LIXAR | DRIVEN BY DATA

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Databricks Deep Dive for Public Sector

May 27, 2021

Speaker Intros

Eric Rops

I am a Data Engineer, coming from seven years of industry experience as a Geophysicist harnessing multi-terabyte seismic, well log, and mineral exploration datasets to target the most economic prospects (both oil and mining sectors). During that time I became highly involved in data analytics, completing projects in workflow automation, machine learning, data pipelines, and dashboards for executives.

At Lixar BDO, I am currently building production data pipelines, data warehouses, and data lakes, enabling our clients to make the best possible decisions with their datasets.

I love turning large and complex data into something that is understandable and useable, and look forward to giving this workshop and hopefully passing some of that on!

Speaker Intros

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Tom Walsh

I am a Solutions Architect with Lixar Fuelled by BDO who specializes in the architecture and implementation of Data Analytics solutions in Azure.

I come from a consulting background with a decade of experience delivering to a variety of industries including Energy, Law, Telcom, Dentistry, Investments and Sports. For these projects I have leveraged many Azure tools including of course Azure Databricks.

In addition, I have achieved the following certifications Microsoft Azure Solutions Architect, Databricks Associate Developer and Microsoft Data Azure Data Scientist Associate. I am looking forward to showing you what is possible with these tools during this workshop!

AGENDA

Morning Session

9:30 – 10:00 AM | Environment Setup

10:00 – 12:30 PM | Data Engineering in Azure Databricks

- Databricks Overview
- Apache Spark in Notebooks
- Databricks leveraging Azure Storage and Azure Key Vault
- Orchestrating Databricks with Azure Data Factory
- Delta Lake Architecture and Delta Tables

12:30 - 1:00 PM | LUNCH BREAK

Afternoon Session

1:00 – 2:30 PM | Spark Machine Learning in Azure Databricks

- Machine Learning Overview
- Linear Regression with Spark Machine Learning
- Classification Machine Learning - Fraud Detection
- MLflow platform for the machine learning lifecycle
- Distributed ML with Koalas

2:30 – 3:00 PM | Q&A

Azure Setup

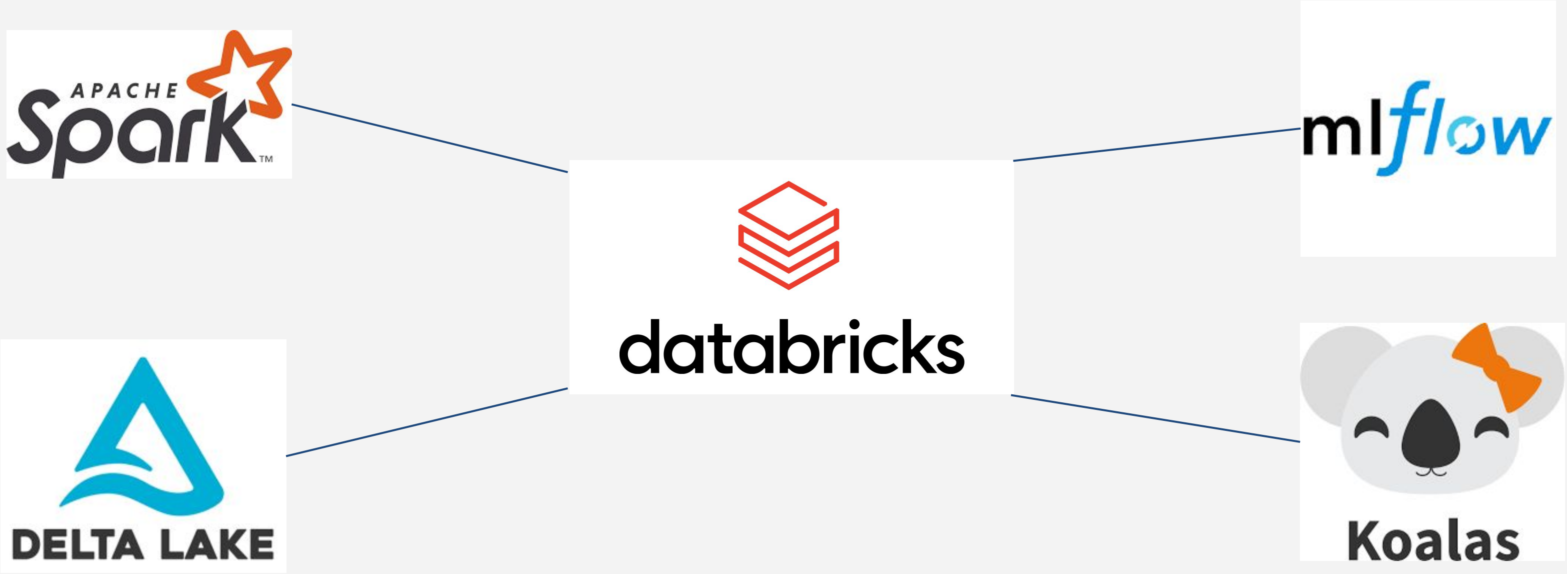
Ensure the following Azure resources are setup:

- Storage Account (with Data Lake Storage gen2 enabled)
- Azure Key Vault
- Data Factory V2
- Databricks

Databricks Overview

Databricks is a unified data platform that makes it easy to collaborate on data engineering, analytics, and machine learning workflows.

It is built on top of Spark, and three other extremely popular open source projects.



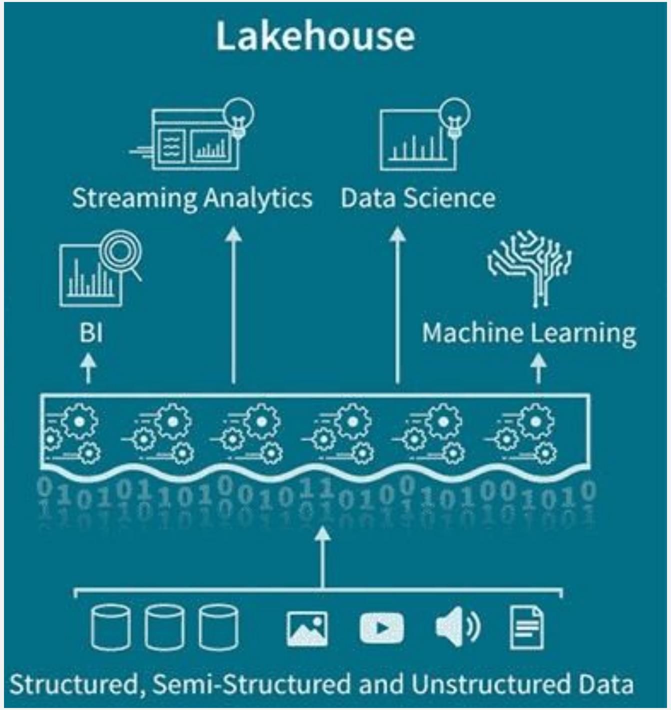
Databricks Overview

Databricks provides a smooth implementation of the **Lakehouse Architecture,** which combines the best features of Data Warehouses and Data Lakes.

One platform for every use case

Structured transactional layer

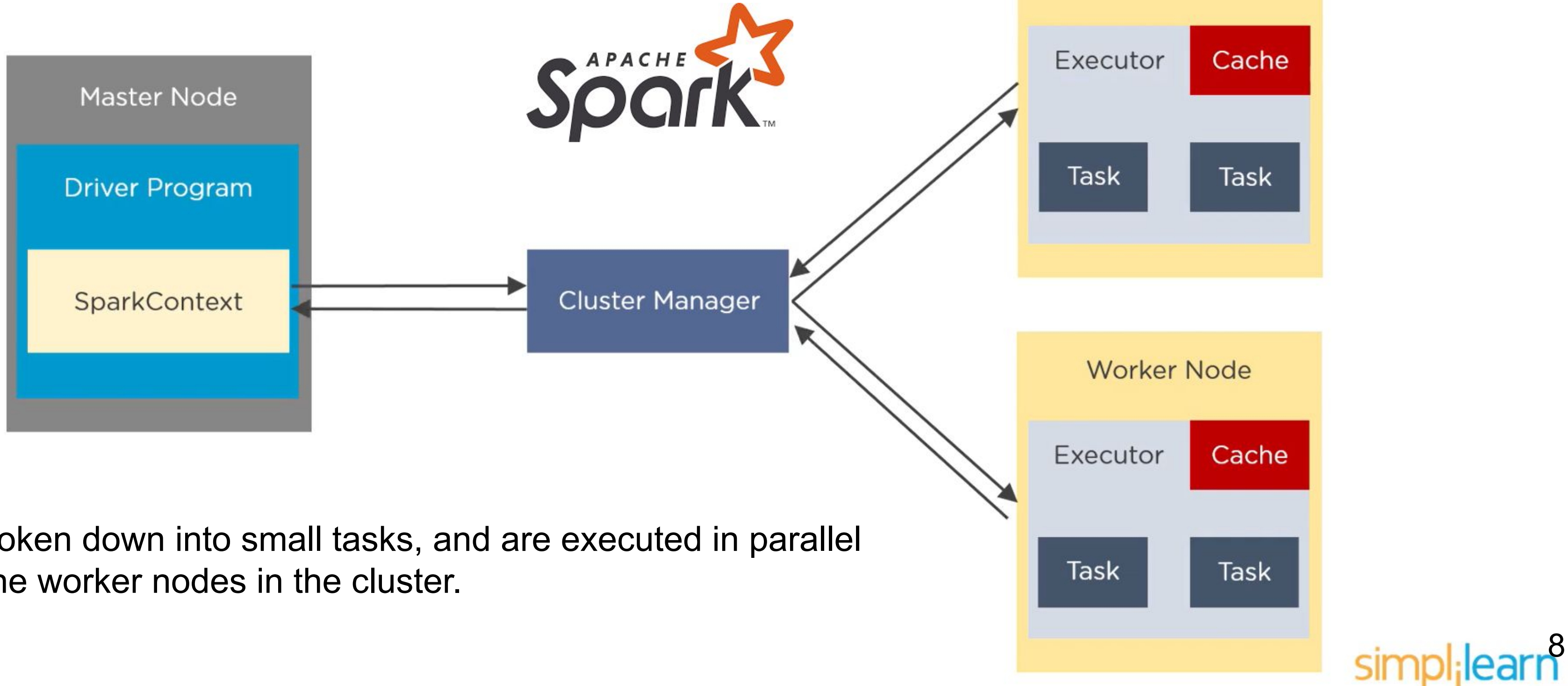
Data Lake for all your data



https://databricks.com/blog/2020/01/30/what-is-a-data-lakehouse.html

Apache Spark Overview (Source: SimpliLearn)

Spark is an **open-source**, **in-memory**, **cluster-computing** framework used for batch and real-time processing of large datasets.



