Azure Databricks Mastery:

Hands-on project

with

Unity Catalog, Delta Lake, Medallion Architecture

Azure Databricks Free notes

Azure Databricks end to end project with Unity Catalog

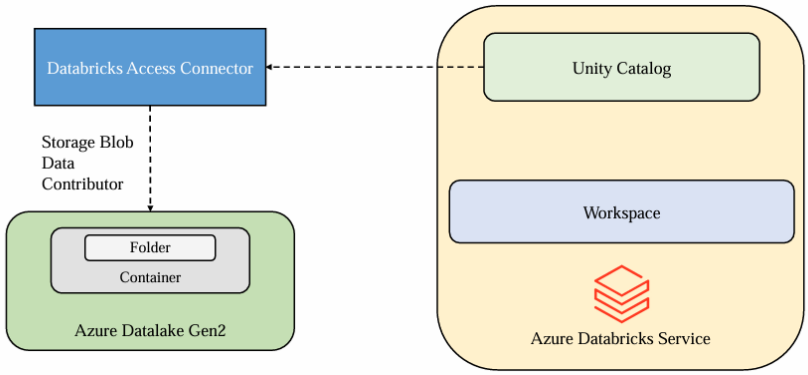
Azure Databricks Mastery: Hands-on project with Unity Catalog, Delta lake, Medallion Architecture

Day 1: Create DataBricks resource using Azure Portal

Environment Setup: Login to your Azure Portal

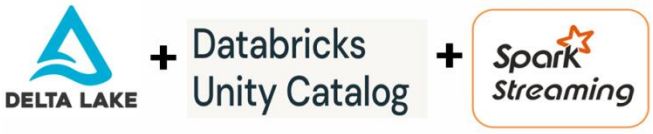
Step 1: Creating a budget for project: search and type budget, "ADD" on Cost Management, "Add Filter" in "Create budget", select Service Name: Azure Databricks in drop down menu.

Step 2: Set alerts as well in next step. Finally click on "Create".



Step 3: Create a Databricks resource, for "pricing tier", click here for more details: https://azure.microsoft.com/en-us/pricing/details/databricks/

Hence select for Premium (+ Role based access controls), skip "Managed Resource Group Name", not any changes required in "Networking", "Encryption", "Security", "Tags" also.



Continuous Integration + Continuous Deployment

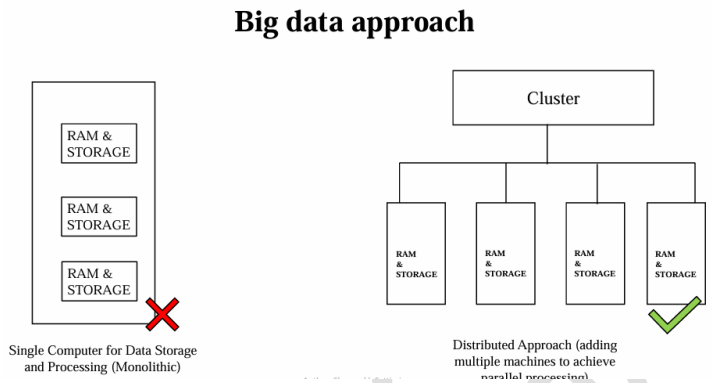
Step 4: Create a "Storage Account" from "Microsoft Vendor", select "Resource Group" as previous one, "Primary Service" as "ADLS Gen 2", select "Performance" as "standard", "Redundancy" as "LRS", not any changes required in "Networking", "Encryption", "Security", "Tags" also.

Step 5: Walkthough on databricks Workspace UI: click on "Launch Workspace" or go through URL: looks like https://_____azuredatbricks.net, Databricks keep updating UI, click on "New" for "Repo"

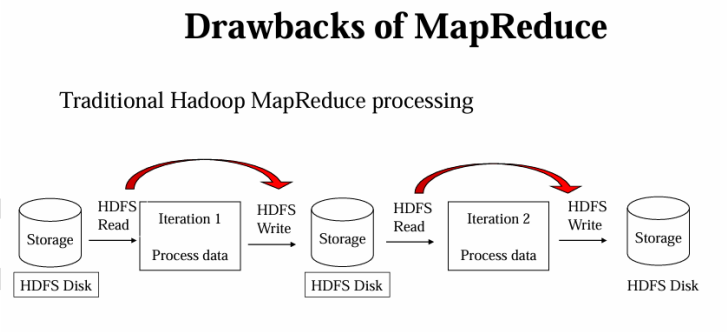
as CI/CD, “Add data” in “New”, “Workflow” are just like Pipeline at high level, “Search” bar for searching also.

- **Databricks admin types: https://learn.microsoft.com/en-us/azure/databricks/admin/**

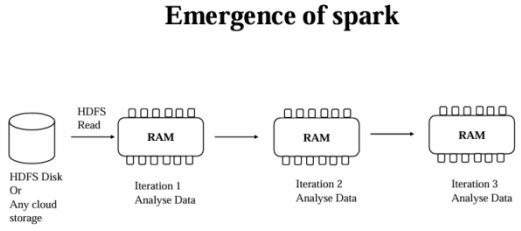
Theory 1: What is Big Data approach?: Monolithic is used for Single Computer and distributed Approach using Cluster which is group of computers.



Theory 2: Drawbacks of MapReduce: In HDFS, in the each iteration, Read and Write operation from disk which will take place high I/O disk costs, developer also have to write complex program, Hadoop is only single super Computer.



Theory 3: Emergence of Spark: First it uses HDFS or Any cloud Storage then further process takes place in RAM, it uses in-memory process which is 10-100 times faster than Disk based application, here database is detached from memory and process aloof.



Theory 4: Apache Spark: it is an in-memory application framework.

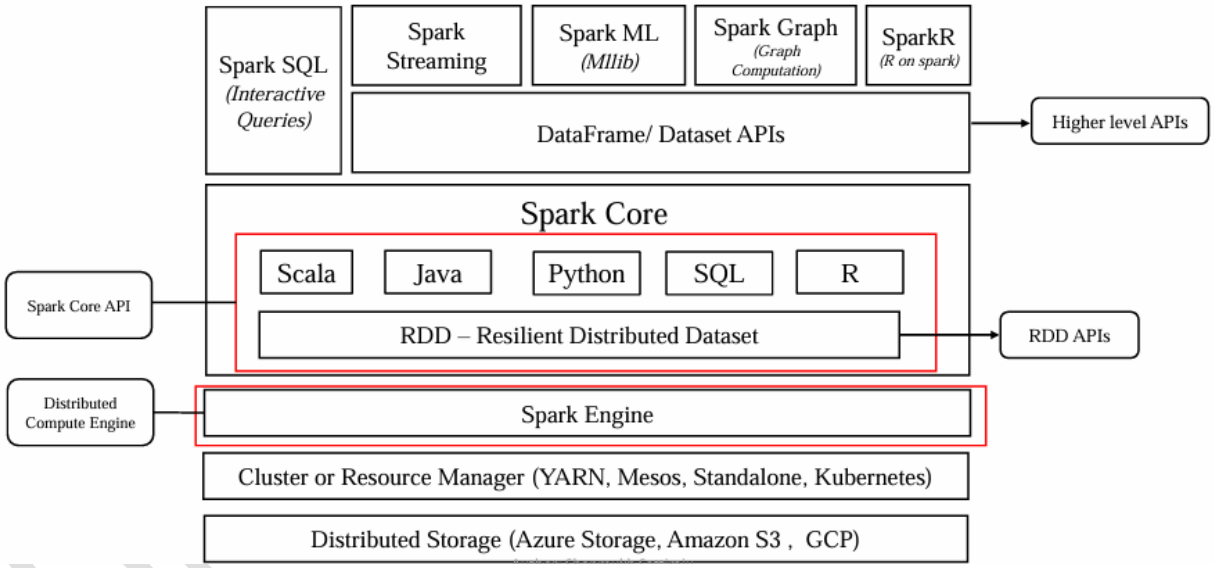
Apache Spark

Apache Spark is an **open** source **in-memory** application framework for **distributed data processing** and iterative analysis on massive data volumes

In simple terms, Spark is a
- Compute Engine
- Unified data processing System

Theory 5: Apche Spark Ecosystem: Spark Core, special data structure RDD, this is collection of items distributed across the compute nodes in the cluster, these will be processed in parallel, but RDDs are difficult to use for complex operations and they are difficult to optimize , now we are making use of Higher level APIs and libraries like Data Frames and Data Set APIs. Also, uses other high level APIs like Spark SQL, Spark Streaming, Spark ML etc.

