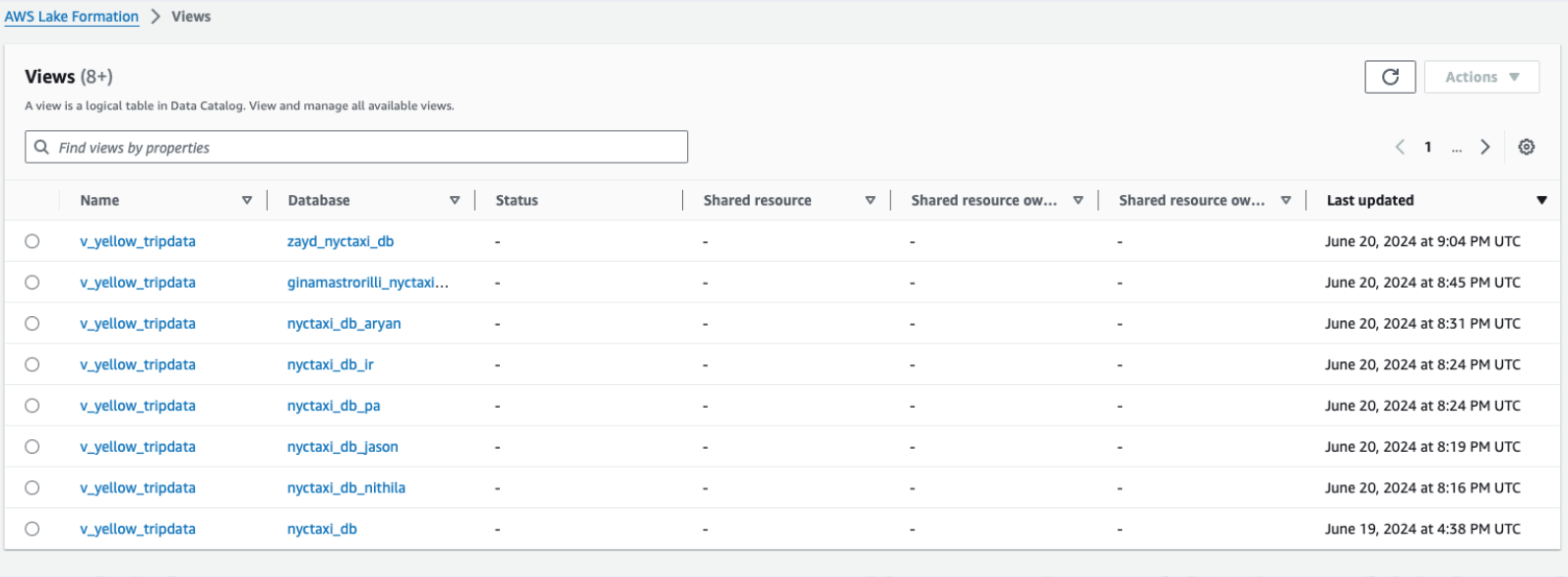


AWS Lake Formation - Tables



Name	Database	Data ac...	Lake Fo...	Governance	Owner ...	Shared ...	Shared ...	Shared ...	Location	Classification
taxi_zone_lookup	nyctaxi_db_nabila	Other	No users	-	53514683...	-	-	-	s3://nabil...	CSV
raw_yellow_tripdata	nyctaxi_db_nabila	Other	No users	-	53514683...	-	-	-	s3://nabil...	CSV
zaydghaffar_s3_tr...	zayd_nyctaxi_db	Other	No users	-	53514683...	-	-	-	s3://zayd...	Parquet
yellow_tripdata	ginamastrorilli_n...	Other	No users	-	53514683...	-	-	-	s3://gina...	Parquet
samee_hartford_...	nyctaxi-db-samee	Other	No users	-	53514683...	-	-	-	s3://same...	Parquet
aryan_aws_glue_a...	nyctaxi_db_aryan	Other	No users	-	53514683...	-	-	-	s3://arya...	Parquet
yellow_tripdata	nyctaxi_db_pa	Other	No users	-	53514683...	-	-	-	s3://peter...	Parquet
yellow_tripdata	nyctaxi_db_ir	Other	No users	-	53514683...	-	-	-	s3://ir-my...	Parquet
ben_bucket_trans...	nyctaxi_db-bc	Other	No users	-	53514683...	-	-	-	s3://ben-...	Parquet
day_3_lab_jason_...	nyctaxi_db_jason	Other	No users	-	53514683...	-	-	-	s3://day-...	Parquet
nithila_demo_tra...	nyctaxi_db_nithila	Other	No users	-	53514683...	-	-	-	s3://nithil...	Parquet
taxi_zone_lookup	nyctaxi_db_pa	Other	No users	-	53514683...	-	-	-	s3://peter...	CSV

AWS Lake Formation - Views

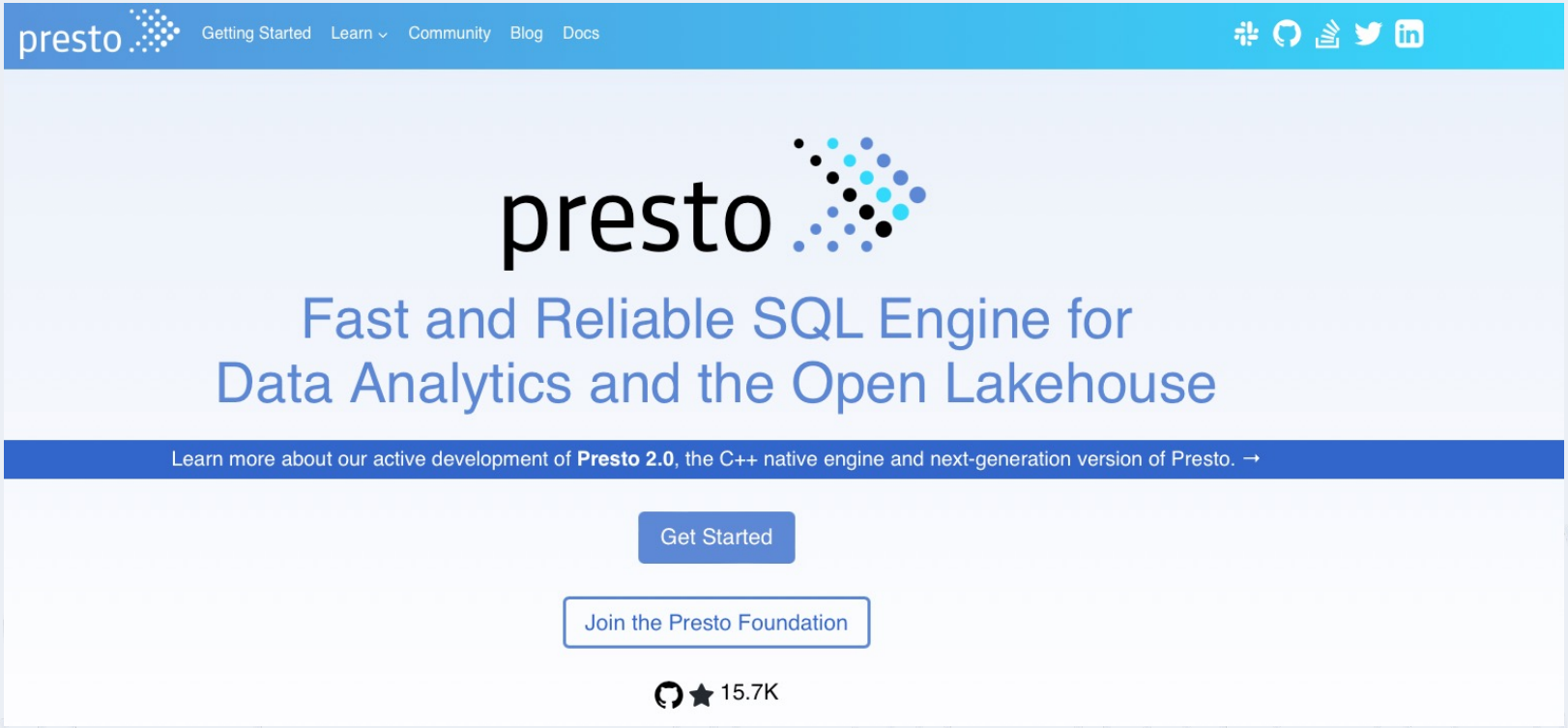


Name	Database	Status	Shared resource	Shared resource ow...	Shared resource ow...	Last updated
v_yellow_tripdata	zayd_nyctaxi_db	-	-	-	-	June 20, 2024 at 9:04 PM UTC
v_yellow_tripdata	ginamastrorilli_nyctaxi...	-	-	-	-	June 20, 2024 at 8:45 PM UTC
v_yellow_tripdata	nyctaxi_db_aryan	-	-	-	-	June 20, 2024 at 8:31 PM UTC
v_yellow_tripdata	nyctaxi_db_ir	-	-	-	-	June 20, 2024 at 8:24 PM UTC
v_yellow_tripdata	nyctaxi_db_pa	-	-	-	-	June 20, 2024 at 8:24 PM UTC
v_yellow_tripdata	nyctaxi_db_jason	-	-	-	-	June 20, 2024 at 8:19 PM UTC
v_yellow_tripdata	nyctaxi_db_nithila	-	-	-	-	June 20, 2024 at 8:16 PM UTC
v_yellow_tripdata	nyctaxi_db	-	-	-	-	June 19, 2024 at 4:38 PM UTC

Amazon Athena

Amazon Athena is an **interactive query service** that makes it easy to analyze data directly in Amazon Simple Storage Service (Amazon S3) using standard **SQL**. With a few actions in the AWS Management Console, you can point Athena at your data stored in **Amazon S3** and begin using standard SQL to run ad-hoc queries and get results in seconds.