Jobs are broken down into small tasks, and are executed in parallel across all the worker nodes in the cluster.

Data Analytics with Databricks at the Heart

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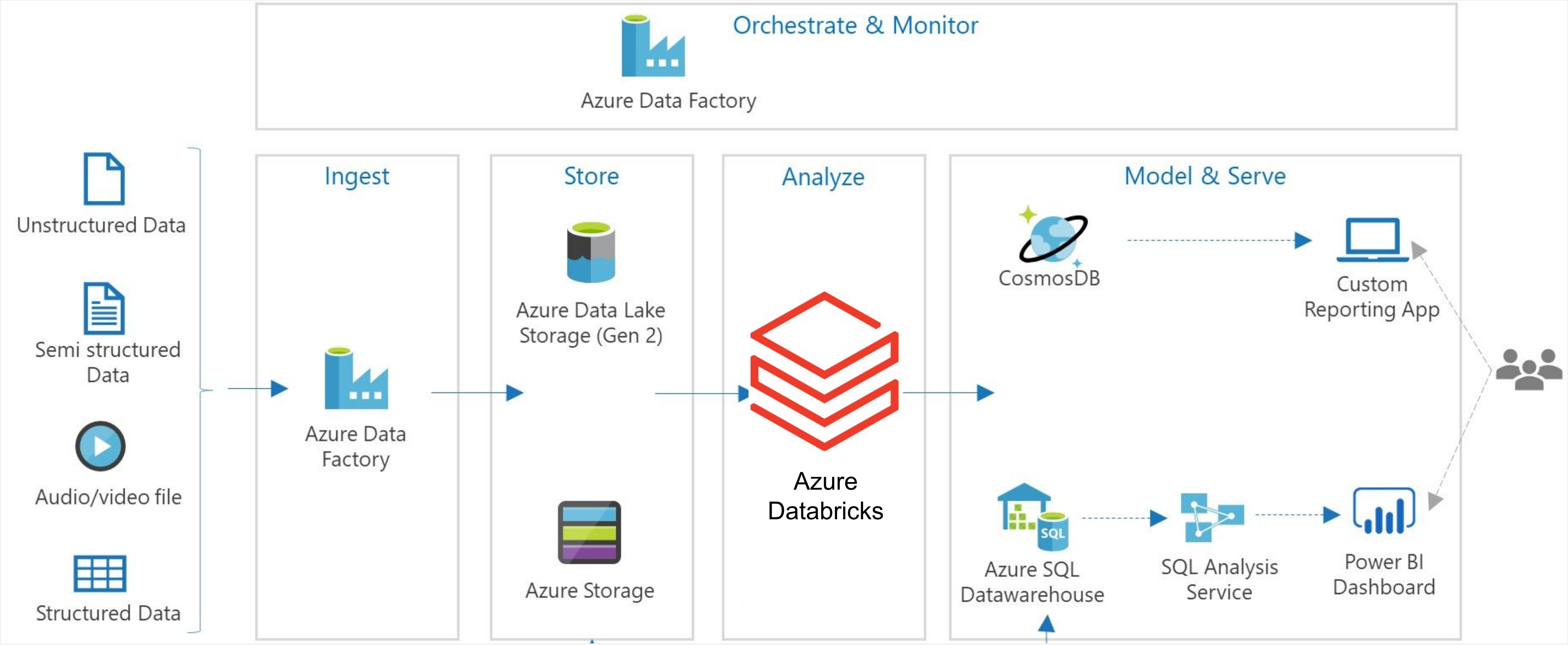
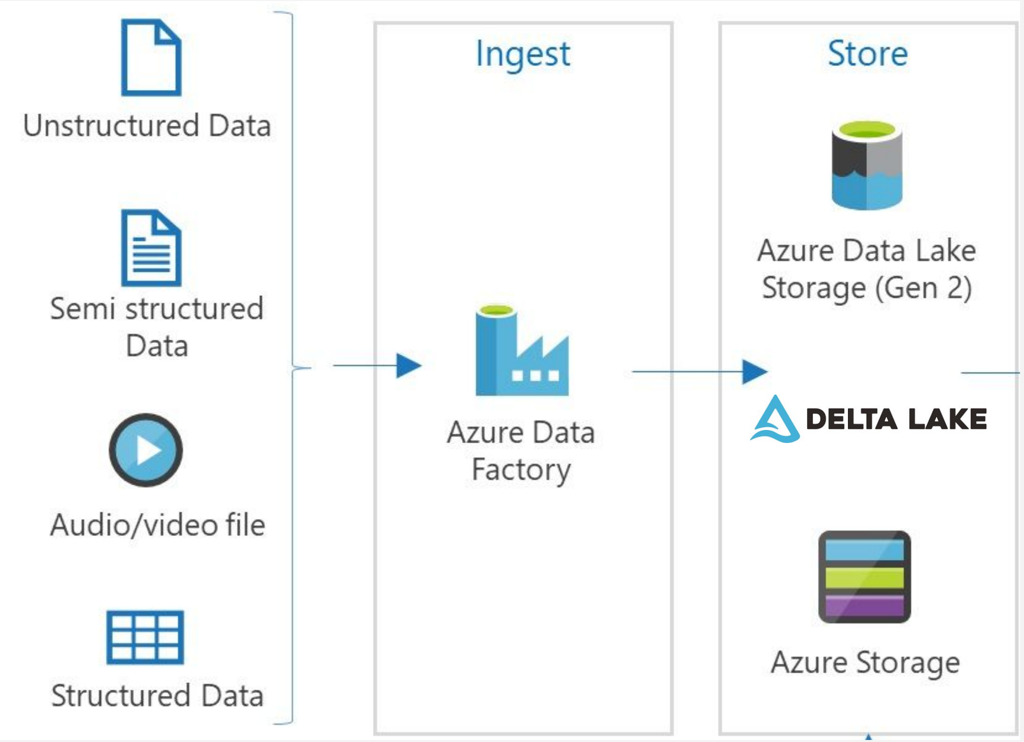


https://res.infoq.com/articles/azure-data-lake-analytics-usql/en/resources/azure-data-2-1568098316593.jpg

Data Analytics with Databricks at the Heart (Ingest and Store)



- Mix of structured and unstructured, batch and streaming data sources
- Azure Data Factory can Extract, Transform, and Load (**ETL**) the other data into object storage
- Can leverage the Delta format, which brings Data Warehousing features to the Data Lake

Data Analytics with Databricks at the Heart (Delta Table tiers)

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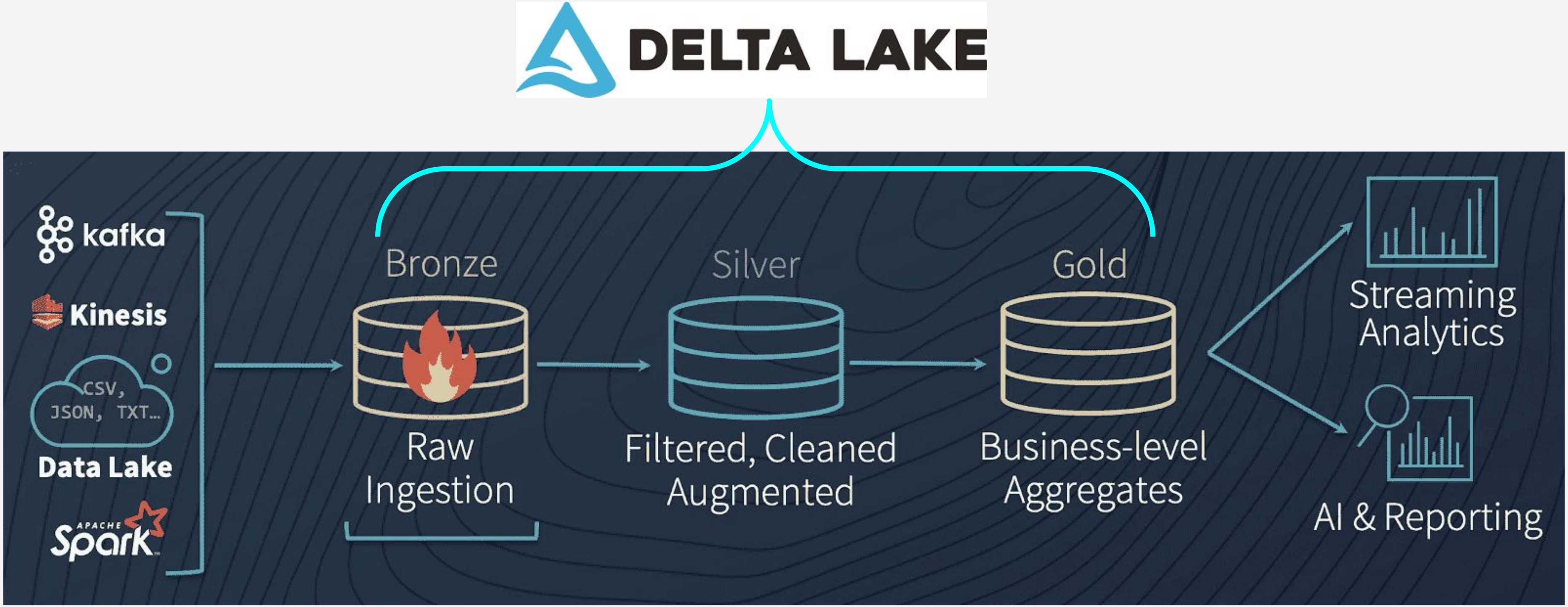
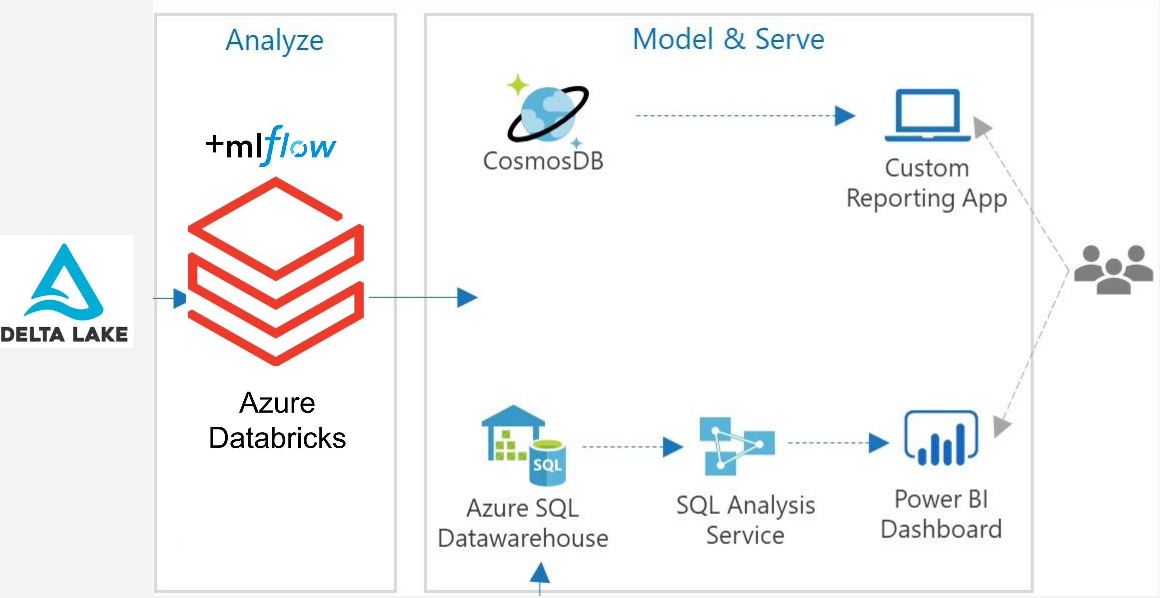