Apache Spark Ecosystem



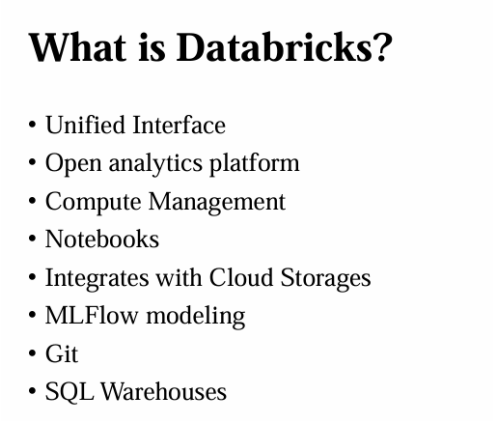
In the real time, we do not use RDD but higher level APIs to do our programming or coding, data frame APIs to interact with spark and these data frames can be invoked using any languages like Java, Python, SQL or R and internally spark has two parts: set of core APIs, and the Spark Engine: this distributed Computing engine is responsible for all functionalities, there is an OS which will manage this group of computers (cluster) is called Cluster Manager, In Spark, there are many Cluster Managers in which you can use like YARN Resource Manager or Resource standalone, Mesos or Kubernetes.

So, Spark is a distributed data processing solution not a storage system, Spark does not come with storage system, can be used like Amazon S3, Azure Storage or GCP.

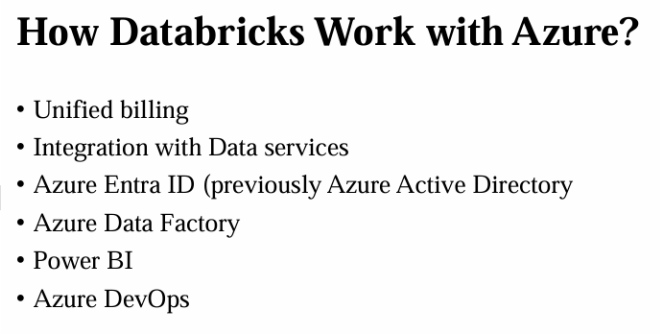
We have Spark Context, which is Spark Engine, to break down the task and scheduling the task for parallel execution.

So, what is Databricks? The founders of the Spark developed a commercial product and this is called Databricks to work with Apache Spark in more efficient way, Databricks is available on Azure, GCP and AWS also.

Theory 6: What is Databricks?: DB is a way to interact with Spark, to set up our own clusters, manage the security, and use the network to write the code. It provides single interface where you can manage data engineering, data science and data analyst workloads.

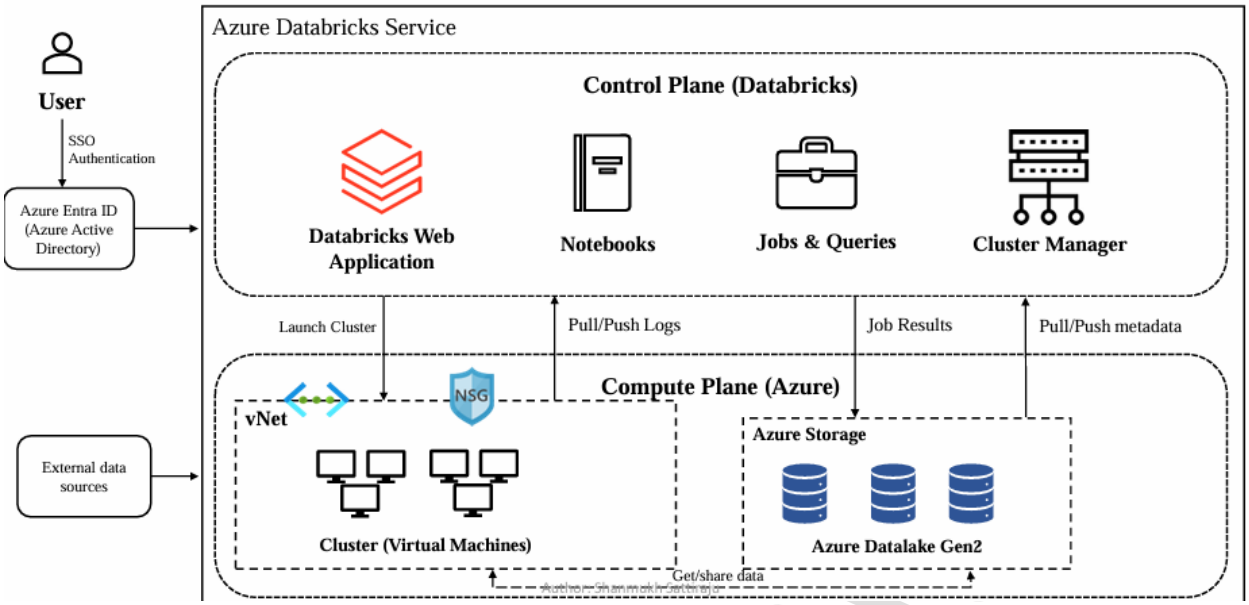


Theory 7: How Databricks Works with Azure? DB can integrate with data services like Blod storage, Data Lake Storage and SQL Database and security Entra ID, Data Factory, Power BI and Azure DevOps.



Theory 8: Azure Databricks Architecture: Control plane is taken care by DB and Compute Plane is taken care by Azure.

Azure Databricks Architecture



Theory 9: Cluster Types: All purpose Cluster and Job cluster. Multi-node cluster is not available in Azure Free subscription because it's allowed to use only maximum of four CPU cores.

Azure Databricks Compute

- Cluster is a set of computation resources and configurations to run your workloads
- Workloads can be:
  1. Set of commands in a notebook
  2. A job that you run as a automated workflow
- Cluster types:
  1. **All purpose Cluster**
     - To execute set of commands in a notebook
  2. **Job Cluster**
     - To execute a job that you run as a automated workflow

In DB workspace: (inside Azure Portal), "create cluster", select "Multi-node": Driver node and worker node are at different machines. In "Access mode", if you will select "No isolation shared" then "Unity Catalogue" is not available. Always uncheck "Use Photon Acceleration" which will reduce your DBU/h, can be seen from "Summary" pane at right top.

Cluster Types

1. **All purpose Cluster**
   - To interactively run the commands in your notebook
   - Multiple users can share such clusters to do collaborative interactive analysis.
   - You can terminate, restart, attach , detach these clusters to multiple notebooks
   - You can choose
     - Multi-node cluster = Driver node and executor nodes will be on separate machine
     - Single node cluster = Only there will be a single driver node with single machine
2. **Job Cluster**
   - To run a job that you run as a automated workflow
   - It runs a new job cluster and terminates the cluster automatically when the job is complete.
   - You cannot restart a job cluster.

Theory 10: Behind the scenes when creating cluster: click on "Databricks" instance in Azure portal before clicking on Databricks "Launch Workspace", there is "Managed Resource Group": open this link; there is a Virtual network and Network security group and Storage account.