Amazon Athena – Presto under the hood



Amazon Athena – When to use

Data Analysis:
- Analyzes unstructured, semi-structured, and structured data stored in Amazon S3.
- Supports various data formats including CSV, JSON, Apache Parquet, and Apache ORC.

Ad-Hoc Queries:
- Run ad-hoc queries using ANSI SQL.
- No need to aggregate or load data into Athena.

Integration with Visualization and BI Tools:
- Integrates with Amazon QuickSight for easy data visualization.
- Supports generating reports and data exploration with BI tools or SQL clients via JDBC or ODBC drivers.

Amazon Athena – When to use

AWS Glue Integration:
- Works with AWS Glue Data Catalog for a persistent metadata store.
- Enables table creation and querying based on a central metadata store.
- Integrated with AWS Glue's ETL and data discovery features.

Ease of Use:
- Allows running interactive queries directly against data in Amazon S3.
- Requires no data formatting or infrastructure management.
- Quick setup: define a table and start querying using standard SQL.

Ideal Use Cases:
- Suitable for running interactive ad-hoc SQL queries against Amazon S3 data.
- Eliminates the need to manage infrastructure or clusters.
- Perfect for quick queries, such as troubleshooting web log performance issues.

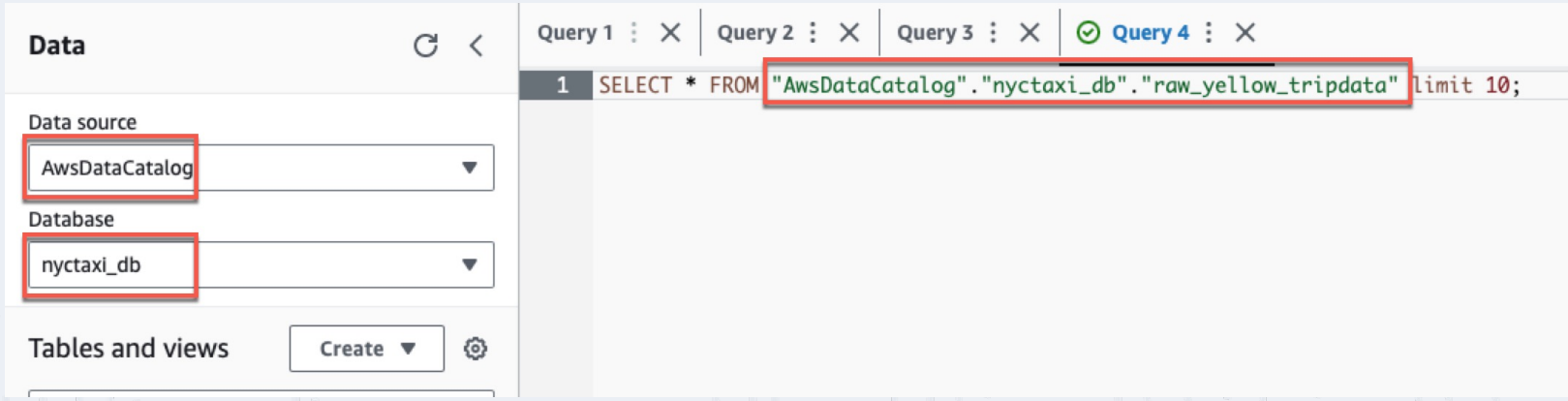
Amazon Athena – When to use

Athena uses the following terms to refer to hierarchies of data objects:

- **Data source** – a group of databases
- **Database** – a group of tables
- **Table** – data organized as a group of rows or columns

Sometimes these objects are also referred to with alternate but equivalent names such as the following:

- A **data source** is sometimes referred to as a **catalog**.
- A **database** is sometimes referred to as a **schema**.



Amazon Athena – When to use

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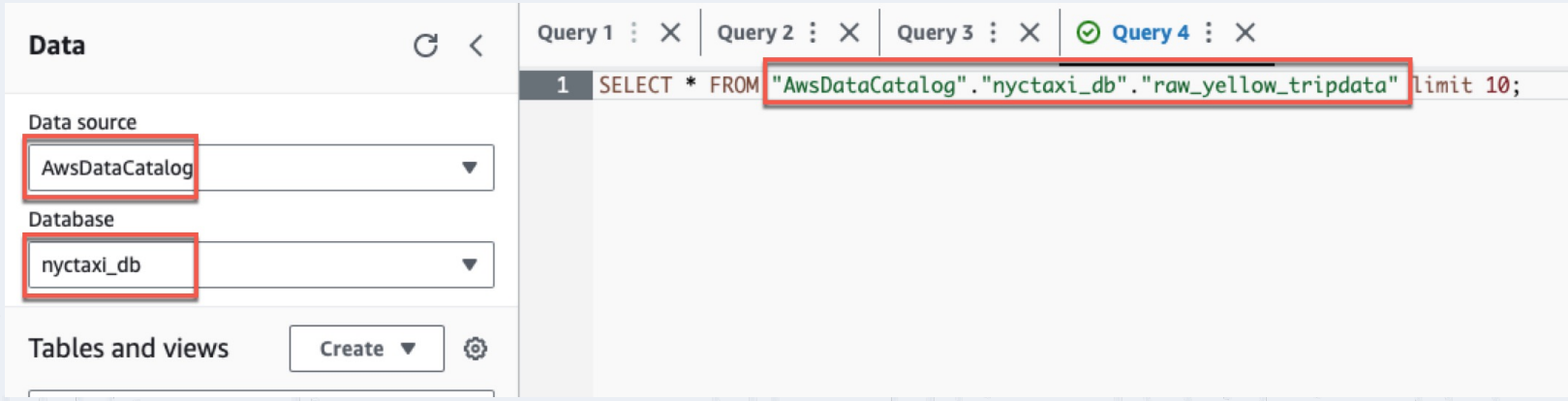


Amazon Athena – CTAS

- A **CREATE TABLE AS SELECT** (CTAS) query creates a new table in Athena from the results of a SELECT statement from another query. Athena stores data files created by the CTAS statement in a specified location in Amazon S3.

- **CREATE TABLE AS** combines a **CREATE TABLE** DDL statement with a **SELECT** DML statement and therefore technically contains both DDL and DML. However, note that for Service Quotas purposes, CTAS queries in Athena are treated as DML

Amazon Athena – ACID Transactions

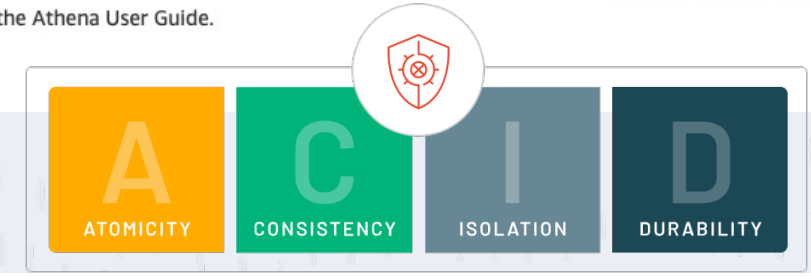
Announcing general availability of Amazon Athena ACID transactions, powered by Apache Iceberg

Posted On: Apr 5, 2022

We are excited to announce the general availability of Amazon Athena ACID transactions, a new capability that adds insert, update, delete, and time travel operations to Athena's SQL data manipulation language (DML). Athena ACID transactions enable multiple concurrent users to make reliable, row-level modifications to their Amazon S3 data from Athena's console, API, and ODBC and JDBC drivers. Built on the Apache Iceberg table format, Athena ACID transactions are optimized for Amazon S3 storage, support seamless schema evolution, and ensure atomic operations across other services and engines that support the Iceberg table format such as Amazon EMR, Apache Spark, and Apache Flink.

Athena ACID transactions can help you make business- and regulatory-driven updates to your data using familiar SQL syntax and without requiring a custom record locking solution. Responding to a data erasure request is as simple as issuing a SQL DELETE operation. Making manual record corrections can be accomplished via a single UPDATE statement. And with time travel capability, you can recover data that was recently deleted using just a SELECT statement.

To learn more about Athena ACID transactions and Apache Iceberg integration, see Using Amazon Athena Transactions and Using Iceberg Tables in the Athena User Guide.



What are ACID Transactions

If a database operation has these ACID properties, it can be called an ACID transaction, and data storage systems that apply these operations are called transactional systems. ACID transactions guarantee that each read, write, or modification of a table has the following properties:

Atomicity

- This means that all parts of a transaction must be completed successfully. If any part fails, the entire transaction is rolled back, leaving the system as if the transaction never happened. Think of it as an all-or-nothing rule.

Consistency

- A transaction must bring the database from one valid state to another, maintaining all predefined rules, such as data integrity constraints. This ensures that the database remains accurate and reliable throughout the transaction process.

Isolation

- Transactions are isolated from each other, meaning the operations of one transaction cannot interfere with those of another. This is like making sure that if multiple people are making changes at the same time, each change is processed separately without causing conflicts.