https://blog.knoldus.com/databricks-delta-architecture/

Data Analytics with Databricks at the Heart (Prep/Model and Serve)



Machine Learning:

- Data from the Silver or Gold tables can be used to prep and train a Machine Learning (ML) model using **mlflow** or **Spark ML**

- Models results can be stored in Operational Databases, and fed to business apps

Analytics and BI:

- Data from the gold tables flow to a Data Warehouse, and / or to a dashboard

Resource Group for Databricks

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Follow-along session to locate the following:

- Resource Group
- Azure Databricks

Create Databricks Cluster

Follow-along session to do the following:

- Import the Databricks DBC archive (sent to your email)
- Create Databricks cluster
  - Select Terminate after **1 hour** of inactivity

Choose this cluster type

Exercise: Intro Notebook

Exercise in notebook file: **01_Intro**

NOTE:

- **Running the notebooks yourselves is optional**
- **It's a good idea to Clear State & Results before running a new notebook**

Exercise: Basic Databricks notebook

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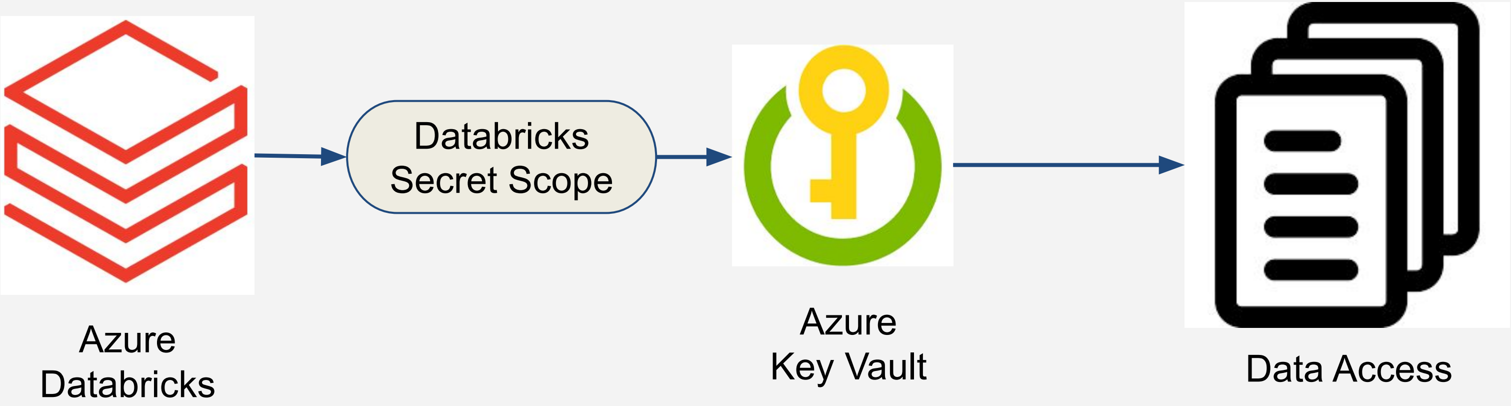
Exercise in notebook file: **02_Basic_Notebook**

10 minute break

Azure Storage Account and Secrets

- Before we start loading data, we need to securely store our Storage Account access credentials to prevent outsiders from accessing the data!
- We can store our access credentials as secrets inside the **Azure Key Vault**.
- To access the secrets from Databricks, we create a **Secret Scope** link to the Key Vault.



Setup Azure Storage Account Key Vault

Follow-along session to do the following:

- Azure Storage Account (with Data Lake Storage gen2 enabled)
  - Upload the Data files (CSV.GZ and JSON) to your storage account
- Create Azure Key Vault
- Azure Access Policies
- Add the Storage primary access key as a secret
- Create Databricks Secret Scope back to the Key Vault

Please raise your hand if you run into issues!

Exercise: Secrets and Azure Storage

Exercise in notebook file: **03_Secrets_And_Azure_Storage**

Fundamentals of the Delta Lake Architecture

Evolution: Data Warehouse to Delta "Lakehouse"

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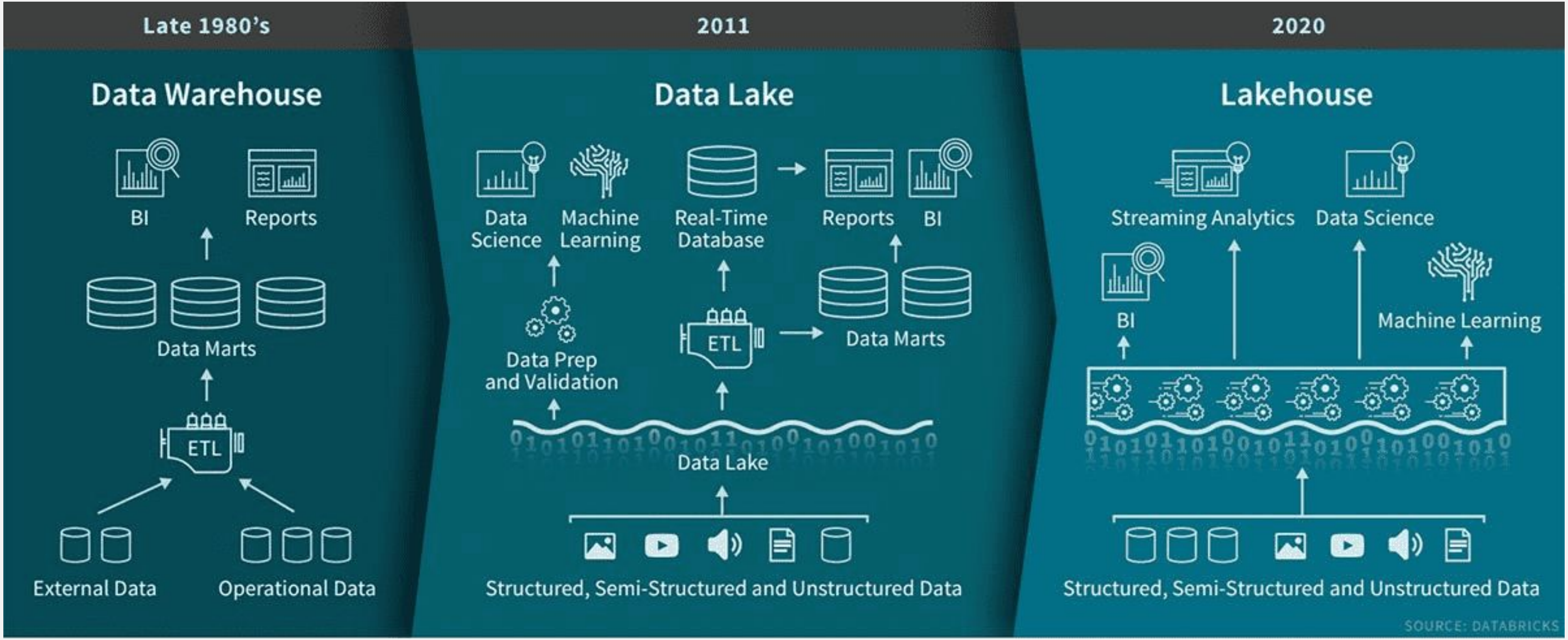
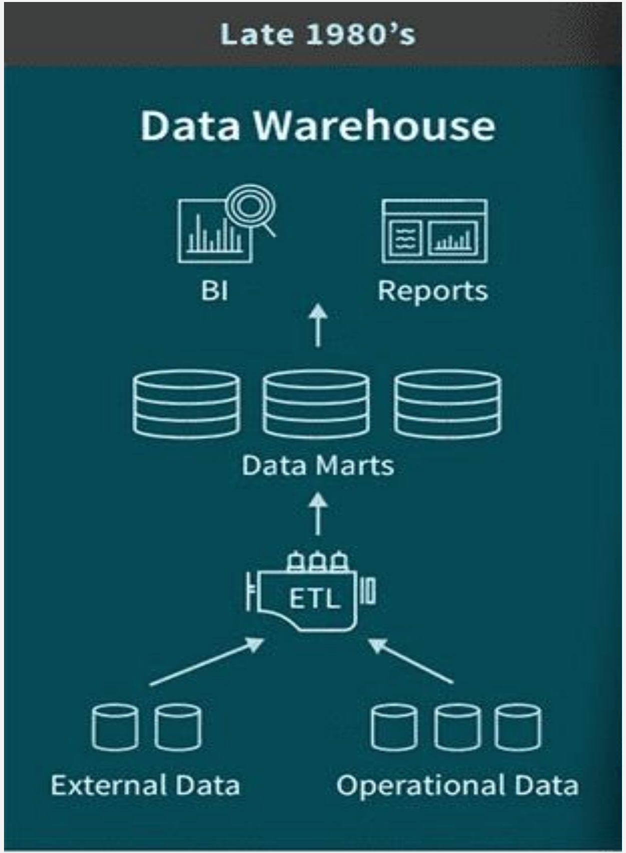