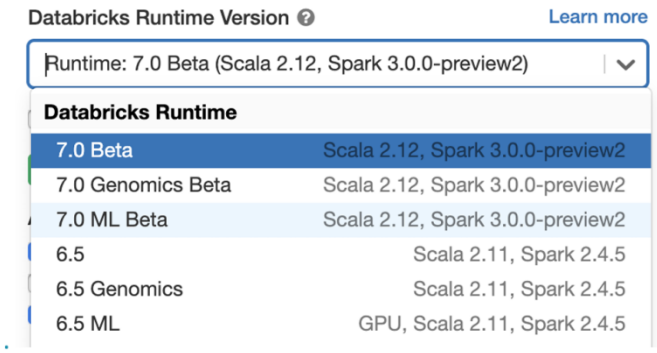
Cluster Access modes

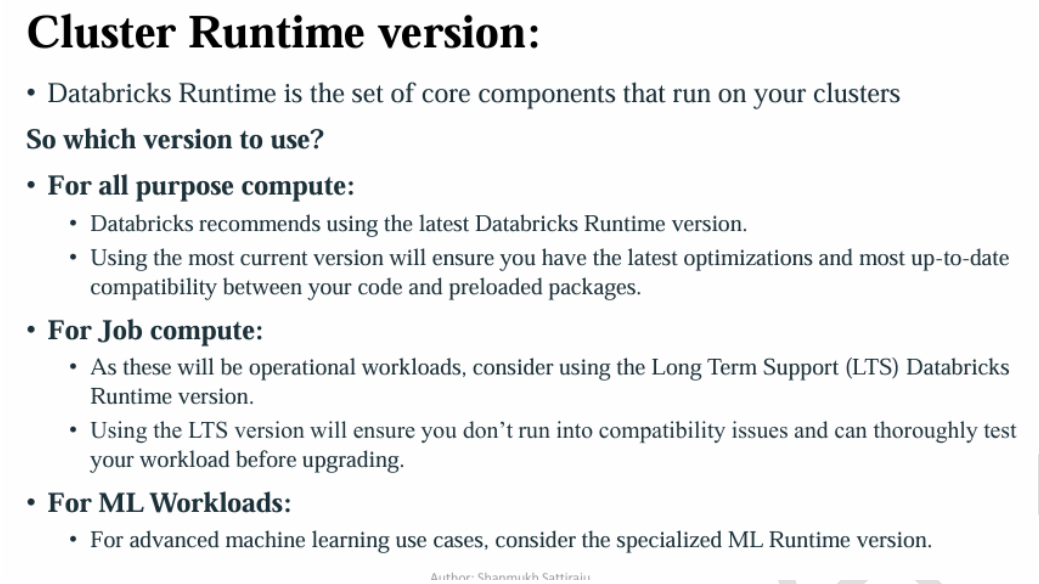
Access Mode	Visible to user	UC Support	Supported Languages	Notes
Single user	Always	Yes	Python, SQL, Scala, R	Can be assigned to and used by a single user.
Shared	Always (**Premium plan or above required**)	Yes	1. Python (on Databricks Runtime 11.1 and above), 2. SQL, 3. Scala (on Unity Catalog-enabled clusters using Databricks Runtime 13.3 and above)	Can be used by multiple users with data isolation among users.
No Isolation Shared	Yes, Admins can hide this cluster type by enforcing user isolation in the admin settings page.	No	Python, SQL, Scala, R	There is a related account-level setting for No Isolation Shared clusters.

This Storage account is going to store Meta Data of it, we will see Virtual Machine, when we will create any compute Resource, now go to Databricks workspace, create any compute resource and then come back here, will find some disks, Public IP address and VM. For all these, we will be charged as DBU/h.

Question: What is Databricks Runtime?

The set of core components that run on the clusters managed by Databricks. Consists of the underlying Ubuntu OS, pre-installed languages and libraries (Java, Scala, Python, and R), Apache Spark, and various proprietary Databricks modules (e.g. DBIO, Databricks Serverless, etc.). Azure Databricks offers several types of runtimes and several versions of those runtime types in the Databricks Runtime Version drop-down when you create or edit a cluster.





Question: What are the types of Databricks Runtimes?

There are major 4 types of Databricks Runtimes.

a) Databricks Runtime for Standard
b) Databricks Runtime for Machine Learning
c) Databricks Runtime for Genomics
d) Databricks Light

Databricks Runtime for Standard

Databricks Runtime includes Apache Spark but also adds a number of components and updates that substantially improve the usability, performance, and security of big data analytics.

Databricks Runtime for Machine Learning

Databricks Runtime ML is a variant of Databricks Runtime that adds multiple popular machine learning libraries, including TensorFlow, Keras, PyTorch, and XGBoost. ML also supports additional GPU supporting libraries clusters. Graphics processing Units Speeding up Machine Learning models. GPUs can drastically lower the cost because they support efficient parallel computation.

Databricks Runtime for Genomics

Databricks Runtime for Genomics is a variant of Databricks Runtime optimized for working with genomic and biomedical data.

Databricks Light

Databricks Light provides a runtime option for jobs that don't need the advanced performance, reliability, or autoscaling benefits provided by Databricks Runtime.

Databricks Light does not support:

- Delta Lake

- Autopilot features such as autoscaling
- Highly concurrent, all-purpose clusters
- Notebooks, dashboards, and collaboration features
- Connectors to various data sources and BI tools

Cluster policies (in Unity Catalog)

- Policies are a set of rules configured by admins
- These are used to limit the configuration options available to users when they create a cluster
- Policies have access control lists that regulate which users and groups have access to the policies.
- Any user with unrestricted policy can create any type of cluster

Stop our compute resource, nothing is deleted in Azure portal, but when we will click on Virtual Machine, then that will show not "start". But if you delete compute resource from Databricks workspace, check your Azure portal again, will find all resources i.e. disks, Public IP address and VM etc are deleted.

Day 2: Understanding notebook and Markdown basics : Hands-on

Note: this part can be executed in Databricks Community edition, not necessarily to be run in Azure Databricks resource

```
%md
### Heading 3
#### Heading 4
##### Heading 5
###### Heading 6

####### Heading 7
-----------------------------------------------------------
%md
# This is a comment
-----------------------------------------------------------

%md

1. HTML Style <b> Blod </b>
2. Astricks style **Blod**
-----------------------------------------------------------

%md

*Italics* style
-----------------------------------------------------------

%md

`print(df)` is the statement to print something

```
This
is multiline
```
```

code
```

---

%md

- one
- two
- three
---

%md
To highlight something

<span style="background-color: #FFFF00"> Highlight this </span>
---

%md
![Profile Pic](https://media.licdn.com/dms/image/C4E03AQGx8W5WMxE5pw/profile-displayphoto-shrink_400_400/0/1594735450010?e=1705536000&v=beta&t=_he0R75U4AKYCbcLgDRDakzKvYZybksWRoqYvDL-alA)
---

%md
Click on [Profile Pic](https://media.licdn.com/dms/image/C4E03AQGx8W5WMxE5pw/profile-displayphoto-shrink_400_400/0/1594735450010?e=1705536000&v=beta&t=_he0R75U4AKYCbcLgDRDakzKvYZybksWRoqYvDL-alA)

# Day 3: DataBricks in Notebook - Magic Commands : Hands-on

**Magic commands in Databricks: if any SQL command is to be executed then select 'SQL'.**

**Note: this part can be executed in Databricks Community edition, not necessarily to be run in Azure Databricks resource**

**1. Select 'Python' from top and type**
**print('hello')**
**#Comments**
**Default language is Python**
---

## Magic commands

- You can use multiple languages in one notebook
- You need to specify language magic command at the beginning of a cell.
- By default, the entire notebook will work on the language that you choose at the top

| Magic command | Language | Description |
|---|---|---|
| %python | Python | Execute a Python query against Spark Context. |
| %scala | Scala | Execute a Scala query against Spark Context. |
| %sql | Spark SQL | Execute a SparkSQL query against Spark Context. |
| %r | R | Execute a R query against Spark Context. |

**2. %scala**
**print("hello") will work and also #comments will also not work.**
**For comments in Scala use //Comments**
---

**3. Comments in SQL -- Comments**
**now in %sql**
**select 2+5 as sum**
```

4. in %r
x <-"Hello"
print(x)
---

5. There are much more magic commands in DB.
%fs ls
List all things in all the directories inside DBFS ie Databricks File System.

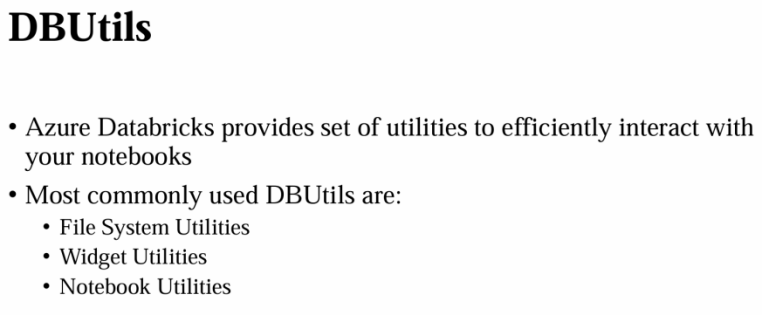
---

6. Know all the Magic commands available:
type:
%lsmagic
---

7. Summary of Magic commands: You can use multiple languages in one notebook and you need to specify language magic commands at the beginning of a cell. By default, the entire notebook will work on the language that you choose at the top.