Durability

- Once a transaction is successfully completed, the changes it made are permanent, even in the event of a system failure. This ensures that once you have made a change and the system confirms it, that change will not be lost.

Amazon Athena – ACID Transactions

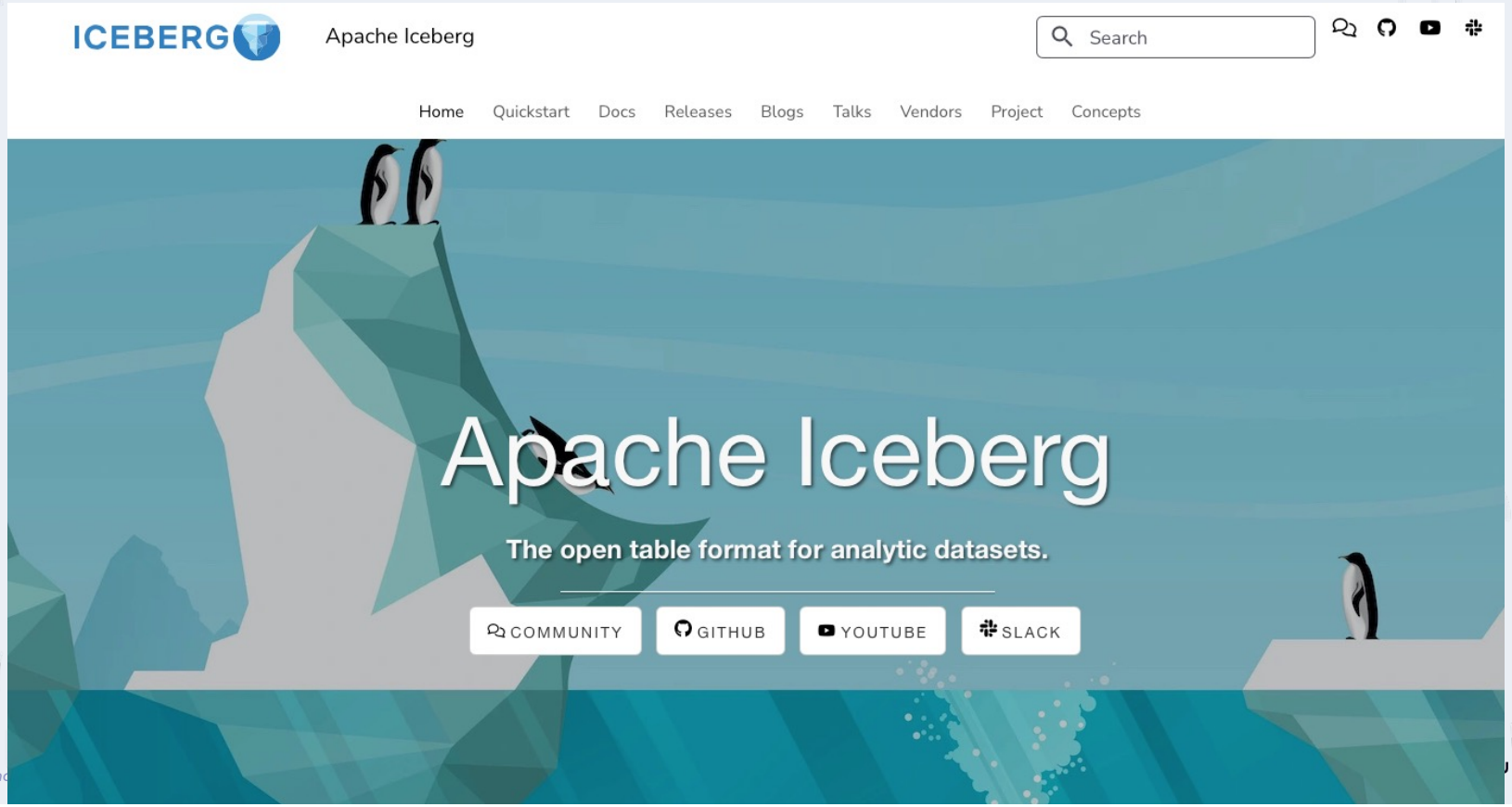
- The term "ACID transactions" refers to a set of properties (**atomicity**, **consistency**, **isolation**, and **durability**) that ensure data integrity in database transactions.

- ACID transactions enable multiple users to **concurrently** and reliably **add** and **delete** Amazon S3 objects in an atomic manner, while isolating any existing queries by maintaining read consistency for queries against the data lake.

- Athena ACID transactions add single-table support for insert, delete, update, and time travel operations to the Athena SQL data manipulation language (DML).

- You and multiple concurrent users can use Athena ACID transactions to make reliable, row-level modifications to Amazon S3 data. Athena transactions automatically manage locking semantics and coordination and do not require a custom record locking solution.