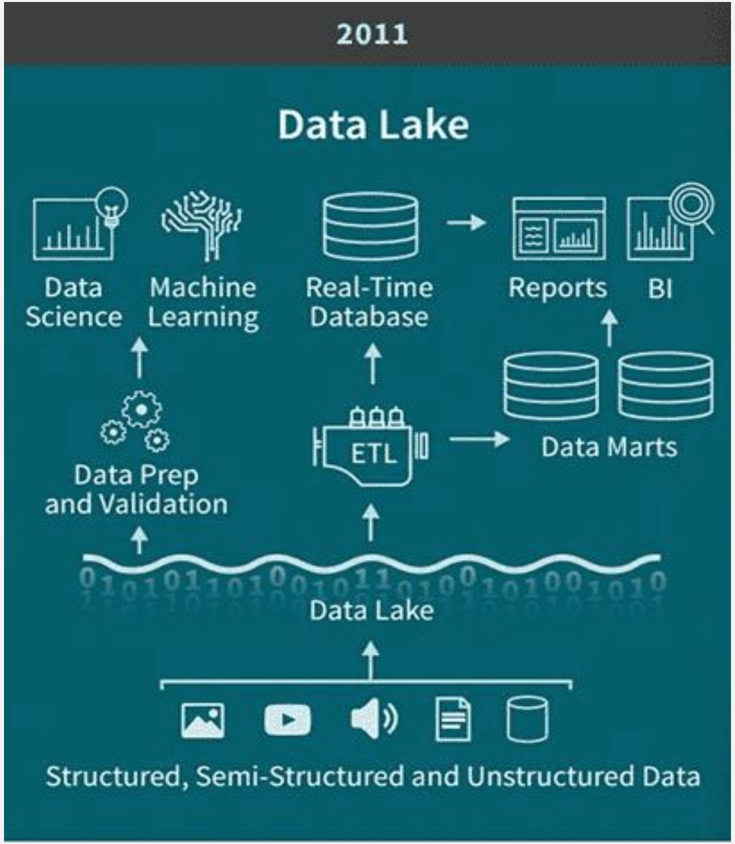
https://databricks.com/blog/2020/01/30/what-is-a-data-lakehouse.html

Data Warehouse



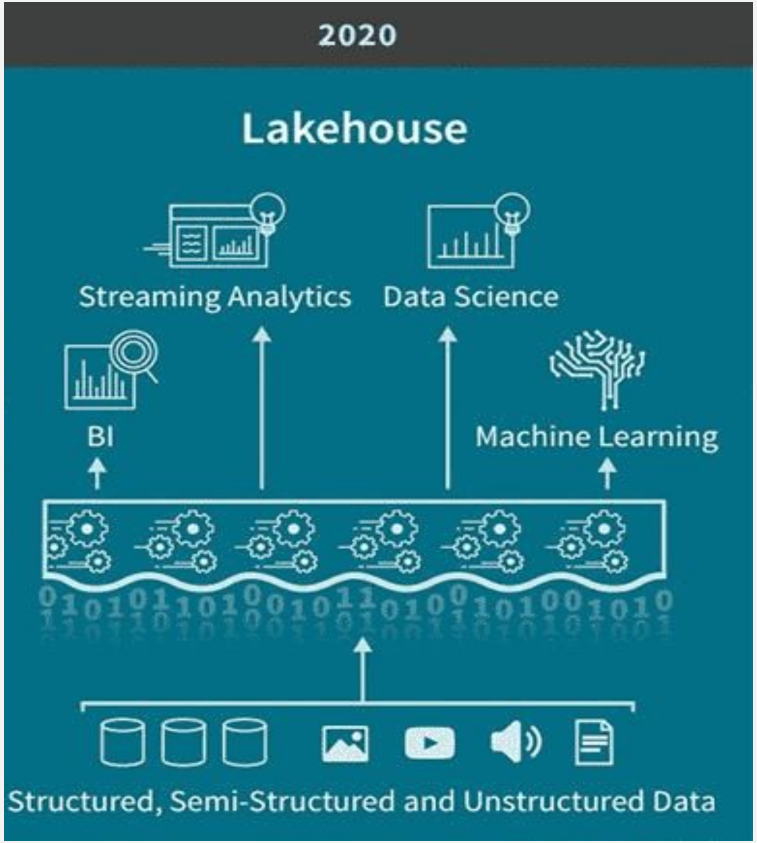
- Built for business intelligence and reporting
- Support for data consistency and quick ad-hoc queries.
- However, they're unable to store unstructured raw data (which are crucial for modern machine learning uses)

Data Lake



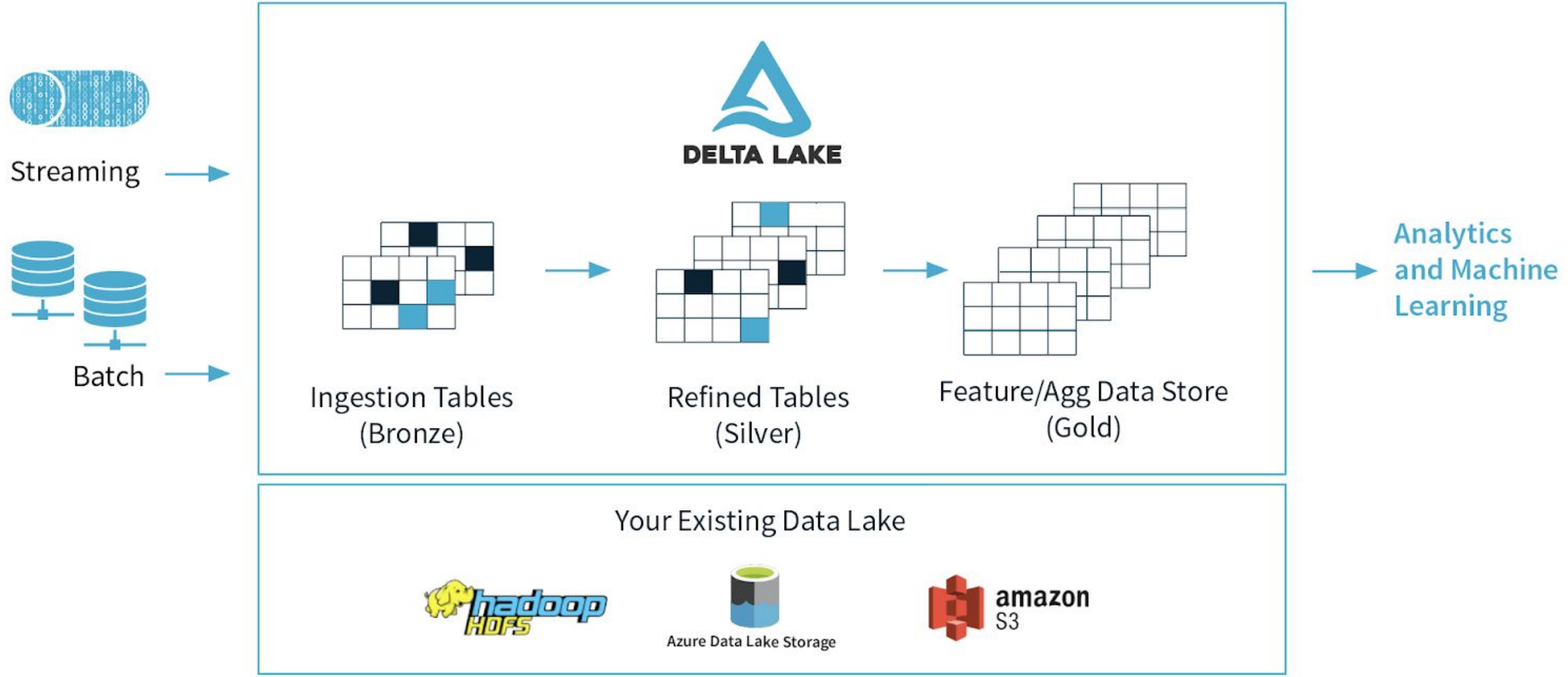
- Can store structured and unstructured data in a variety of formats (Parquet and ORC are popular formats)
- Easy to access without the need of additional data stores
- However, the lack of data governance causes data corruption, inconsistent queries, and overall confusion!

Delta “Lakehouse”



- It is a **structured transaction layer** built on top of a Data Lake
- It enables Data Warehousing features, such as ACID transactions, data versioning, and schema management
- The “Lakehouse” is the Data Warehouse of the modern world, powered by Delta Lake technology

Delta Architecture

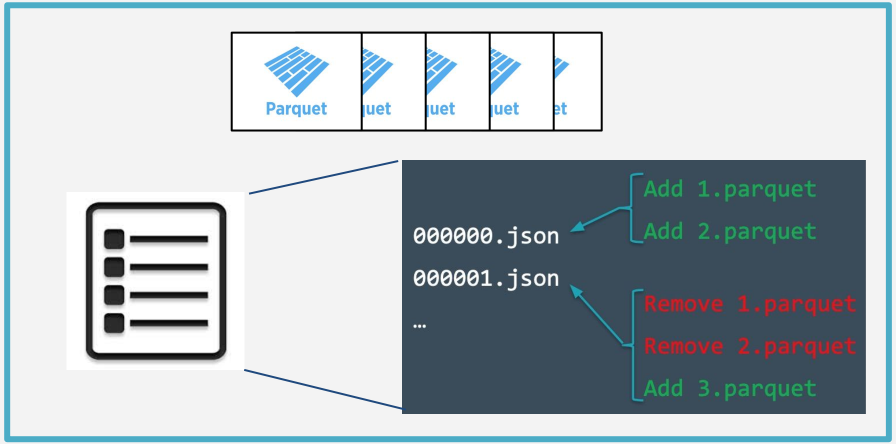


https://databricks.com/blog/2019/08/14/productionizing-machine-learning-with-delta-lake.html

Delta Tables

A **Delta Table** is a collection of data kept using the Delta Lake technology and consists of three things:

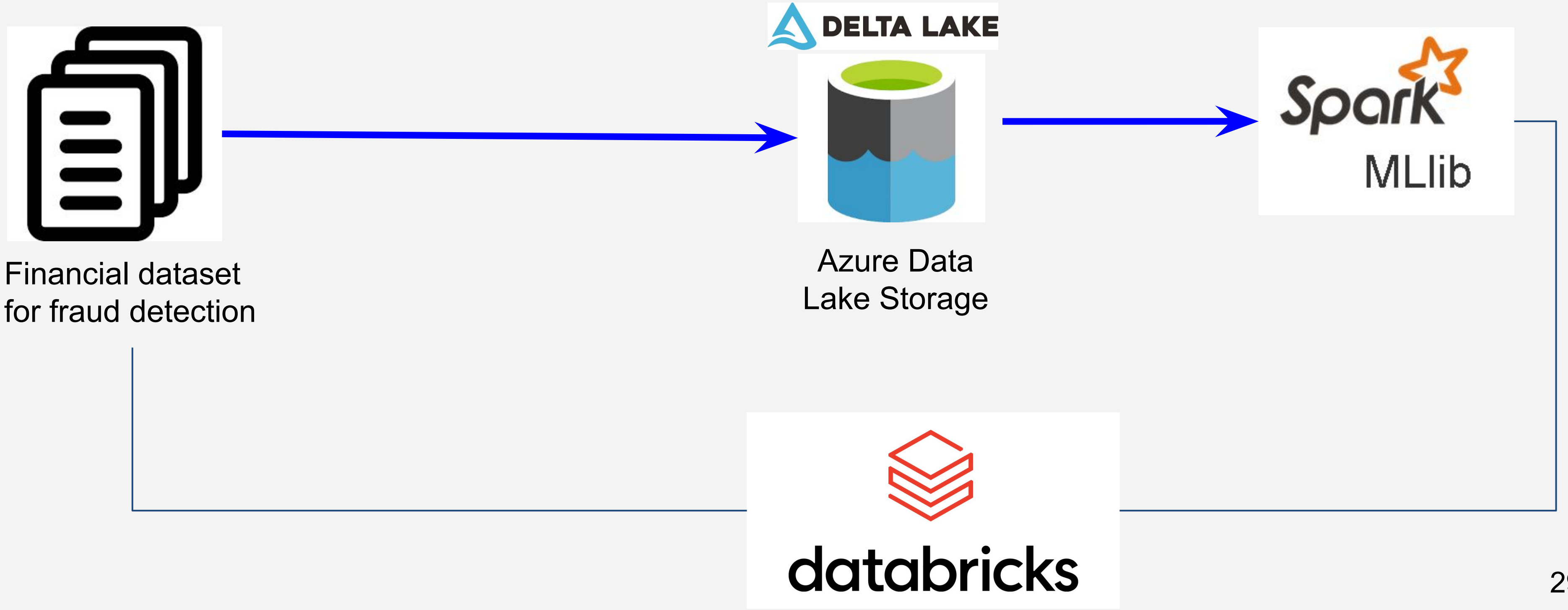
- **Parquet files** containing the data inside object storage
- Delta **transaction log** kept with the Delta files in object storage
- A table registered in the **Metastore**



Exercise: Delta Tables

Exercise in notebook files: **04_Delta_Tables**

Pathway for this workshop



Azure Data Factory

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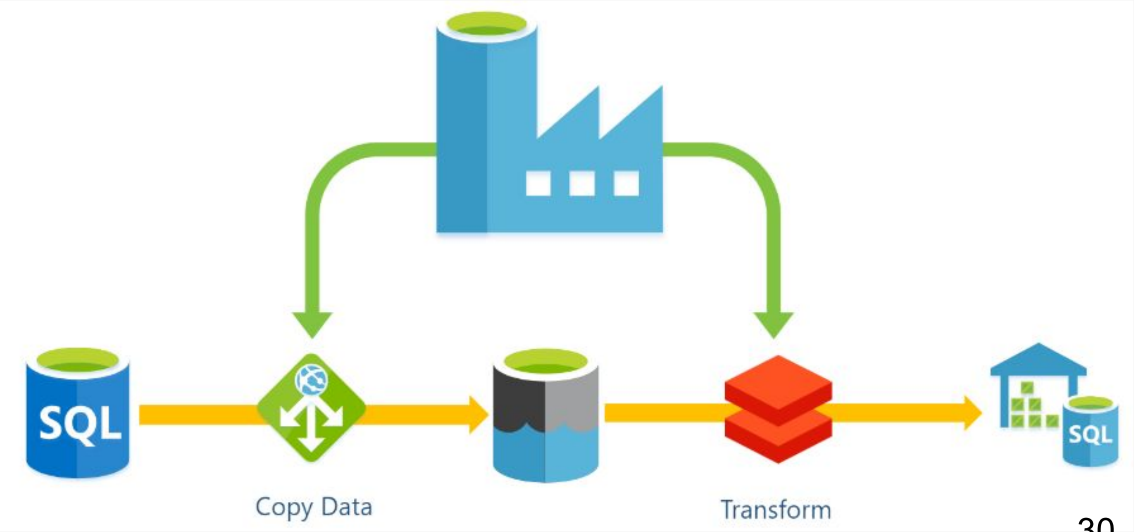
- Azure Data Factory (ADF) is a **serverless, data orchestration** service

- Data pipelines can be managed to run on a schedule, or based on triggers (such as new data arriving)

- ADF can ingest data from multiple sources, transform it, and load it to almost any data store

- ADF can also trigger Databricks notebooks, pass parameters and environment variables



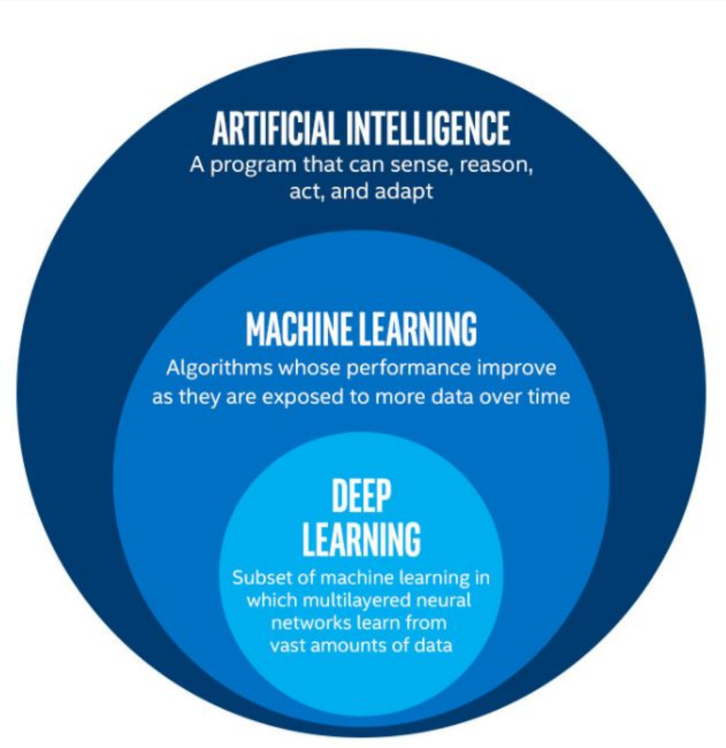
https://github.com/mrpaulandrew/CommunityEvents/blob/master/DataPlatformDiscoveryDay-2020/Slides.pdf

Lunch Break - 30 mins

Spark Machine Learning with Azure Databricks

Machine Learning overview

Machine Learning (ML) is a type of **Artificial Intelligence** (AI) that enables a system to learn from data rather than through explicit programming.



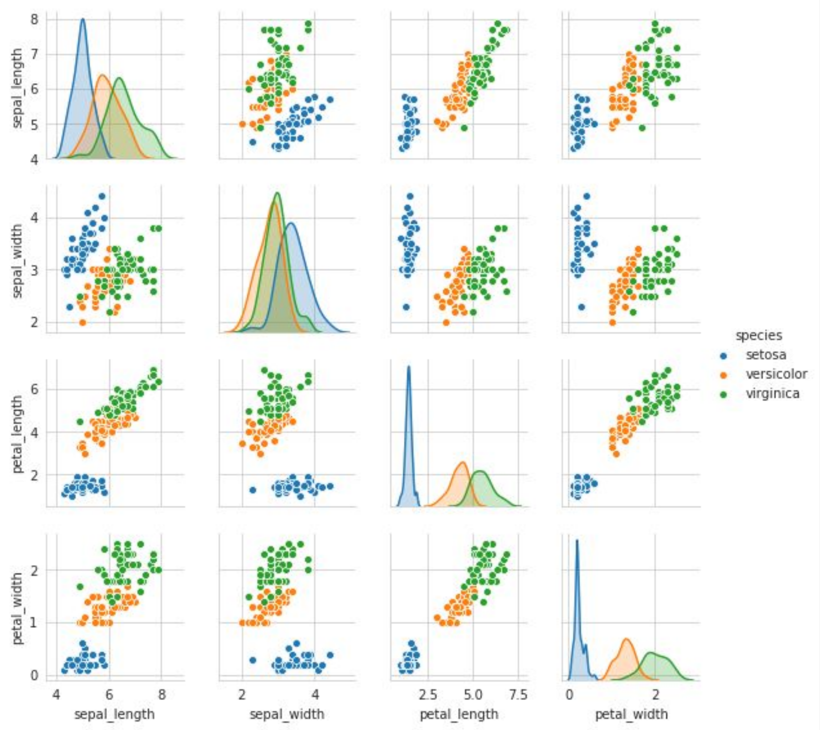
https://www.edureka.co/blog/ai-vs-machine-learning-vs-deep-learning/

Data Exploration

Before we decide which Machine Learning method to use, we need to first understand the data

Data Exploration techniques:

- Data visualization
- Data relationships
- Data cleaning



https://manisha-sirsat.blogspot.com/2019/12/exploratory-data-analysis.html

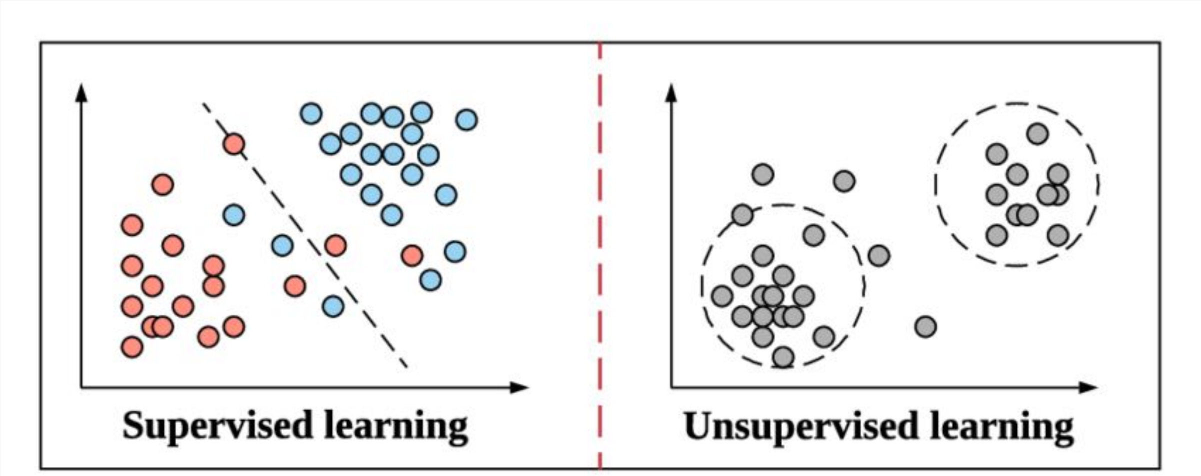
Supervised vs Unsupervised Learning

Supervised learning: Uses a training dataset to learn how to predict a desired output. An iterative process until the prediction error has been sufficiently minimized.

- Examples: Image recognition, fraud detection, predicting sports outcomes

Unsupervised learning: Analyze and cluster vast unlabeled datasets. These algorithms discover hidden patterns or data groupings without the need for human intervention

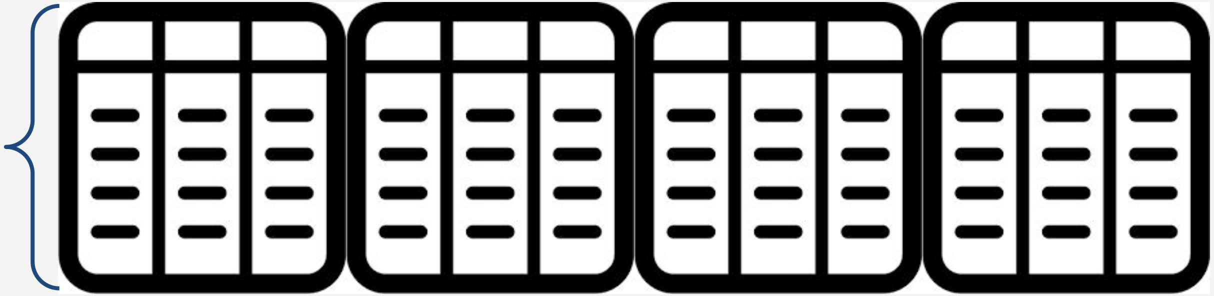
- Examples: clustering, categorize news articles, product recommendations



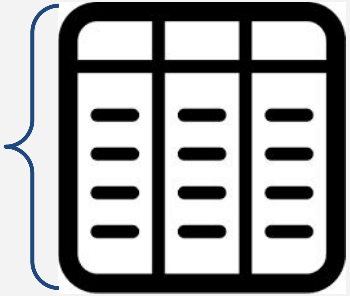
https://www.researchgate.net/figure/Examples-of-Supervised-Learning-Linear-Regression-and-Unsupervised-Learning_fig3_336642133

Train vs Test split

Training Dataset:
A larger portion of the data is used to train the model



Test Dataset:
A smaller portion of the data is used to test the model performance



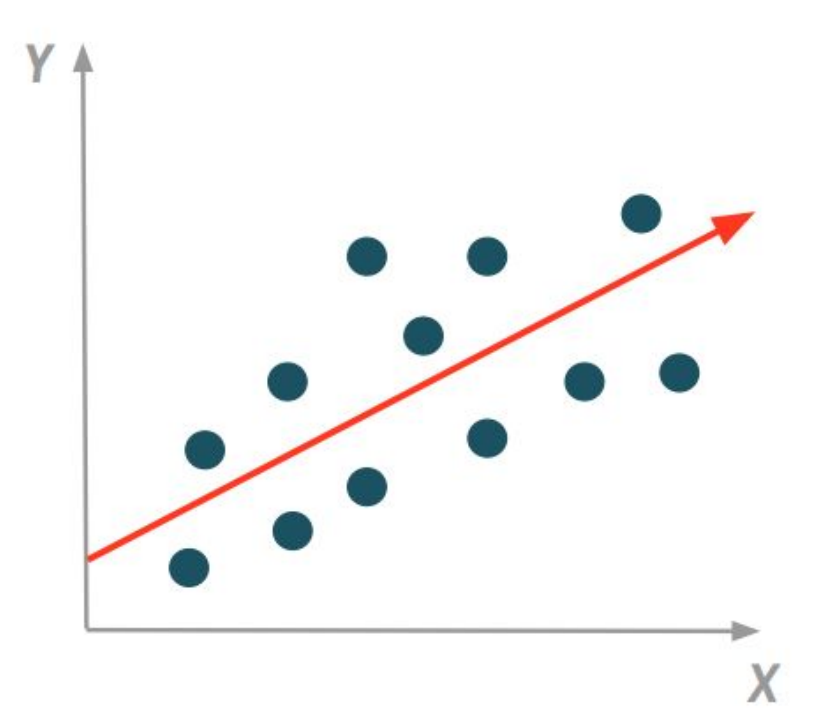
Linear Regression

Goal: find the line of best fit:

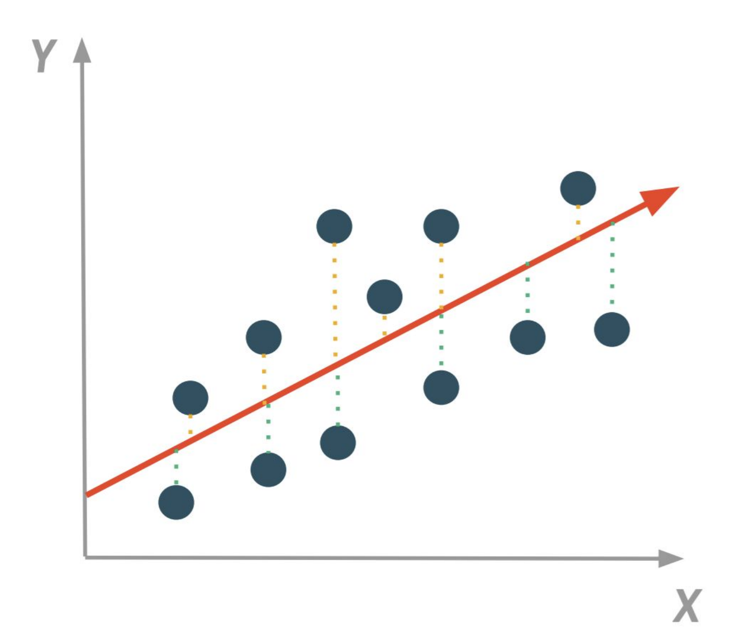
$y = mx + b$

where:

x: a feature (real data, ex: person's height)
y: label (something we want to predict, ex: weight)
b: y-intercept
m: slope of best fit line



Line of Best Fit



Black dots: True values
Green dotted lines: Positive residual
Orange dotted lines: Negative residuals
Red line: Line of best fit

The goal is to draw a line that minimizes the sum of the squared residuals, or Root Mean Squared Error

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(observed_t - predicted_t)^2}$$

Machine Learning Libraries

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Scikit-learn is a popular single-node machine learning library

But what if our data or model gets too big?

Machine Learning in Spark

Scale Out and **Speed Up**

Machine learning in Spark allows us to work with bigger data and train models faster by **distributing the data and computations across multiple workers.**

Spark ML (older version called MLlib)

```
Cmd 1

from pyspark.ml import * #dataframes

from pyspark.mllib import * #RDD's
```

ML API

Based on DataFrames

Supported API (MLlib in maintenance)

Exercise: Linear Regression

Exercise in notebook files:
05_Machine_Learning_Overview

Exercise: Feature Scaling and Pipelines

Exercise in notebook files:
06_Feature_Scaling_And_Pipelines

Platform for the Machine Learning Lifecycle

MLflow core components:

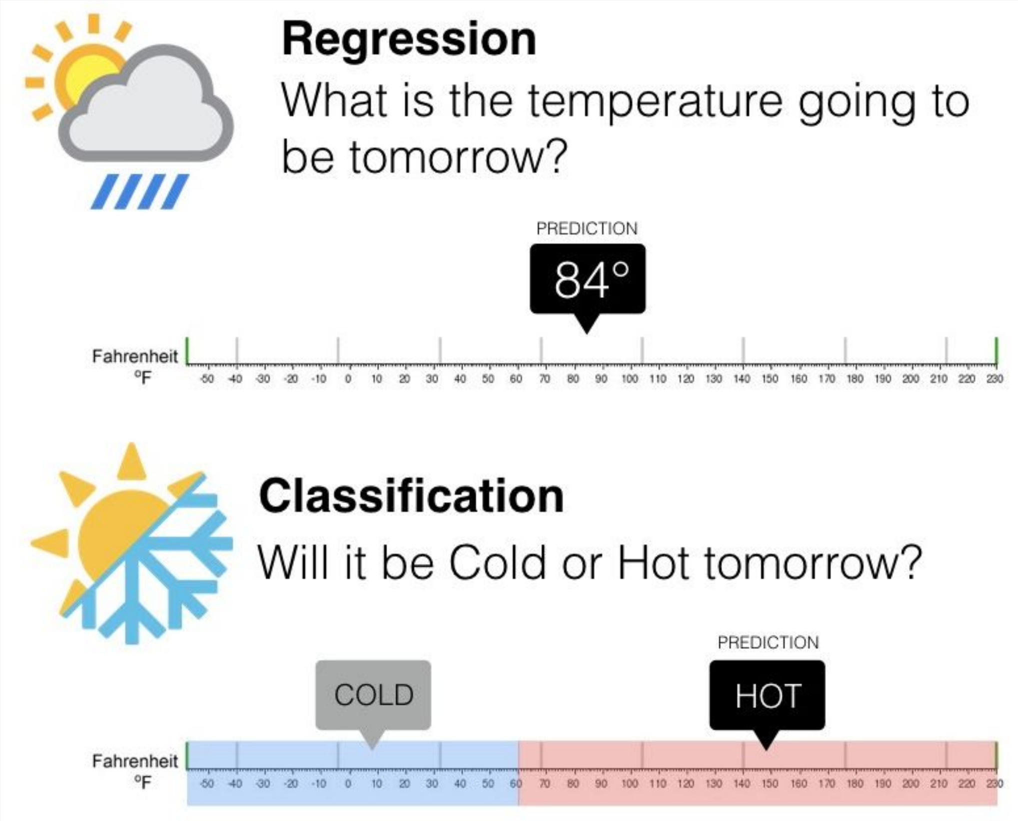
- **Tracking** - logs key parameters, code, and results from multiple model runs
  - intended for experimentation and development
- **Projects** - package code in a consistent reproducible way, including code and all dependencies
- **Models** - package models for later use - such as in a docker container for real time inference
- **Model Registry** - centralized model store, for full model lifecycle, lineage and environment promotion
  - this is where a model goes from development to deployment