DBUtils:

 # DBUtils: Azure Databricks provides set of utilities to efficiently interact with your notebook.
Most commonly used DBUtils are:
1. File System Uttilities
2. Widget Utilities
3. Notebook Utilities



---

1. What are the availble utilities?
 # just type:
dbutils.help()

 # 2. Lets see File System Utilities
%md
 # File System Utilities
 # click new cell:
 # type:
dbutils.fs.help()

Ls utility

 # what are available list in particular directory: Enable DBFS, click on "Admin setting" from right top, click on "Workspace Settings",
 # scroll down, enable 'DBFS File Browser', now you can see 'DBFS' tab, after clicking on 'DBFS' tab, some set on folders are there,
You will find "FileStore" in left pane in "Catalog" button, somewhere, copy path from "spark API format",
path = 'dbfs:/FileStore'

```
dbutils.fs.ls(path)

# why ls, see just above from dbutils.fs.help() details.
```


```
---------------------------------------------------------------

# remove any directory:
# just copy following addres from above:such as FileInfo(path='dbfs:/FileStore/temp/', name='temp/', size=0, modificationTime=0)
dbutils.fs.rm('dbfs:/FileStore/CopiedFolder/',True)

# True is added bcs if this file is not exisiting than it will just reply 'True'
# just check directory list again, that file has been removed.
dbutils.fs.ls(path)

---------------------------------------------------------------

#### mkdir

# why heading are important bcs, left side "Table of Contents" are there, which showing all the headings

dbutils.fs.mkdirs(path+'/SachinFileTest/')

---------------------------------------------------------------

# list all files so that we can see newly created directory is there or not?
dbutils.fs.ls(path)

### put: Inside a folder lets put something,

dbutils.fs.put(path+ '/SachinFileTest/test.csv','1, Test')
---------------------------------------------------------------


# also check using manual "DBFS" tab
### head : read the file conten, which we just written,
filepath = path+ '/SachinFileTest/test.csv'
dbutils.fs.head(filepath)

dbutils.fs.head("/Volumes/main/default/my-volume/data.csv", 25)
This example displays the first 25 bytes of the file data.csv located in /Volumes/main/default/my-volume/.
---------------------------------------------------------------

### Copy: Move this newly created file from one location to another
source_path = path+ '/SachinFileTest/test.csv'
destination_path = path+ '/CopiedFolder/test.csv'
dbutils.fs.cp(source_path,destination_path,True)

---------------------------------------------------------------

# display content from recently pasted values
dbutils.fs.head(destination_path)
---------------------------------------------------------------


# same activity can be done by right click of that file *.csv
# with "Copy path", "Move", "Rename", "Delete"

---------------------------------------------------------------

# Move is cut and paste/move
# copy is just copy and paste

source_path = path+ '/FileTest/test.csv'
destination_path = path+ '/MovedFolder/test.csv'
dbutils.fs.mv(source_path,destination_path,True)
---------------------------------------------------------------
```


```
# remove folder
dbutils.fs.rm(path+ '/MovedFolder/',True)
dbutils.fs.help()
```

Day 4: DBUitls -Widget Utilities : Hands-on

Note: this part can be executed in Databricks Community edition, not necessarily to be run in Azure Databricks resource

Why Widgets: Widgets are helpful to parameterize the Notebook, imagine, in real world you are working in heterogeneous environment, either in DEV env, Test env or Production env, to change everywhere, just parameterize the notebook, instead of hard coding the values everywhere.

Details: Coding:

```
# what are vailavle tools, just type:
dbutils.widgets.help()
```

```
%md
## Widget Utilities
```

```
%md
## Let's start with combo Box
### Combo Box
dbutils.widgets.combobox(name='combobox_name',defaultValue='Employee',choices=['Employee','Developer','Tester','Manager'],label="Combobox Label ")
```

```
# Extract the value from "Combobox Label"
emp=dbutils.widgets.get('combobox_name')

# dbutils.widgets.get retrieves the current value of a widget, allowing you to use the value in your Spark jobs or SQL Queries.

print(emp)
type(emp)
```

```
# DropDown Menu
dbutils.widgets.dropdown(name='dropdown_name',defaultValue='Employee',choices=['Employee','Developer','Tester','Manager'],label="Dropdown Label")
```

```
# Multiselect
dbutils.widgets.multiselect(name='Multiselect_name',defaultValue='Employee',choices=['Employee','Developer','Tester','Manager'],label="MultiSelect Label")
```

```
# Text
dbutils.widgets.text(name='text_name',defaultValue='',label="Text Label")
```

```
dbutils.widgets.get('text_name')
# dbutils.widgets.get retrieves the current value of a widget, allowing you to use the value in your Spark jobs or SQL Queries.
```

```
result = dbutils.widgets.get('text_name')
print(f"SELECT * FROM Schema.Table WHERE Year = {result}")
```

```
# go to Widget setting from right, change setting to "On Widget change"--> "Run notebook", now entire notebook is getting executed

print('execute theseeeSachin ')
```

Day 5: DBUtils - Notebook Utils : Hands-on

Note: this part can be executed in Azure Databricks resource, not in Databricks Community edition, otherwise it will give like: To enable notebook workflows, please upgrade your Databricks subscription.

Create a compute resource with Policy: "Unrestricted", "Single node", uncheck "Use Photon Acceleration", select least node type,

Now go to Workspace-> Users-> your email id will be displayed, add notebook from right, click on "notebook" rename as

Notebook 1: "Day 5: Part 1: DBUtils Notebook Utils: Child"

```
dbutils.notebook.help()
-------------------------
a = 10
b = 20
-------------------------

c = a + b
-------------------------
print(c)
-------------------------
# And I'm going to use the exit here. So basically what exit will do is it is going to execute all the commands before that. And it is going to come here. And if ever there is an exit command, it is going to stop executing the notebook at that particular point and it is going to return the value, whatever you are going to enter here.
dbutils.notebook.exit(f'Notebook Executed Successfully and returned {c}')

# We are going to access this notebook in another Notebook
-------------------------
print('Test')
```

Notebook 2: "Day 5: Part 2: DBUtils Notebook Utils: Parent"

```
print('hello')
-------------------------
```

```
dbutils.notebook.run('Day 5 Part 1 DBUtils Notebook Utils Child',60)
60 is timeout parameter


Click on "Notebook Job", will lend you to "Workflow", where it is executed as job, there are two kinds of clusters, one is interactive and another is "Job", it's executed as a "Job", under "Workflow", check all "Runs".
```

Now "clone" Notebook 1: "Day 5: Part 1: DBUtils Notebook Utils: Child" and Notebook 2: "Day 5: Part 2: DBUtils Notebook Utils: Parent" and rename as "Day 5: Part 3: DBUtils Notebook Utils: Child Parameter" and "Day 5: Part 4: DBUtils Notebook Utils: Parent Parameter"

Notebook 3: "Day 5: Part 1: DBUtils Notebook Utils: Child Parameter"

```
dbutils.notebook.help()

---------------------------
dbutils.widgets.text(name='a',defaultValue='',label = 'Enter value of a ')
```

```
dbutils.widgets.text(name='b',defaultValue='',label = 'Enter value of b ')
---------------------------
a = int(dbutils.widgets.get('a'))
b = int(dbutils.widgets.get('b'))
```
 # The dbutils.widgets.get function in Azure Databricks is used to retrieve the current value of a widget. This allows you to dynamically incorporate the widget value into your Spark jobs or SQL queries within the notebook.

```
---------------------------
c = a + b
---------------------------
print(c)
---------------------------
dbutils.notebook.exit(f'Notebook Executed Successfully and returned {c}')
```

Notebook 4: "Day 5: Part 4: DBUtils Notebook Utils: Parent Parameter"

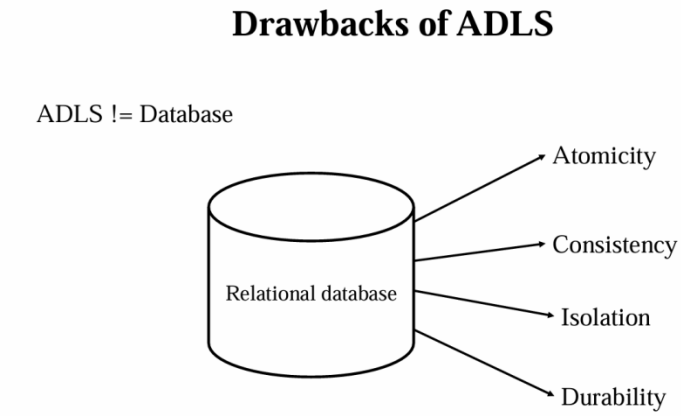
```
print('hello')
-------------------
dbutils.notebook.run(Day 5: Part 1: DBUtils Notebook Utils: Child Parameter',60,{'a' : '50', 'b': '40'})
# 60 is timeout parameter
```

 # go to Widget setting from right, change setting to "On Widget change"--> "Run notebook", now entire notebook is getting executed

On right hand side in "Workflow" → "Runs", there are Parameters called a and b.