What is Apache Iceberg

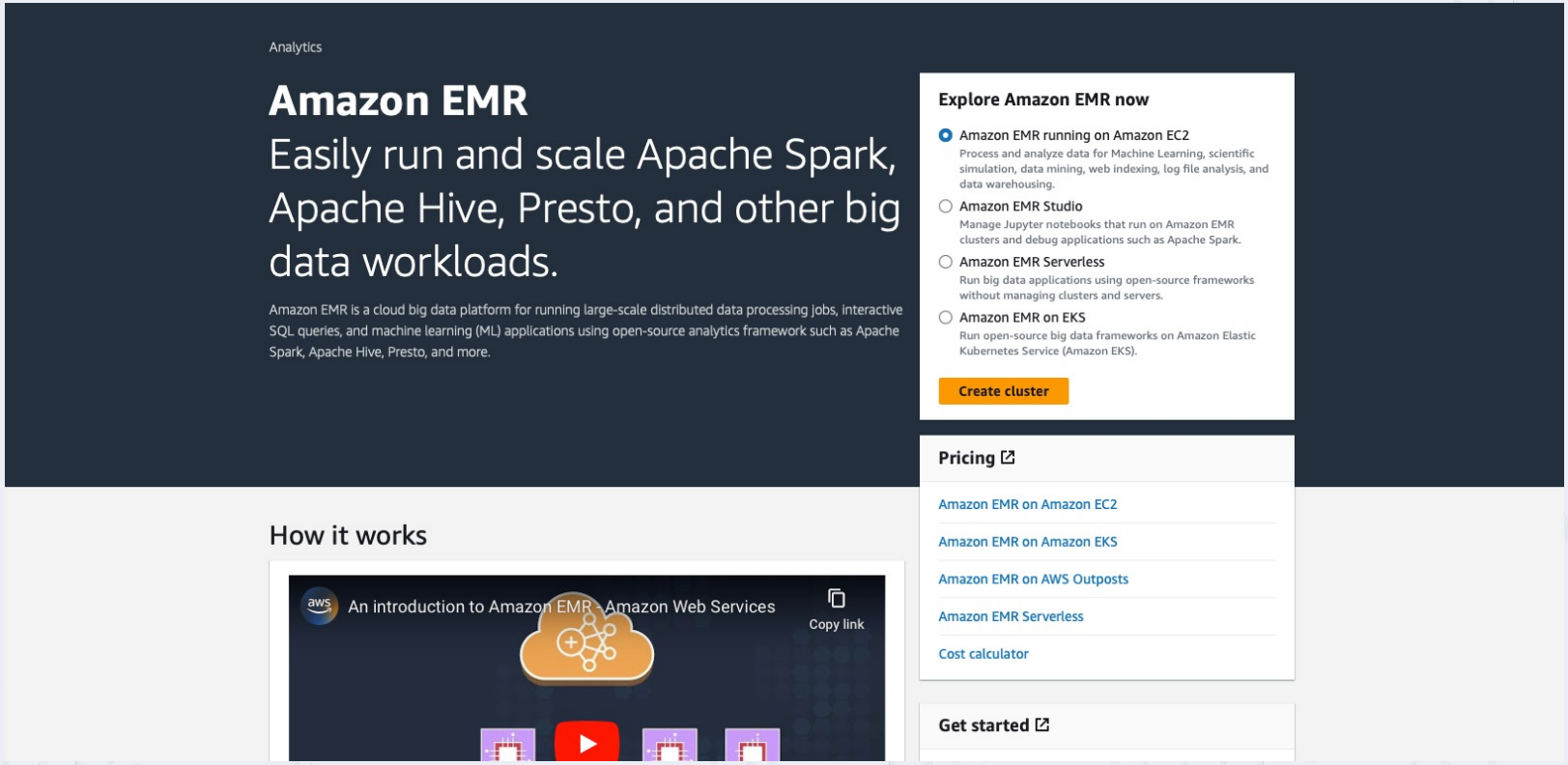


What is Apache Iceberg

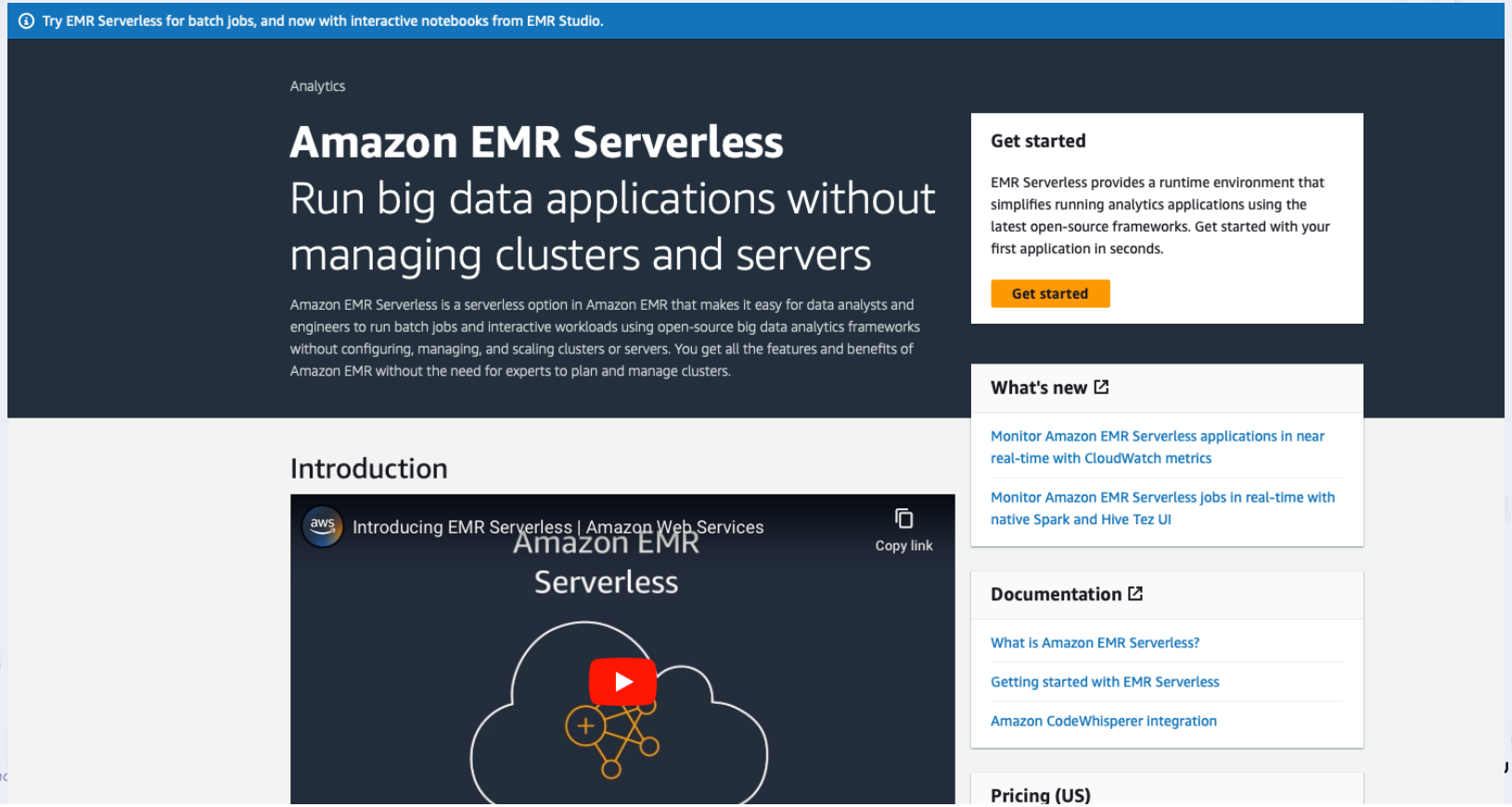
Apache Iceberg is an open-source high-performance table format designed for massive analytic tables. It enables the use of **SQL tables** for big data and allows multiple engines like Apache Spark, Trino, Flink, Presto, Hive, Impala, and others to safely work with the same tables **simultaneously**. Iceberg addresses the performance and usability challenges of using Apache Hive tables in large and demanding data lake environments by providing features such as:

- **ACID Transactions**: Ensures data accuracy by guaranteeing atomicity, consistency, isolation, and durability.
- **Schema Evolution**: Supports add, drop, update, or rename operations without side effects.
- **Partition Evolution**: Allows updates to partition schemes as queries and data volumes change.
- **Time Tra**vel: Enables reproducible queries using exact table snapshots or examining changes.
- **Version Roll**back: Quickly corrects problems by resetting tables to a known good state.

Amazon EMR (Elastic MapReduce)



Amazon EMR Serverless



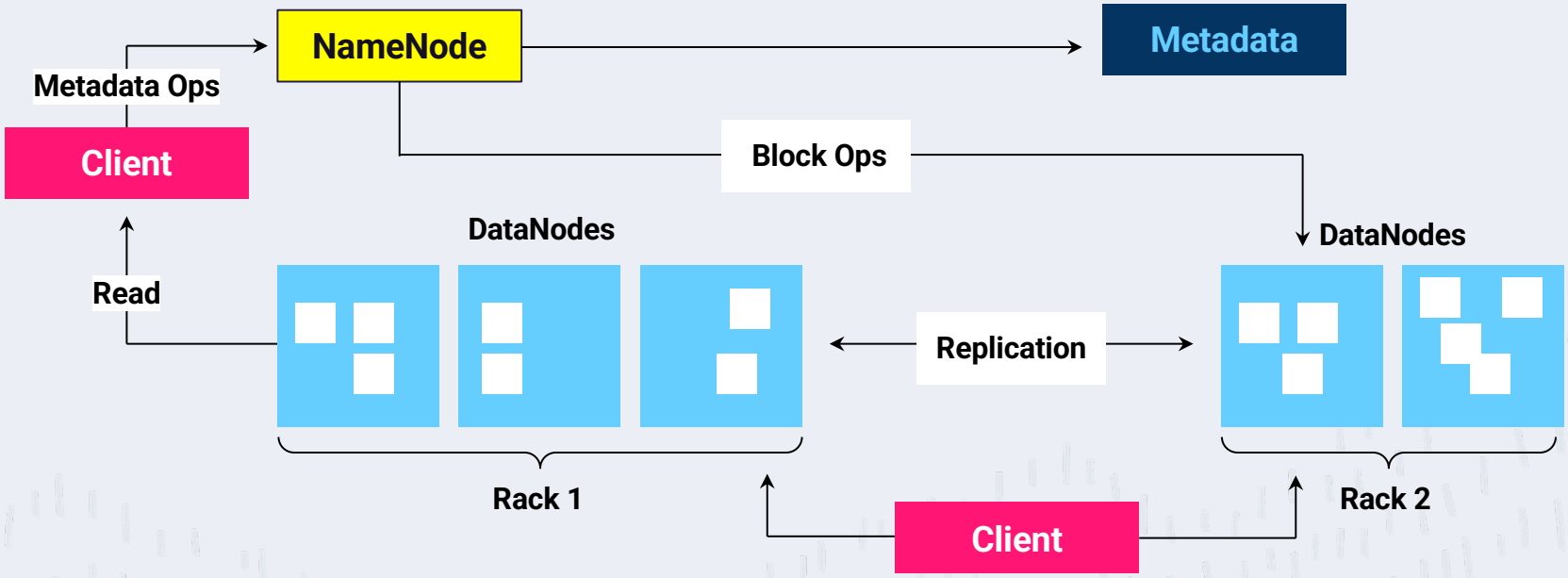
Hadoop

Hadoop consists of a cluster of tools designed to meet the challenges of processing large amounts of data, including:

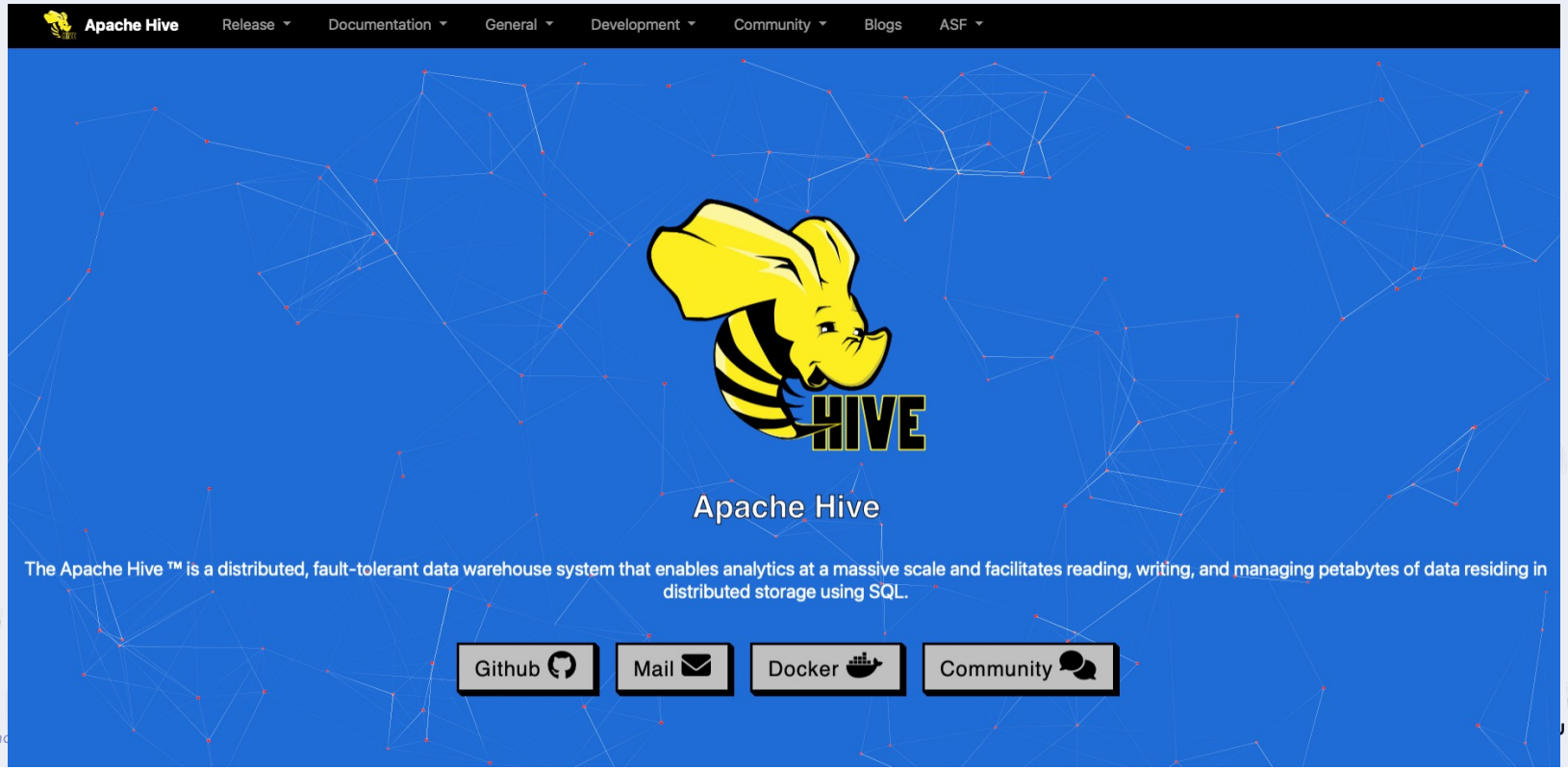
- The Hadoop Distributed File System, or HDFS
- Apache Hive
- MapReduce