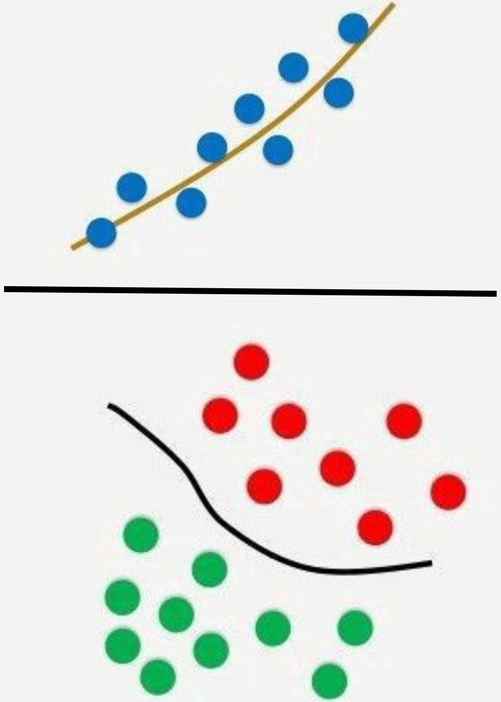
Pre-installed on the Databricks cluster upon creation!

Exercise: MLFlow

Exercise in notebook files:
07_ML_Flow

Regression vs Classification

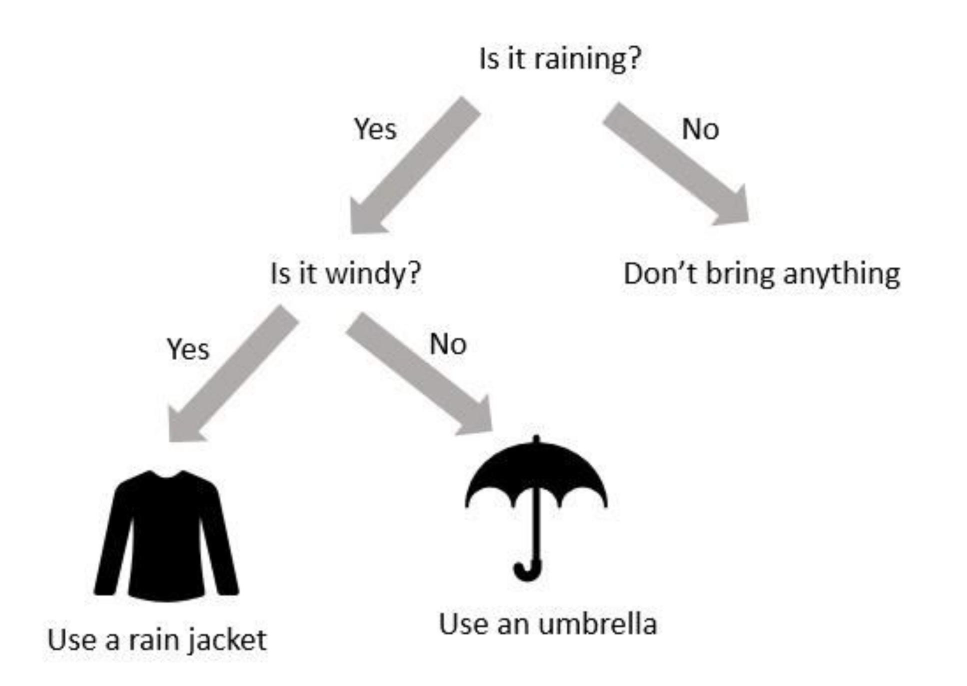




https://towardsdatascience.com/regression-or-classification-linear-or-logistic-f093e8757b9c

Decision Trees

Make a decision based on a set of criteria:



https://medium.com/x8-the-ai-community/decision-trees-an-intuitive-introduction-86c2b39c1a6c

Classification ML - Fraud Detection

Classification: Using ML to predict a class, out of one or many classes

Can no longer use Root Mean Squared Error

In this example we have 100 data points, 1 one which is fraud, 99 which are not fraud

Looks Good To Me! 99% Accuracy

	Actual Fraud	Actually NOT Fraud
Predicted Fraud	0 (True Positive)	0 (False Positive)
Predicted NOT Fraud	1 (False Negative)	99 (True Negative)

Recall And Precision (Subtle difference)

Recall = True Positive / (True Positive + **False Negative**) = 0/(0+1) = 0

Considering actual is positive, how often did we predict positive

Precision = True Positive / (True Positive + **False Positive**) = 0 / 0+0 = undetermined

We can determine it’s not very good

Considering our predicted positives, how often did we predicts positive.

Looks Good To Me! 99% Accuracy

	Actual Fraud	Actually NOT Fraud
Predicted Fraud	0 (True Positive)	0 (False Positive)
Predicted NOT Fraud	1 (False Negative)	99 (True Negative)

Exercise: Classification

Exercise in notebook files:
08_Classification_Fraud_Detection

Koalas - For a Specific Persona

Implementation of the pandas Dataframe API on top of Apache Spark

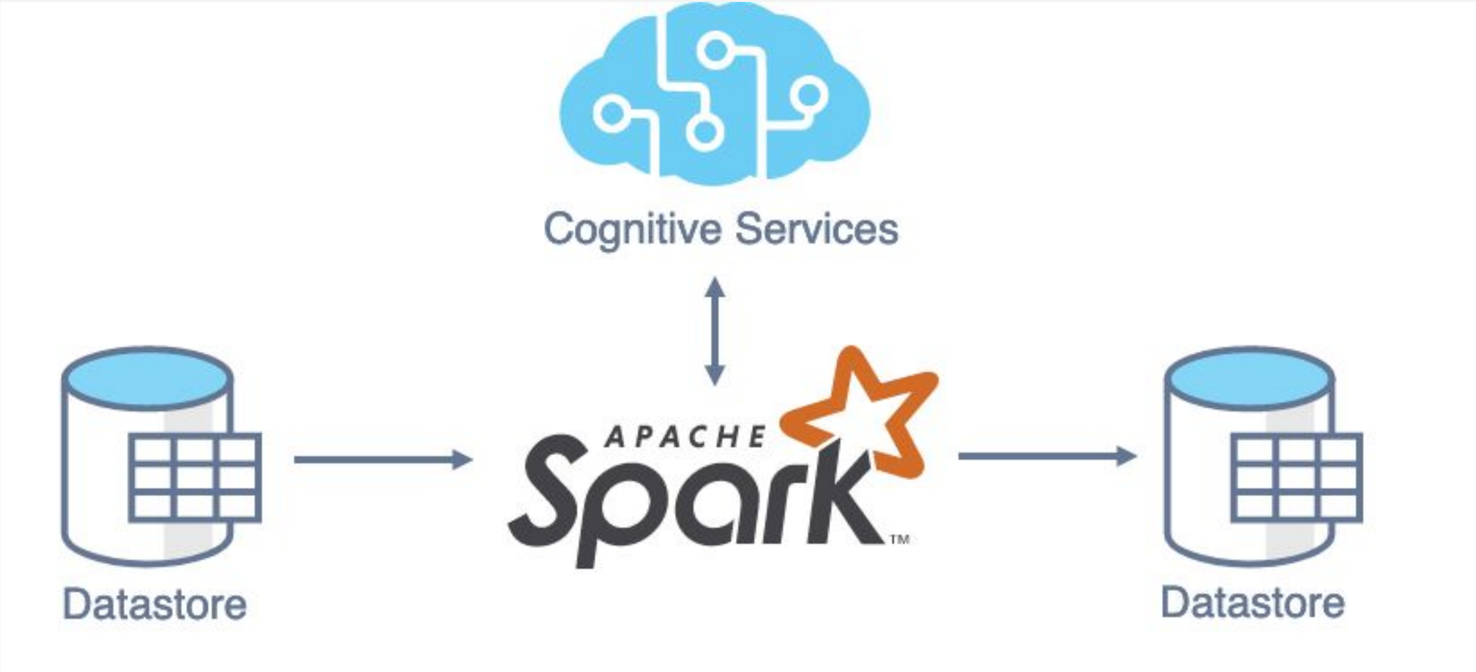
Similar to pandas API not exactly the same, however Koalas is much faster with large data sets

Not quite as performant as Spark ML due to Internal Frame overhead

Smaller Delta to refactor non-performant Pandas ML pipelines to Koalas

Honorable Mention: Cognitive Services

Leverage pre-built AI Services available in Azure



Extra Notebooks Provided

Extra notebook files:

- **01_Update_Delta_Tables**
- **02_Azure_Data_Factory**
- **03_SQL_Database**
- **04_Koalas_API_for_Pandas**

Future Learning With Databricks & Azure

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Databricks Academy : http://academy.databricks.com/catalog