Day 6: What is delta lake, Accessing Datalake storage using service principal:

- ✓ **Introduction to section Delta Lake: Delta is a key feature in Azure Databricks designed for managing data lakes effectively. It brings ACID transactions to Apache Spark and big data workloads, ensuring data consistency, reliability, and enabling version control. Delta helps users maintain and track different versions of their data, providing capabilities for rollback and audit.**



- ✓ **In this section, we will dive into Delta Lake, where the reliability of structured data meets the flexibility of data lakes.**

- ➢ **We'll explore how Delta Lake revolutionizes data storage and management, ensuring ACID transactions and seamless schema evolution within a unified framework.**
- ✓ **Discover how Delta Lake enhances your data lake experience with exceptional robustness and simplicity.**

Drawbacks of ADLS

- No ACID properties
- Job failures lead to inconsistent data
- Simultaneous writes on same folder brings incorrect results
- No schema enforcement
- No support for updates
- No support for versioning
- Data quality issues

- ✓ **We'll cover the key features of Delta Lake, accompanied by practical implementations in notebooks.**
- ✓ **By the end of this section, you'll have a solid understanding of Delta Lake, its features, and how to implement them effectively.**

- ❖ **Delta Lake: One of the foundational technologies provided by the Databricks Lakehouse Platform is an open-source, file-based storage format that brings reliability to data lakes. Delta Lake is an open source technology that extends Parquet data files with a file-based transaction log for ACID transactions that brings reliability to data lakes.**

  Reference: https://docs.databricks.com/delta/index.html

- ✓ **ADLS != Database, in RDBMS there is called ACID Properties which is not available in ADLS.**

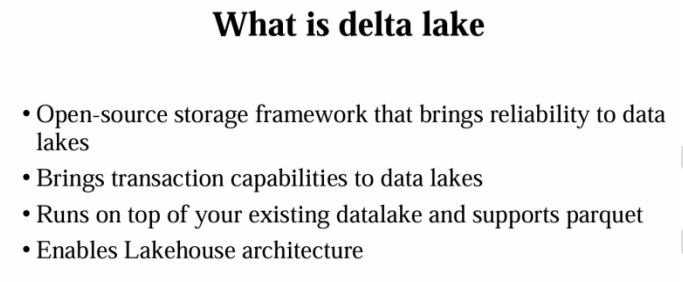
Data Lake came forward to solve following drawback of ADLS:

- ✓ **Drawbacks of ADLS:**

1. **No ACID properties**
2. **Job failures lead to inconsistent data**
3. **Simultaneous writes on same folder brings incorrect results**
4. **No schema enforcement**
5. **No support for updates**
6. **No support for versioning**
7. **Data quality issues**

✓ **What is Delta Lake?**

- **It is an Open-source framework that brings reliability to data lakes.**
- **Brings transaction capabilities to data lakes.**
- **Runs on top of your existing data lake and supports parquet.**
- **Delta Lake is not a data warehouse or a database.**
- **Enables Lakehouse architecture.**



A. Datawarehouse can work only on structure data, which is first generation evolution. However it is supporting ACID properties. One can delete, update and perform data governance on it.

Datawarehouse cannot handle the data other than structure cannot serve a ML use cases.

B. Modern data warehouse architecture: There is Modern data warehouse architecture, which includes usage of Data Lakes for object storage, which is cheaper option for storage, this also called two tier architecture.

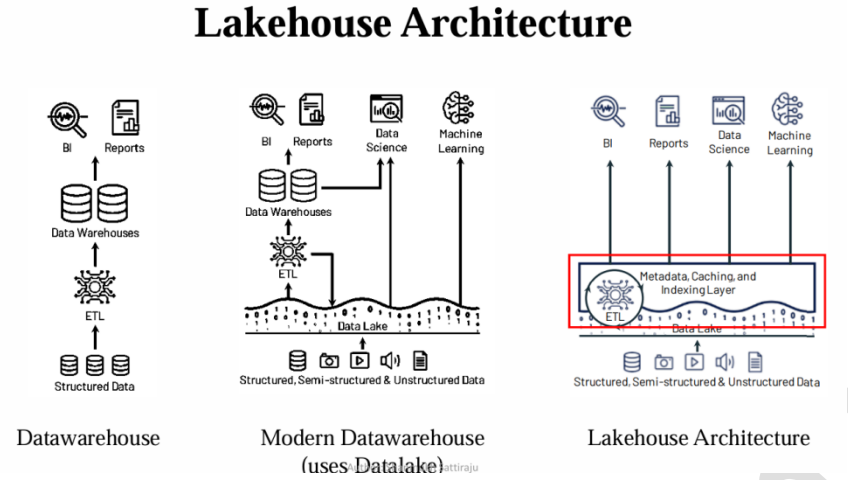
So the best features would be first one.

It supports the any kind of data can be structured or unstructured, and the ingestion of data is much faster. And the data lake is able to scale to any extent. And let us see what the drawbacks here are.

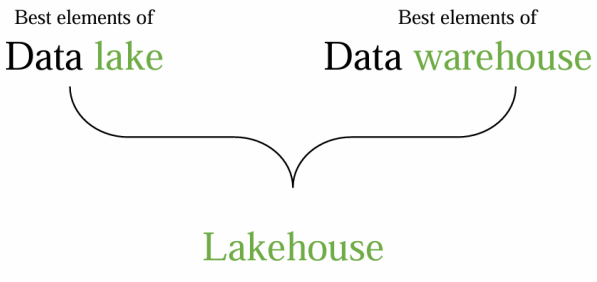
Like we have seen, Data Lake cannot offer the acid guarantees, it cannot offer the schema enforcement, and a data lake can be used for ML kind of use cases, but it cannot serve for BI use case, a BI use case is better served by the data warehouse.

That is the reason we are still using the data warehouse in this architecture.

C. Lakehouse Architecture: Databricks gave a paper on Lakehouse, which proposed the solution by just having a single system that manages both the things.

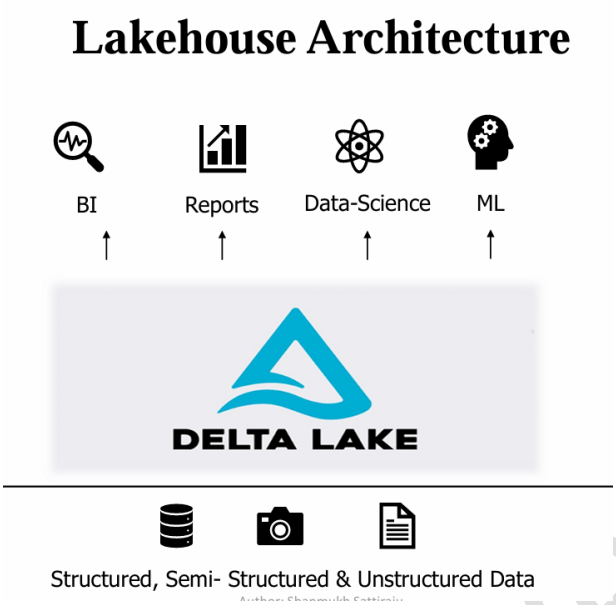


So Databricks has solved this by using Delta Lake. They introduced metadata, which is transaction logs on top of the data lake, which gives us data warehouse like features.



So Delta Lake is one of the implementation that uses the Lakehouse architecture. If you can see in the diagram there is something called metadata caching and indexing layer. So under the hood there will be data lake on the top of the data lake. We are implementing some transaction log feature where that is called the Delta lake, which we will use the Delta Lake to implement Lakehouse architecture.