The Hadoop Distributed File System

The **Hadoop Distributed File System**, or **HDFS**, allows Hadoop to store large quantities of data across multiple servers efficiently (and inexpensively) while minimizing the risk of data loss.



What is HIVE?

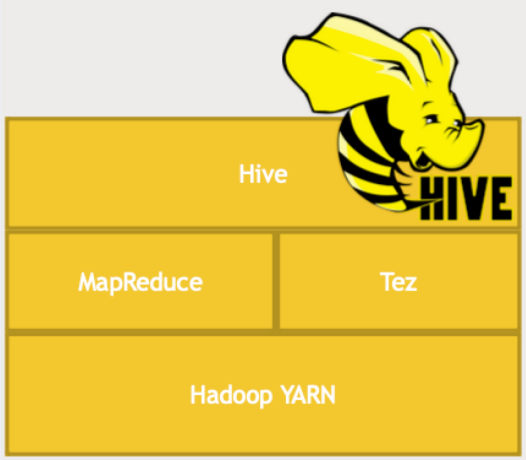


What is HIVE?

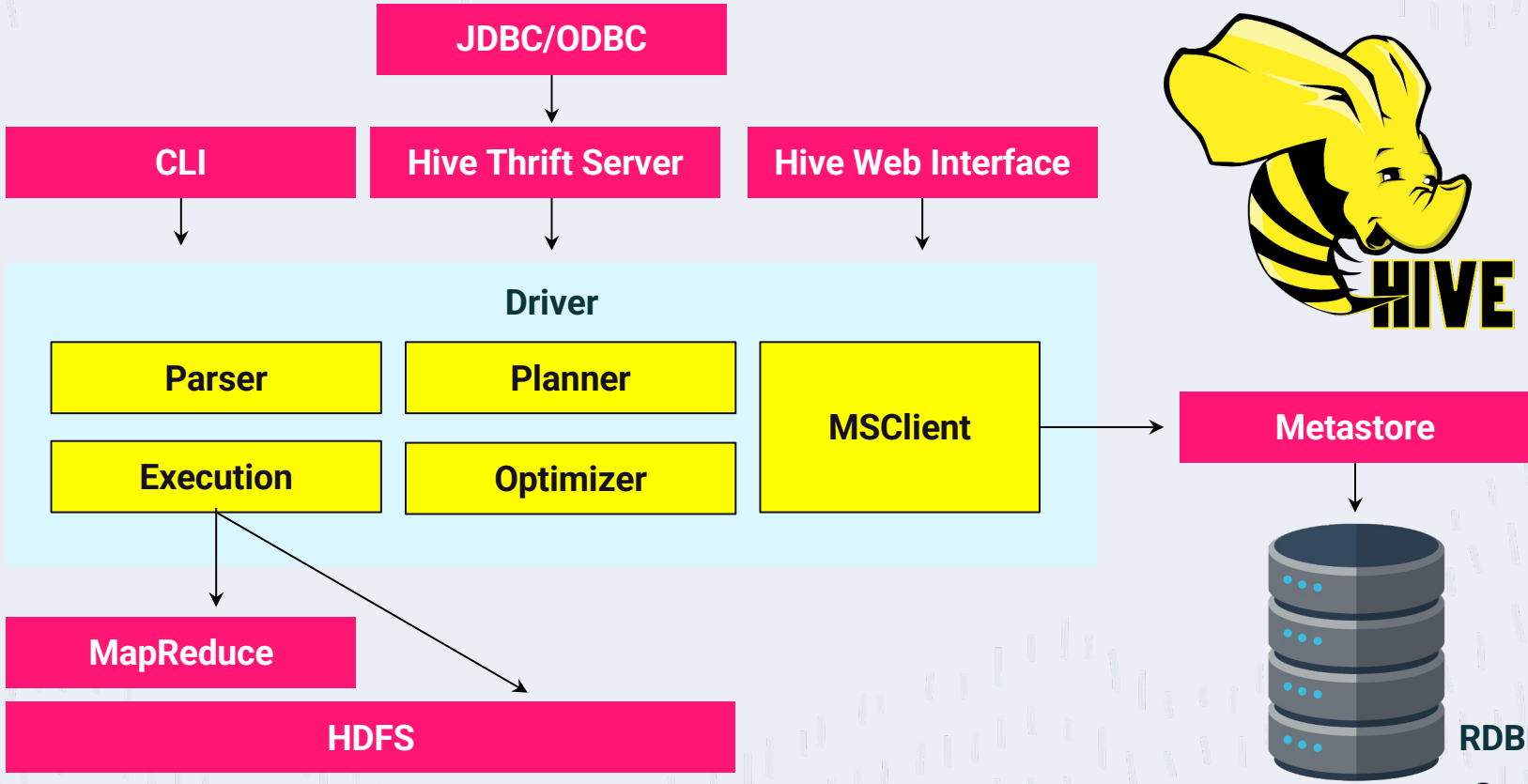
Apache Hive is an SQL-like query tool for big data.

What is HIVE?

- Apache Hive is a **distributed**, fault-tolerant **data warehouse** system that enables analytics at a massive scale. A data warehouse provides a central store of information that can easily be analyzed to make informed, data driven decisions.
- Hive allows users to read, write, and manage petabytes of data using SQL.
- Hive is built on top of Apache Hadoop, which is an open-source framework used to efficiently store and process large datasets.
- As a result, Hive is closely integrated with **Hadoop**, and is designed to work quickly on petabytes of data. What makes Hive unique is the ability to query large datasets, leveraging Apache Tez or MapReduce, with a SQL-like interface.

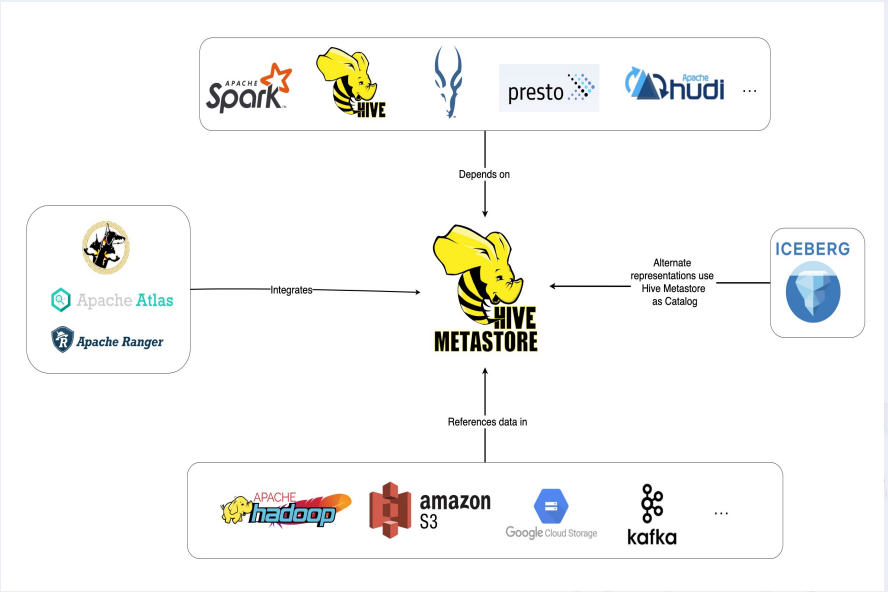


Apache Hive Architecture



What is Hive Metastore?

- The **Hive Metastore (HMS)** is a central repository of metadata for Hive tables and partitions in a relational database, and provides clients (including Hive, Impala and Spark) access to this information using the metastore service API.
- It has become a building block for data lakes that utilize the diverse world of open-source software, such as Apache Spark and Presto. I
- n fact, a whole ecosystem of tools, open-source and otherwise, are built around the Hive Metastore, some of which this diagram illustrates.