MS Learn: https://docs.microsoft.com/en-us/learn/

databricks

Azure

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WE LOVE WORKING WITH PEOPLE
WHO WANT TO BE INNOVATIVE

Extra Slides

Honorable Mention: Azure DevOps

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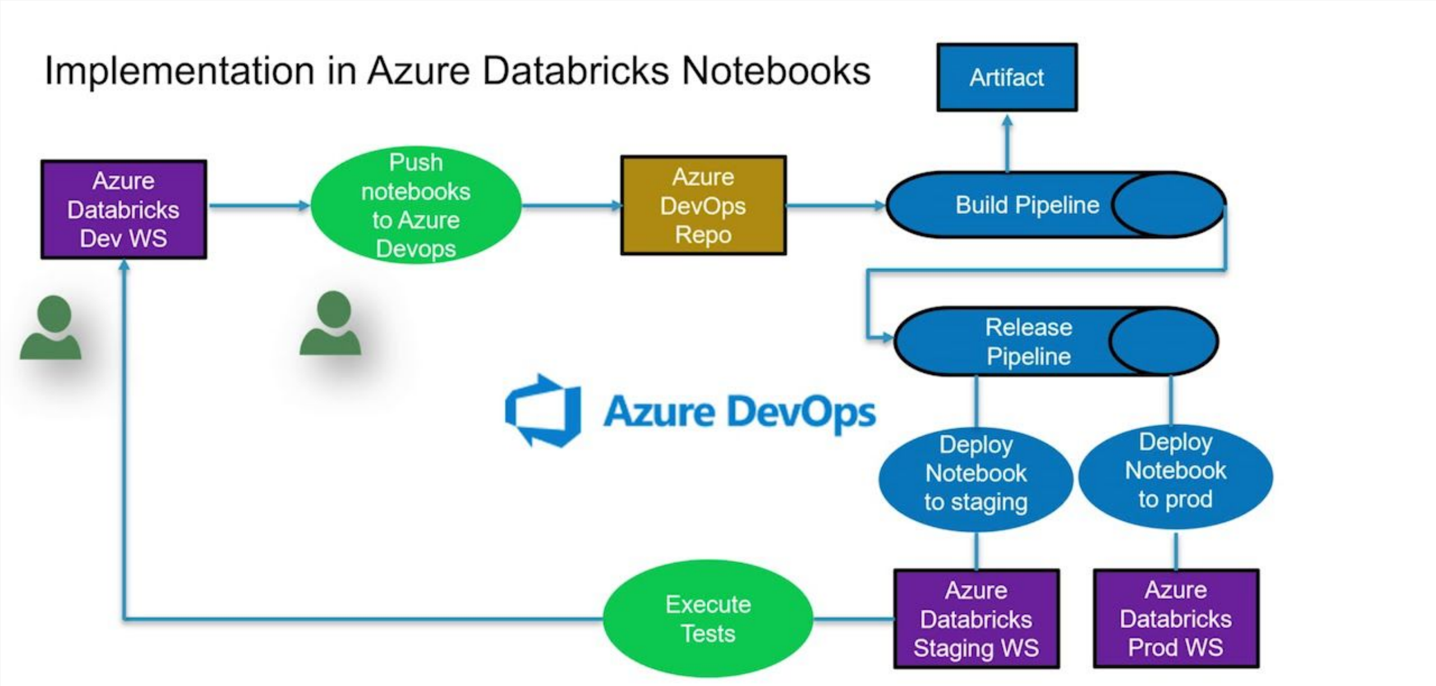
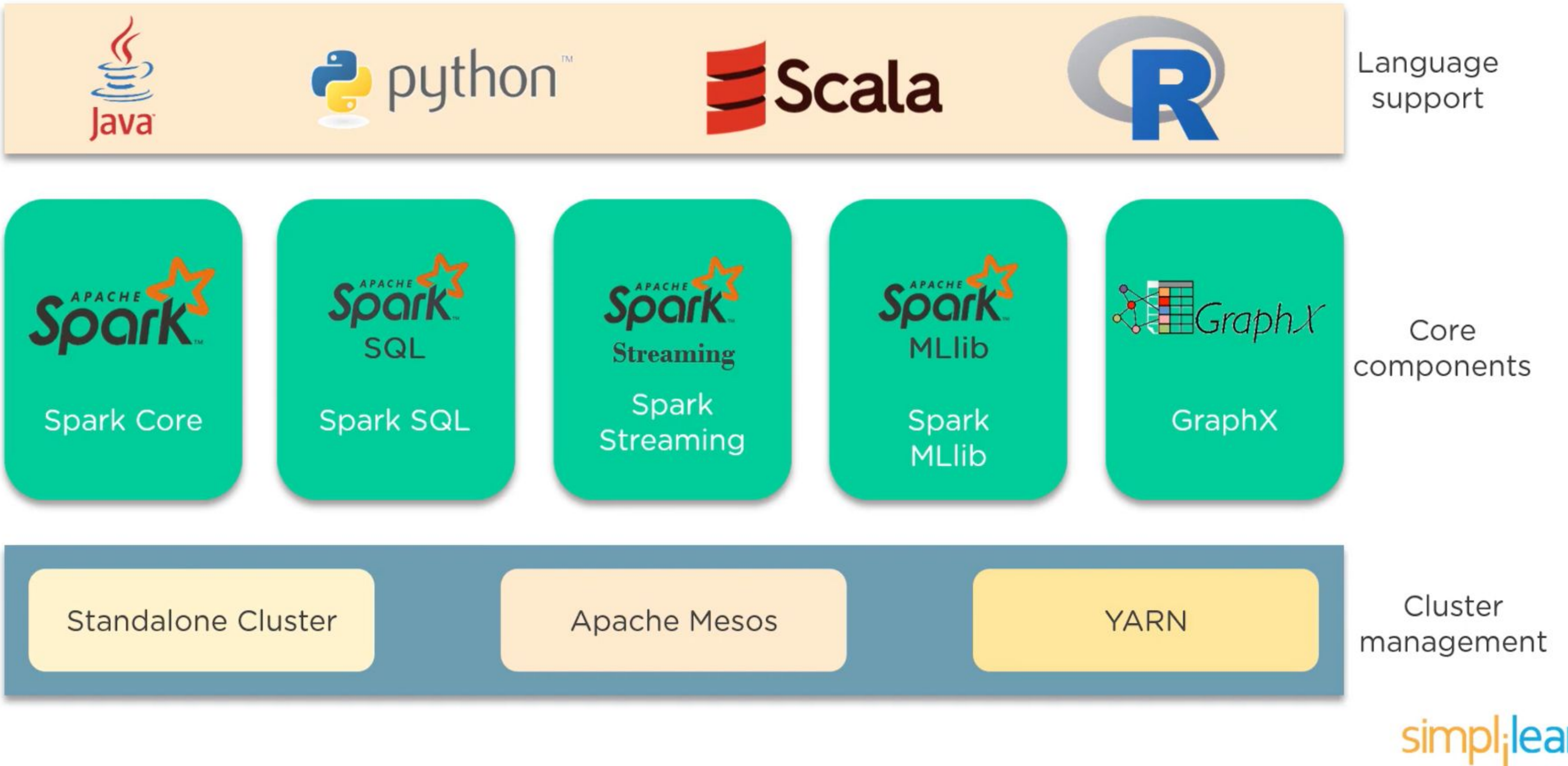
In a production environment, you can connect your Databricks workspace to an Azure DevOps repo, and implement an automated release pipeline to test and deploy updates to your Databrick notebooks.



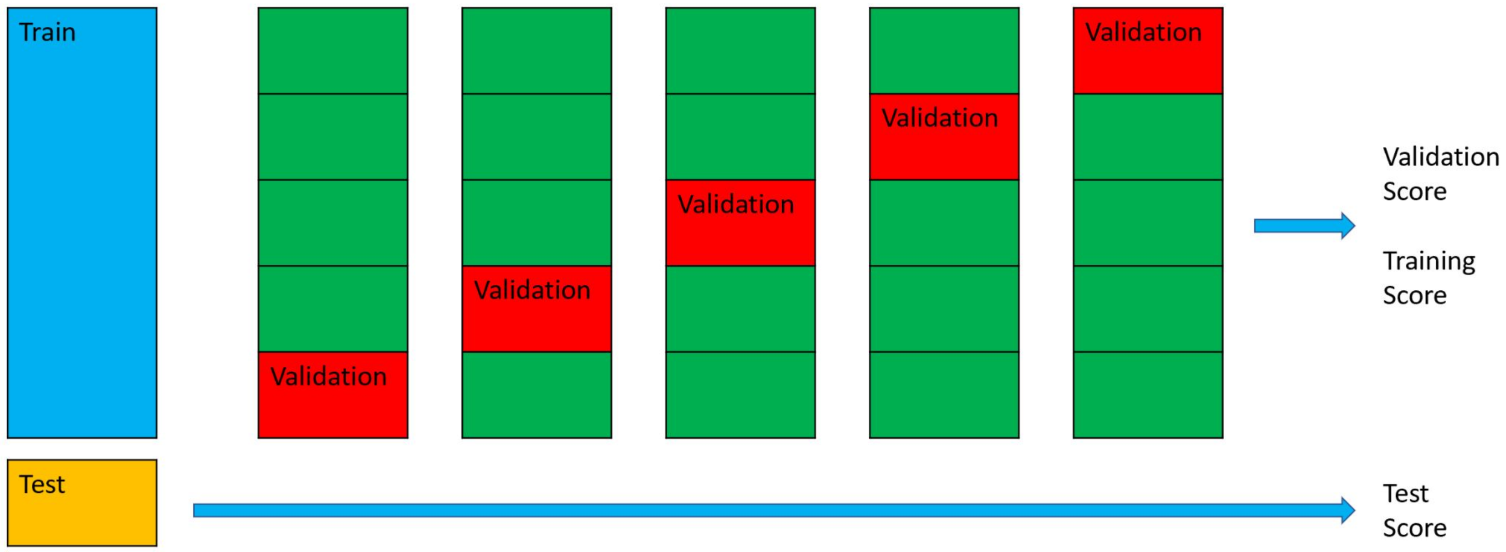
https://databricks.com/session/devops-for-applications-in-azure-databricks-creating-continuous-integration-pipelines-on-azure-using-azure-databricks-and-azure-devops

Components of the Spark Ecosystem (Source: SimpliLearn)



Cross Validation

- Split the training dataset into smaller chunks
- Iterate through the chunks, each time leaving one out for the model training
  - Use the validation set to calculate the error of each iteration
- The optimal model parameters are the ones with the lowest average validation error



https://medium.com/analytics-vidhya/training-validation-and-test-set-in-machine-learning-7fab555c1080