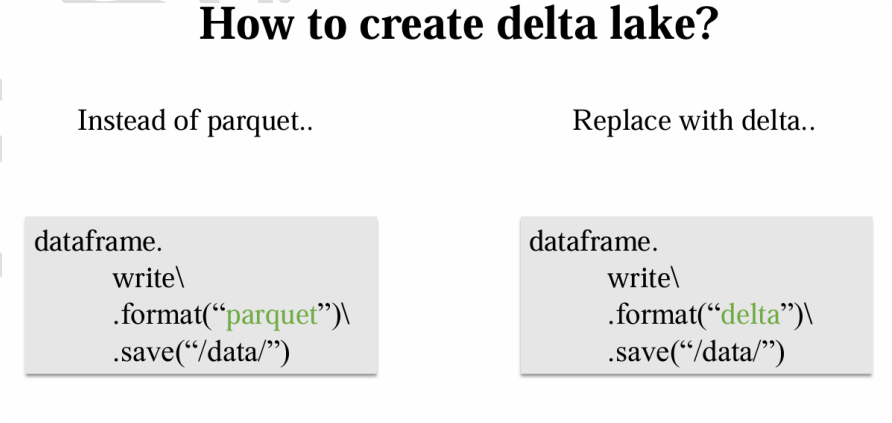
So let's understand about the Lakehouse architecture now. So the combination of best of data warehouses and the data lakes gives the Lakehouse where the Lakehouse architecture is giving the best capabilities of both.



If you can see the diagram, Data Lake itself will be having an additional metadata layer for data management, which having a transaction logs that gives the capability of data warehouse.

So using Delta Lake we can build this architecture. So let's see more about the Lakehouse architecture now. So coming to this we have the data lake and data warehouse which are architecture we have seen. And each is having their own capabilities.

Now Data Lake House is built by best features of both. Now we can see there are some best elements of Data Lake and there are best elements of Data Warehouse. Lake House also provides traditional analytical DBMs management and performance features such as Acid transaction versioning, auditing, indexing, caching, and query optimization.



Create Databricks instances (with standard Workspace otherwise Delta Live tables and SQL warehousing will be disabled) and ADLS Gen 2 instances in Azure Portal.

- **Difference between Data Lake, Data Warehouse and Data Mesh:**

With the rise of modern architectures, terms like Data Lake, Data Warehouse, and Data Mesh often pop up, but how do they differ? Let's break it down:

1 #Data_Lake

Think of it as a vast reservoir—storing raw and unprocessed data in its native format. Perfect for data scientists diving deep into analytics or machine learning use cases. It's flexible and scalable but needs strong #governance to avoid becoming a "data swamp."

💡 Example Tools: #Hadoop, Amazon S3.

📌 Use Case: An e-commerce platform storing clickstream data, user logs, and videos for advanced analytics.

2 #Data_Warehouse

The organized sibling of Data Lakes—storing structured, processed data for immediate analysis. It's built for business intelligence (BI) and reporting, ensuring optimized queries and actionable insights.

💡 Example Tools: Snowflake , Google BigQuery, Amazon Redshift.

📌 Use Case: A bank analyzing customer transaction data for financial forecasting.

3 #Data_Mesh

The modern challenger—focused on decentralized data ownership. Instead of one central repository, teams manage their own domain-specific data products while ensuring self-service and scalability. This is ideal for large organizations tackling agility and scalability issues.

💡 Example Implementation: Leveraging Zhamak Dehghani's principles.

📌 Use Case: A global enterprise empowering cross-functional teams to manage and deliver data products independently.

Delta Lake Importance: Here's a practical walkthrough of some amazing features and techniques for managing Delta Lake tables.

1. Track Changes in Your Delta Table

==========

Delta Lake allows you to view the historical changes made to a table. With simple commands like DESCRIBE HISTORY, you can track updates, additions, and deletions to ensure data integrity and transparency.

DESCRIBE HISTORY student;

2. Access Data at a Specific Timestamp

==========

Ever need to retrieve data as it was at a specific point in time? Delta Lake's TIMESTAMP AS OF lets you query data from the past by specifying a timestamp.

SELECT * FROM student TIMESTAMP AS OF '2025-01-18T13:47:11.000+00:00';

3. Version Control with Delta Tables

==========

Delta Lake allows querying data at specific versions, making it easy to access past states of a table. This helps ensure your data is always recoverable and up to date with precise version control.

SELECT * FROM student VERSION AS OF 1;

4. Restore a Table to a Previous Version

==========

Accidents happen, and sometimes data is deleted or corrupted. Delta Lake's RESTORE feature lets you quickly recover data from a previous version without skipping a beat.

RESTORE TABLE student TO VERSION AS OF 2;

5. Optimizing Tables for Faster Queries

==========

Want faster query performance? Use OPTIMIZE and ZORDER BY to compact smaller files into larger ones, making it easier and quicker to read data by specific columns.

OPTIMIZE student ZORDER BY id;

6. Keep Your Data Clean with Vacuuming

==========

Over time, your Delta Lake tables may accumulate old or uncommitted files. Use the VACUUM command to clean up unnecessary files and remove outdated versions to improve performance and storage.

VACUUM student;

7. Why is Delta Lake important?

==========

Delta Lake combines the scalability and flexibility of a data lake with the reliability and performance of a data warehouse. By incorporating features like version control, time travel, optimization, and vacuuming, it empowers organizations to manage big data efficiently, safely, and with minimal performance impact.

- **Hands-on: Accessing Datalake storage using service principal:**

"Day 6 Part 1 Test+access.ipynb"

Source Link: [Tutorial: Connect to Azure Data Lake Storage Gen2 - Azure Databricks | Microsoft Learn]

Step 1: Create ADLS Gen 2 instance

Inside ADLS Gen 2, create a ADLS Gen 2 with name "deltadbstg", create a container with name "test", inside this container add a directory with name "sample", upload a csv file name "countires1.csv".

Step 2: Databricks instances and Compute resource

Inside Databricks instances: Create a compute resource with Policy: "Unrestricted", "Single node", uncheck "Use Photon Acceleration", select least node type.

Go give permission, we have unity catalogue.

Step 3: Create a Microsoft Entra ID service principal

- **Go to Azure Entra ID (previously Azure Active directory), inside it, going to create some service principle, click on "App Registration" on left hand side where you can create an app. Click on "New Registration",**
- **Give name: "db-access", leave other settings as it is. Copy "Application (client) ID" and "Directory (tenant) ID" from "db-access" overview.**
- **Eg: Application ID: dbf11b5d-9d81-4cc8-82f3-f14da29c8c98**
- **Directory (tenant) ID: 076af1d9-53a7-48e4-9c43-8ae1c16db3e2**

Step 4: Create new New client secret and Copy Secret Key

- **Inside app registration: Also copy secret key from left, "certificates & secrets" from left, click on "+ New client secret", give "Description" as "dbsecret" and click on "Add".**
- **Copy the "Value" from "dbsecret" now.**

- Eg: Client Secret Value or service credential:“HnF8Q~braIA_bVu6IVtDXrvVYzm_YCncVouGtcb.”
- Note three keys “Application (client) ID” and “Directory (tenant) ID” and “Value” from “dbsecret” i.e. secret ID in a text notebook.
- Inside notebook, secret ID is “service credential”.

Step 5: Add Role Assignment from Access Control (IAM)

- To give access to data storage, goto ADLS Gen 2 instances in Azure Portal, go to “Access Control (IAM)”, click on “+Add”, click on “+Add Role Assignment”, “User, Group and service Principal”-> search for “Storage Blob Data Contributor”, click on storage blob contributor” and “+select members”, type service principle which is “db-access”. Select, finally Review and Assign.