What is HiveQL?

HiveQL is a query language for Hive to analyze and process structured data in a Meta-store. It is a mixture of SQL-92, MySQL, and Oracle's SQL.

It is very much **similar to SQL** and highly scalable. It reuses familiar concepts from the relational database world, such as tables, rows, columns and schema, to ease learning. Hive supports four file formats those are TEXT FILE, SEQUENCE FILE, ORC and RC FILE (Record Columnar File).

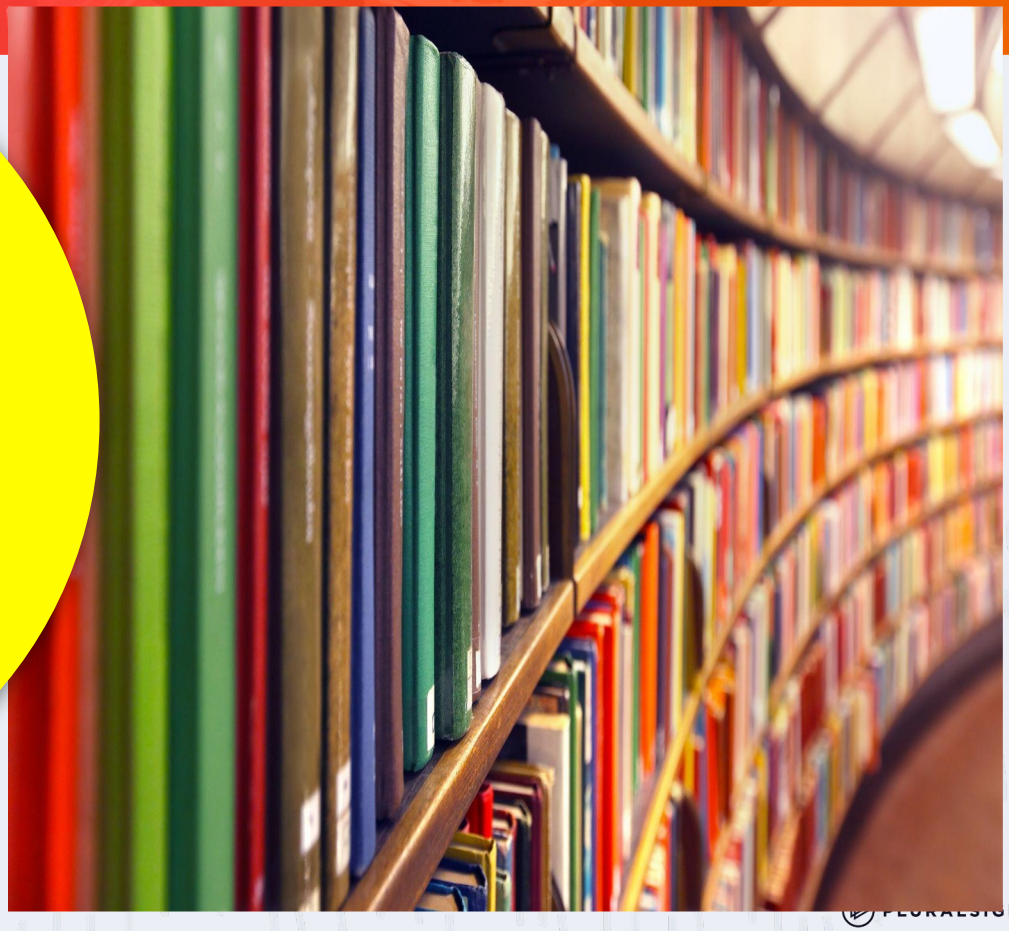
MapReduce

MapReduce distributes large data tasks across multiple servers and then assembles the results.

MapReduce

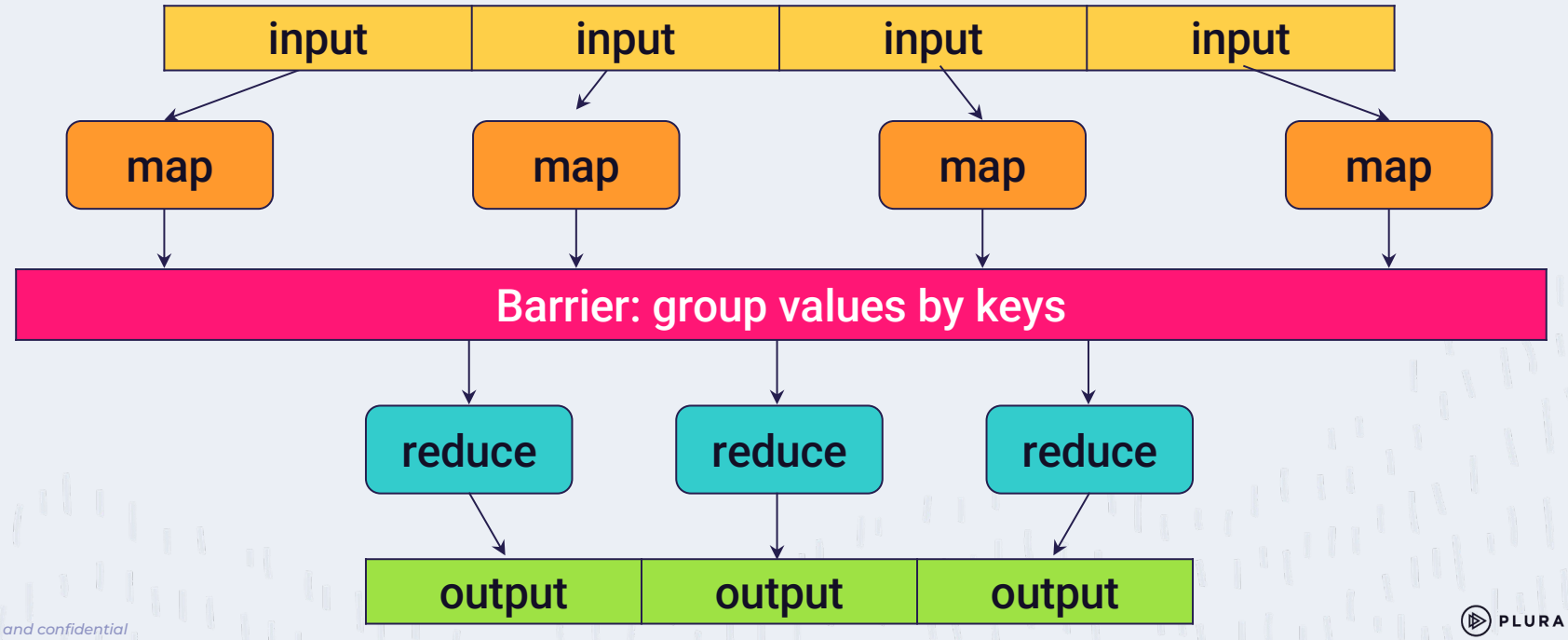
An analogy for MapReduce

If we want to count all the books in a library, we can count each section **(Map)**, and then add all the results **(Reduce)**.



MapReduce

Google created MapReduce to index all information on the internet. You can use MapReduce to distribute and process the data on your cluster.

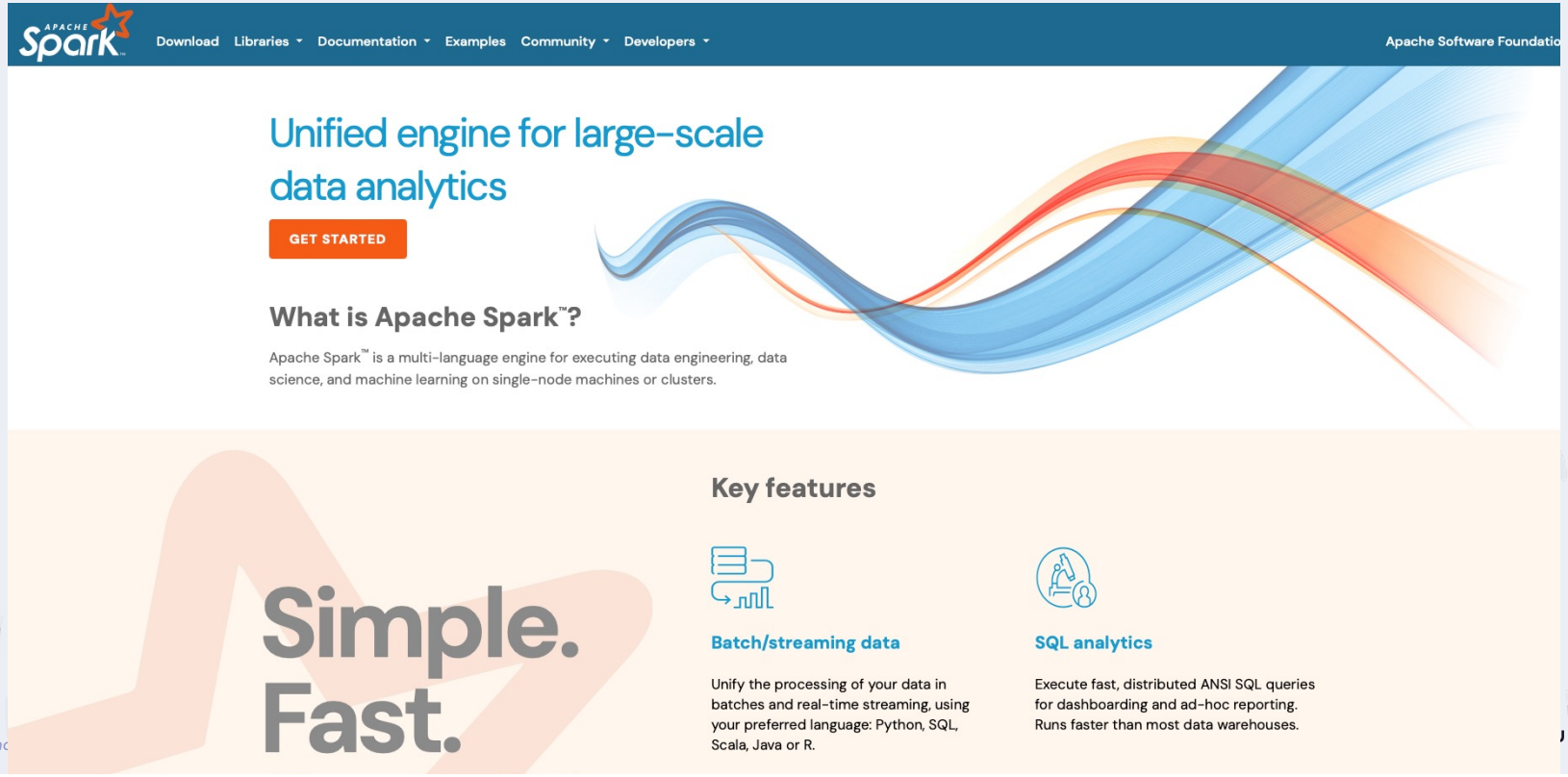


MapReduce

Mapping is the process of splitting up data, preprocessing it, and then converting the data into key-value pairs.

Reducing is the process of aggregating the results.

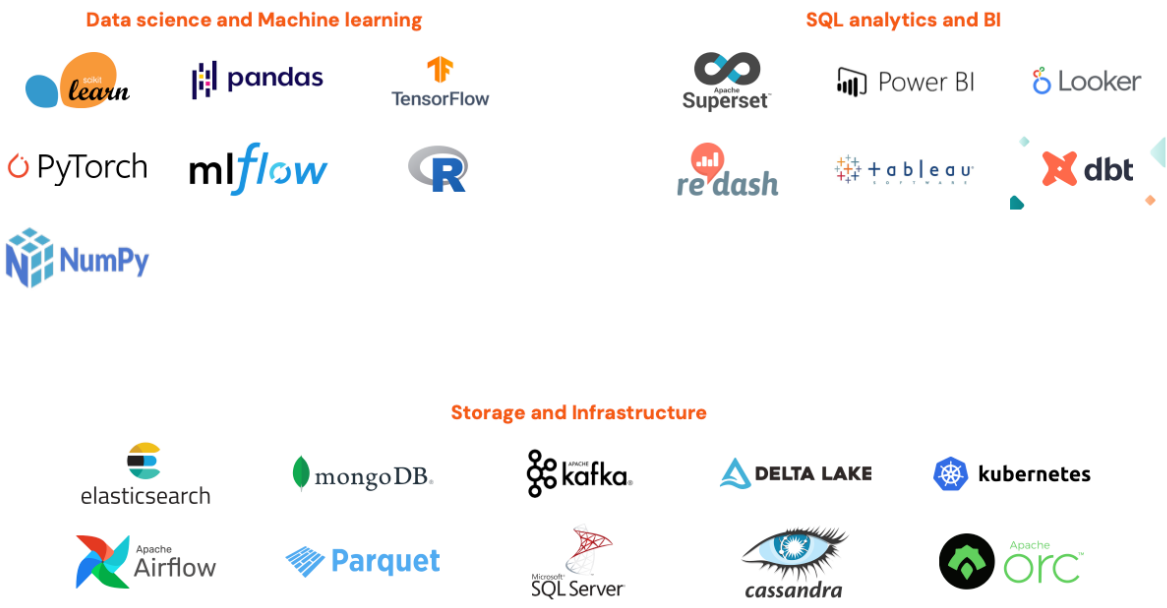
Apache Spark



Apache Spark

Ecosystem

Apache Spark™ integrates with your favorite frameworks, helping to scale them to thousands of machines.



Apache Spark

Spark SQL engine: under the hood

Apache Spark™ is built on an advanced distributed SQL engine for large-scale data

Adaptive Query Execution

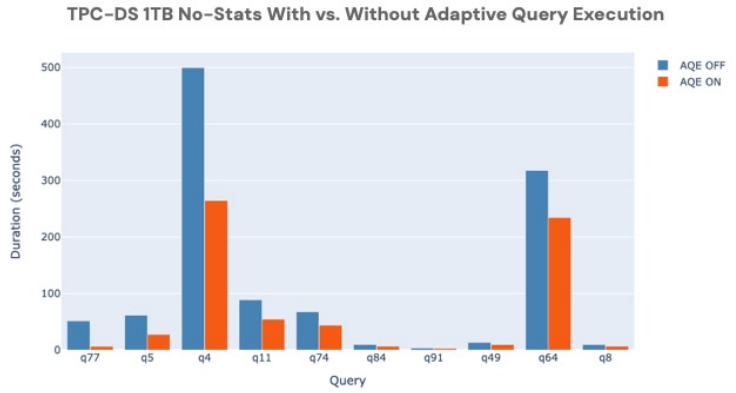
Spark SQL adapts the execution plan at runtime, such as automatically setting the number of reducers and join algorithms.

Support for ANSI SQL

Use the same SQL you're already comfortable with.

Structured and unstructured data

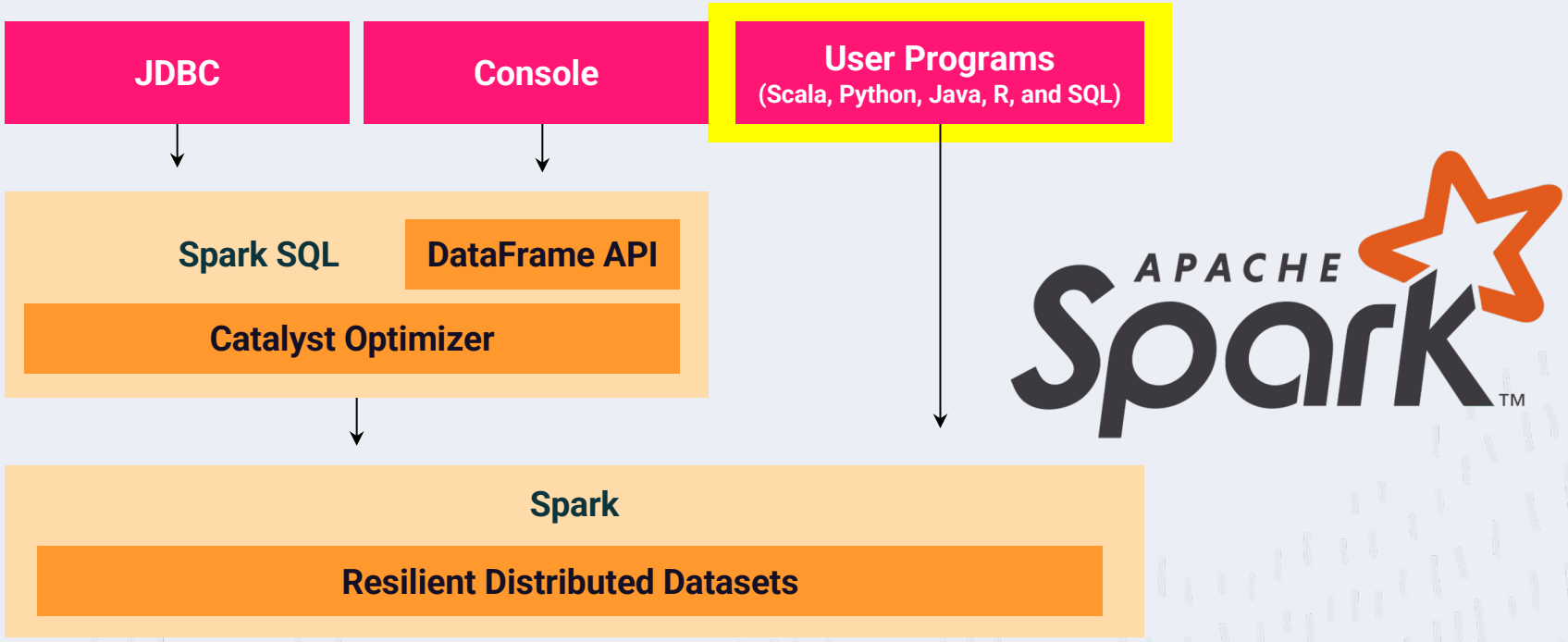
Spark SQL works on structured tables and unstructured data such as JSON or images.