Step 6: Put all these credentials at respective places

Replace everything here:

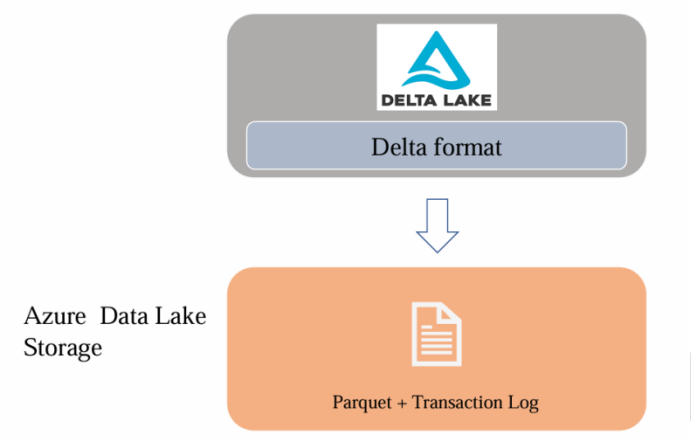
```
service_credential = dbutils.secrets.get(scope="<scope>",key="<service-credential-key>")

spark.conf.set("fs.azure.account.auth.type.<storage-account>.dfs.core.windows.net", "OAuth")

spark.conf.set("fs.azure.account.oauth.provider.type.<storage-account>.dfs.core.windows.net",
"org.apache.hadoop.fs.azurebfs.oauth2.ClientCredsTokenProvider")

spark.conf.set("fs.azure.account.oauth2.client.id.<storage-account>.dfs.core.windows.net",
"<application-id>")

spark.conf.set("fs.azure.account.oauth2.client.secret.<storage-account>.dfs.core.windows.net",
service_credential)

spark.conf.set("fs.azure.account.oauth2.client.endpoint.<storage-account>.dfs.core.windows.net",
"https://login.microsoftonline.com/<directory-id>/oauth2/token")
```

Hands on 2: Drawbacks of ADLS – practical:

Day 6 Part 2 .+Drawbacks+of+ADLS.ipynb

- Create new directory in “test” container with name “files” and upload csv file “SchemaManagementDelta.csv”

This hands on showing that using data lake we are unable to perform Update operation. Only in delta lake this operation is supportive.



Even using spark.sql, are unable to perform Update operation. This is one of Drawbacks of ADLS.

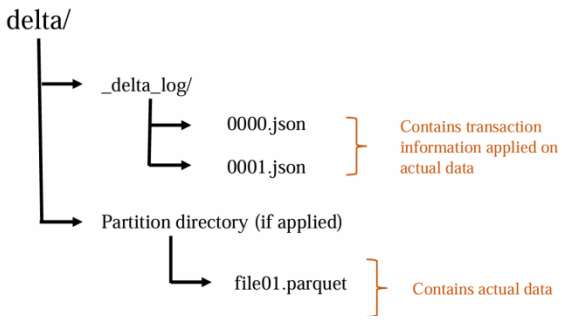
Versioning is also not available in ADLS, which is Drawbacks of ADLS.

Hands on 3: Creating Delta lake:

Day 6 Part 3 +Drawbacks+of+ADLS+-+delta.ipynb

Hands on 4: Understanding Transaction Log:

Day 6 Part 4 Understanding+the+transaction+log.ipynb



Transaction logs tracks changes to delta table and it is responsible for bringing the ACID compliance for Delta lake.

Understanding Transaction log file (Delta Log)

- Contains records of every transaction performed on the delta table
- Files under _delta_log will be stored in JSON format
- Single source of truth

Transaction log contents

JSON File = result of set of actions

- **metadata** – Table's name, schema, partitioning ,etc
- **Add** – info of added file (with optional statistics)
- **Remove** – info of removed file
- **Set Transaction** – contains record of transaction id
- **Change protocol** – Contains the version that is used
- **Commit info** – Contains what operation was performed on this

- **What is Delta Table**?

Delta Tables are a data storage format and technology that allow for efficient management and manipulation of large datasets in data lakes. They are a feature of Delta Lake, an open-source storage layer that runs on top of Apache Spark and Apache Parquet. Delta Tables provide features like ACID transactions, schema enforcement, time travel, and upserts. These features make it easier to work with big data in a consistent, reliable, and efficient manner.

Key Features of Delta Tables:

ACID Transactions: Delta Tables support ACID (Atomicity, Consistency, Isolation, Durability) transactions, ensuring that data operations are reliable and consistent. This is important in big data systems where multiple jobs or users may be reading and writing to the same table concurrently. With ACID guarantees, Delta Tables ensure that operations like insertions, deletions, and updates are atomic and isolated.

Schema Enforcement and Evolution: Delta Tables ensure that the schema of the data is enforced when writing to the table, which means that the data conforms to a predefined schema. If a column is missing or if the type of data in a column doesn't match the expected schema, it will be rejected. Delta Tables also support schema evolution, which allows you to automatically add new columns or modify existing ones without breaking existing processes or applications.

Time Travel: Delta Tables provide a feature called time travel, which allows users to query previous versions of the table. This can be useful for auditing purposes, debugging, or retrieving historical data. Time travel is achieved through Delta's versioning system, where each write operation (like an insert or update) is tracked with a new version.

Data Versioning: Delta Tables automatically track versions of the data, enabling you to perform queries on a specific version. Each time data is written or modified, a new version is created. You can access these versions by specifying a timestamp or version number.

Upserts (**MERGE**): Delta Tables allow upserts (a combination of "update" and "insert") through the MERGE command. This allows you to efficiently update existing records and insert new ones in a single operation. It is commonly used when data

changes over time, and you want to ensure that the latest records are inserted or updated without duplicating data.

Scalable and Efficient Storage: Delta Tables are built on top of Apache Parquet, which is an optimized columnar storage format. This provides significant improvements in query performance, compression, and storage efficiency.

Day 7: Creating delta tables using SQL Command

Day 07 Part 1 pynb

- **Change default language to "SQL", then Create schema with name "delta", before further code, where exactly we can see this table, go to "Catalog", there are two defaults catalogues, "Hive metastore" and "samples". This is not "Unity catalog".**
- **The Hive metastore is a workspace-level object. Permissions defined within the hive_metastore catalog always refer to the local users and groups in the workspace. Hence Unity catalog cannot manage the local hive_metastore objects like other objects. For more refer https://docs.databricks.com/en/data-governance/unity-catalog/hive-metastore.html#access-control-in-unity-catalog-and-the-hive-metastore.**
- **Schema with name "delta" is created in "Hive metastore" catalogue, this is schema not database.**
- **Create table with name "'delta'.deltaFile" , any table which you are creating be default is a delta table in Databricks. Check again Schema with name "delta" which is created in "Hive metastore" catalogue, here one symbol with delta is also showing.**
- **To find exact location of this delta table: Go to "Cataloge"-> "Hive metastore" -> "delta" -> "deltaFile"-> "Details"-> "Location".**
- **There is no parquet file, means we haven't inserted any data.**

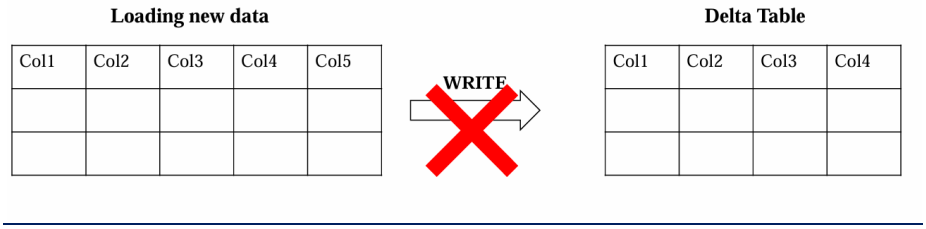
Day 07 Part 2 pynb file

Day 07 Part 3 pynb file

Day 07 Part 4 pynb file

- ✓ **Create "SchemaEvol" in "Test" containers (this is part of Day 6), before running this file upload two csv files, "SchemaLessCols.csv" and "SchemaMoreCols.csv" in "SchemaEvol" directory in "Test".**
- ✓ **Schema Enforcement or Schema Validation: Let's take a delta table, which is maintained strictly, we are ingesting data into this table on daily basis. In one ingestion, if a new data is coming with new "Column" which is not available in this schema.**

Schema Enforcement



- ✓ **Delta Lake uses Schema validation on "Writes".**
- ✓ **Now on a fine day during the data ingestion some data comes with a new column which is not in the schema of our current table, which is being overwritten to the location where our delta lake is present.**

How does schema enforcement works?

Delta lake uses Schema validation on **"writes" .**

Schema Enforcement Rules:

1. Cannot contain any additional columns that are not present in the target table's schema
2. Cannot have column data types that differ from the column data types in the target table.