Accelerates TPC-DS queries up to 8x

Spark Overview

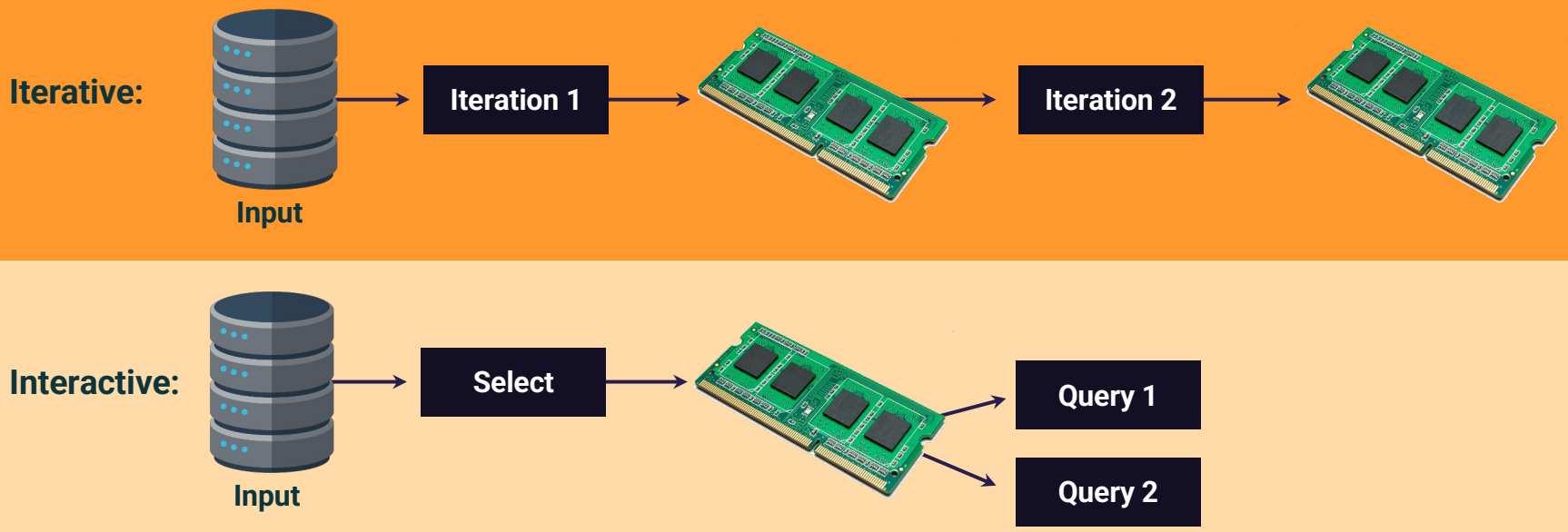
Spark uses **scripts** from programming languages like Python, has a rich ecosystem, and is very scalable.



APACHE Spark™

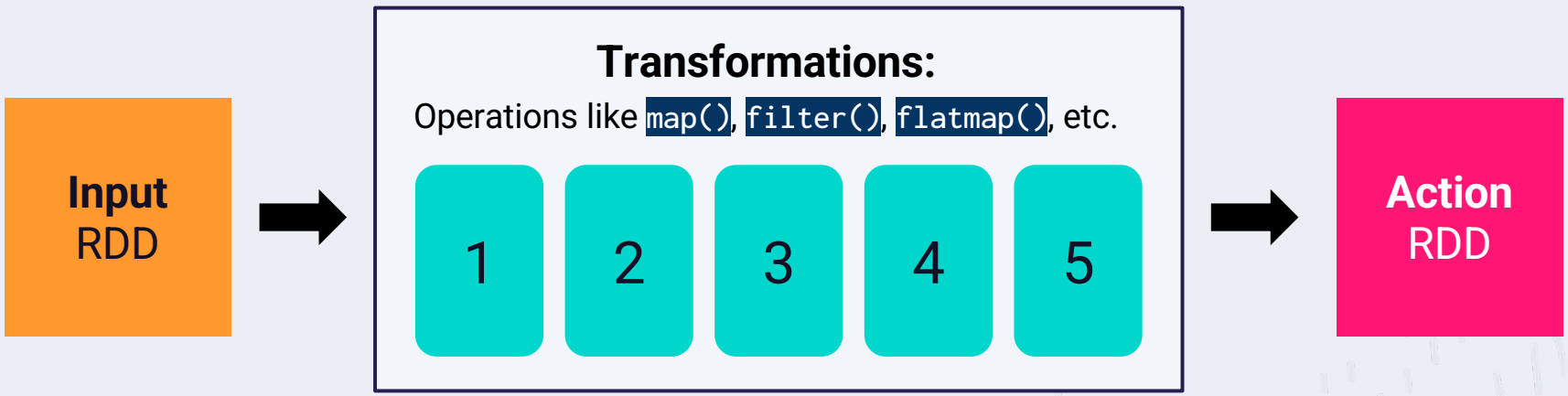
Spark Overview

Spark uses **in-memory computation** instead of a disk-based solution. It doesn't need to talk to the Hadoop Distributed File System (HDFS) for every query, and it retains as much as it can in memory.



Spark Overview

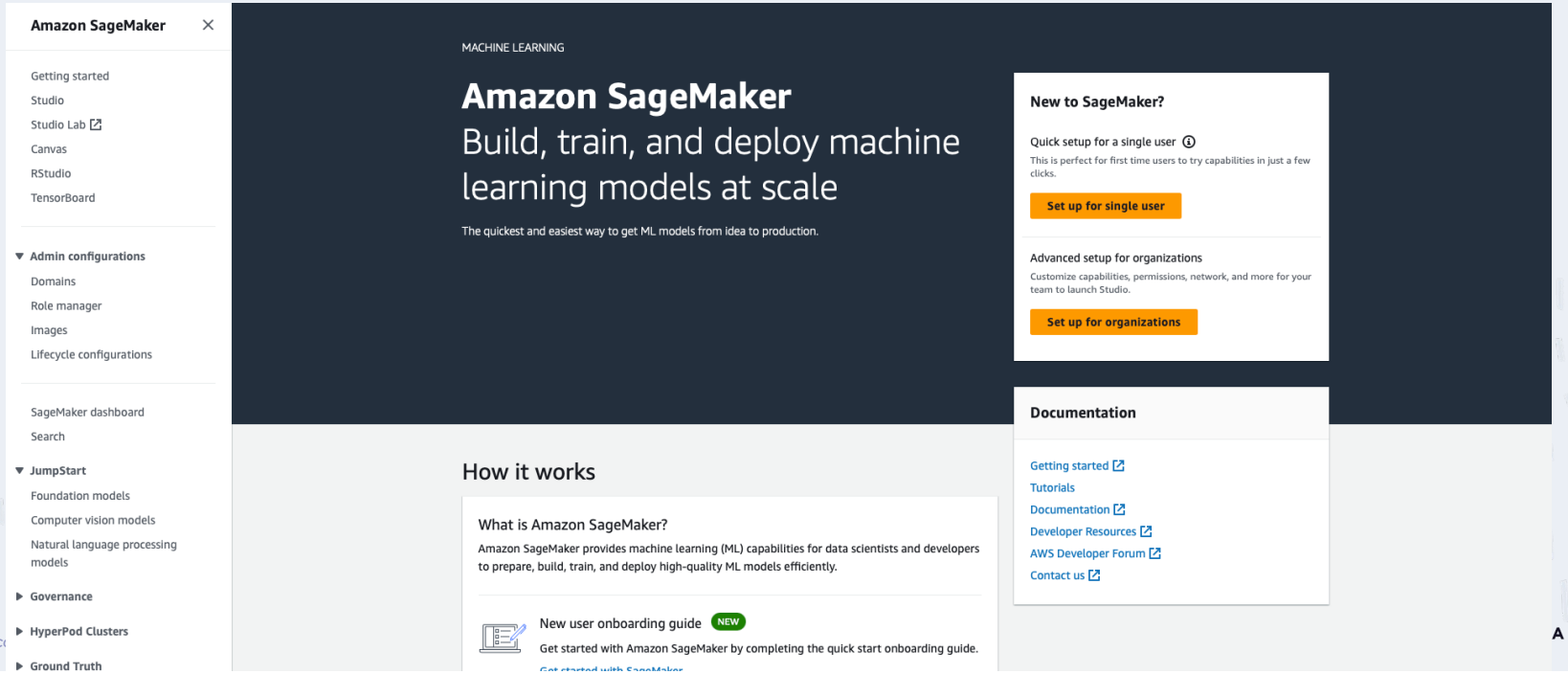
Spark uses **lazy evaluation**, which delays the evaluation of an expression until its value is needed.



Spark **maintains the lineage of transformations** but does not evaluate them until an action is called.

Amazon SageMaker

Amazon SageMaker provides machine learning (ML) capabilities for data scientists and developers to prepare, build, train, and deploy high-quality ML models efficiently.



Amazon SageMaker

Typical SageMaker workflow

1. Label data

Set up and manage labeling jobs for highly accurate training datasets within Amazon SageMaker, using active learning and human labeling.

2. Build

Connect to other AWS services and transform data in Amazon SageMaker notebooks.

3. Train

Use Amazon SageMaker's algorithms and frameworks, or bring your own, for distributed training.

4. Tune

Amazon SageMaker automatically tunes your model by adjusting multiple combinations of algorithm parameters.

5. Deploy

After training is completed, models can be deployed to Amazon SageMaker endpoints, for real-time predictions.

6. Discover

Find, buy, and deploy ready-to-use model packages, algorithms, and data products in AWS Marketplace.

Thank you!

If you have any additional questions, please reach out to me at: (email address).