- ✓ **Now, generally, if you are using the data lake and I'm mentioning it again to prevent any confusion, I mean the data lake, not the delta lake, the general data lake will allow the overwriting of this data and we will lose any of our original schema.**
- ✓ **Like we have seen in the drawback, we try to overwrite to the location where we lost our data and it allowed the write.**

- ✓ **But coming to the Delta Lake, we have a feature called schema enforcement or Schema validation, which will check for the schema for whatever the data that is getting written on the Delta Lake table.**
- ✓ **If the schema does not match with the data which we are trying to write to the destination, it is going to reject that particular data.**
- ✓ **It will cancel the entire write operation and generates an error stating that the schema is not matching the module of the schema.**
- ✓ **Validation is to safeguard the delta lake that ensures the data quality by rejecting the writes to a table that do not match the table schema.**
- ✓ **A classic example is you will be asked to scan your IDs before entering your company premises, so that is going to check if you are the authorized person to enter this.**
- ✓ **Similarly, schema enforcement acts as a gatekeeper who checks for the right data to enter to the Delta Lake.**
- ✓ **Now, how does this schema enforcement works exactly?**
- ✓ **So to understand this, Delta Lake uses the schema validation on writes, which means all the new writes to the new table are checked for the compatibility with the target table.**
- ✓ **So during the right time it is going to check for the schema compatible or not.**
- ✓ **If the schema is not compatible, data is going to cancel. The delta lake cancels the transaction altogether.**

- ✓ **No data is being written, and it raises an exception to let the user know about the mismatch. And there are certain rules on how the schema enforcement works.**
- ✓ **And let us see on what conditions the incoming data will be restricted in writing to the delta table. So let's see about the rules now.**
- ✓ **So it cannot contain any additional columns like we have seen before.**
- ✓ **If the incoming data is having a column more than the one defined in the schema, it is treated as a violation to the schema enforcement.**
- ✓ **But if it is having less number of columns than the target table, it is going to allow the write by giving the null value to the existing columns where there is no data for this particular table.**
- ✓ **But if the incoming data is having more number of columns, it is going to cancel that insert. Now there is one more rule where it cannot have the different data types. If a delta table's column contains the string data, but the corresponding column in the data frame incoming is having the integer data, the schema enforcement will raise an exception and it will prevent the write operation entirely.**
    - **Now how is this schema enforcement useful?**
    - **Because it is such a stringent check, schema enforcement is an excellent tool to use as a gatekeeper to get a clean, fully transformed data set that is ready to use for production or consumption.**
    - **It is typically enforced on tables that directly fed into the machine learning algorithm by dashboard or data analytics or visualization tools, and schema enforcement is used for any production system that is requiring highly structured, strongly typed semantics checks.**
    - **And it's enough with this theory.**
    -

- **Trying to append more columns using code. Extra column is "Max_Salary_USD".**
- **Source with fewer columns will accept.**
-

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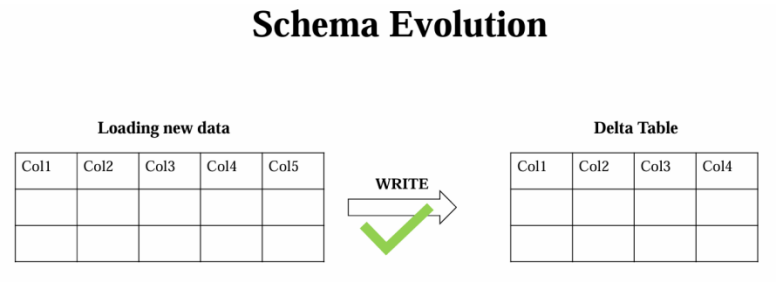
Day 07 Part 5 pynb file

- **Schema Evolution: Schema evolution in Databricks Delta Lake enables the flexible evolution of table schemas, allowing changes such as adding, removing, or modifying columns without the need for rewriting the entire table. This flexibility is beneficial for managing changes in data structures over time.**



- **So schema evolution is a feature that allows the user to easily change the tables current schema to accommodate the data changing over time.**
- **Question**: How would you handle schema evolution in PySpark?

Schema evolution refers to the ability to handle changes in your dataset's structure— ✅ Adding new columns/fields
✅ Dropping existing columns/fields
✅ Changing the datatypes of existing fields.

PySpark Techniques for Schema Evolution:

1) Merge Schemas Automatically : PySpark can merge schemas across files dynamically using the **mergeSchema** option. This works well with formats like Parquet, ORC, and JSON.

Example :
df= spark.read.option("mergeSchema", "true").parquet("path") .

2)Define and Enforce a Custom Schema : When you need strict control over your data structure, define a schema explicitly to ensure consistency.

Example :
schema = StructType([StructField("Name", StringType(), True),
Struct Field("Age", IntegerType(), True), StructField("Salary", Integer Type(), True)])

df = spark.read.schema(schema).parquet("path/to/files")
df.printSchema().

3) Handle Missing Columns Dynamically:When columns are added or missing, handle them programmatically to avoid breaking the pipeline.

Example :
from pyspark.sql.functions import lit

if 'new_column' not in df.columns:
df = df.withColumn("new_column", lit(None)).

4)Schema Evolution for Streaming Data: Streaming pipelines require special attention to schema changes. Tools like Delta Lake offer seamless schema evolution.

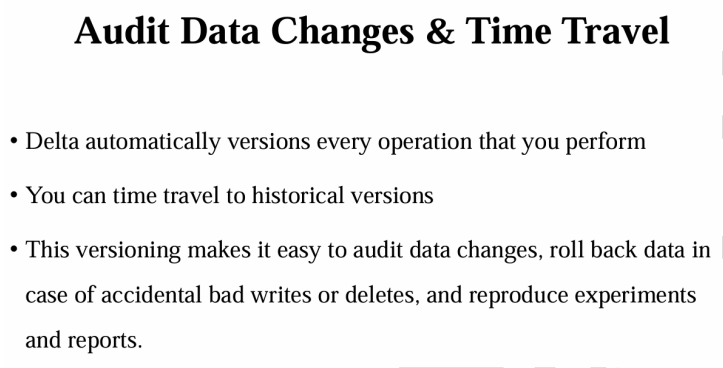
Example :
from delta.tables import DeltaTable

df.write.format("delta").option("mergeSchema",
"true").mode("append").save("path/to/delta/table").
schema registry to validate schema changes.

- **Most commonly, it is used when performing an append or an override operation to automatically adapt the schema to include one or more columns.**
- **"mergeSchema","True" enables this Schema Evolution in Delta tables.**

Day 07 Part 6 pynb file

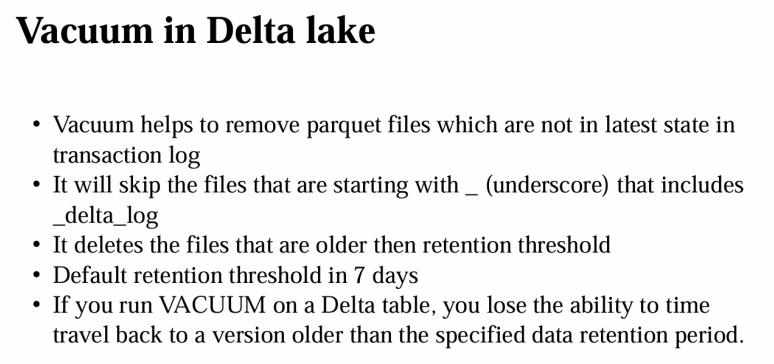
Audit Data changes & Time Travel: "Time travel" in Delta Lake enables users to query a historical snapshot of the data at a specific version, facilitating data correction or analysis at different points in time.



Day 07 Part 7 pynb file

- **Vacuum Command:**

- **If you are getting a very high storage cost now, if your organization wish to delete the old data like a 30 days old data, you can make use of the vacuum command.**
- **Now let's see how we can implement this. Now in order to know how many files will be deleted, you can make use of the dry run feature in the vacuum.**



- **So let's see how you can implement this. Now I am going to use some feature called dry Run.**
- **So it is not actually going to delete any kind of data. It is just going to show us how many files will be deleted. So it will ideally give a list of first thousand files that will be deleted and it will not actually delete.**

- **It will just show what files will be deleted. Now, by default, the retention period of this vacuum command is seven days. So any data that is having the age of more than seven days that will be deleted by default using this vacuum command.**
- **So we just created our table and we just inserted few records, but we haven't have any data which is older than seven days.**
- **Now, if I just try to run this particular command, it is going to show me nothing. And now you can see he's not returning any results because we are not having any data, which is post seven days old, which is the retention period of this particular vacuum command.**

- **Now for testing purpose, if you want to delete the data, which is less than seven period of time than the default duration, you can make use of the retain command.**
- **There is restriction, just make "retentionDuration" to True.**

Q.2. A data engineer is trying to use Delta time travel to rollback a table to a previous version, but the data engineer received an error that the data files are no longer present.

Which of the following commands was run on the table that caused deleting the data files?

Ans: VACUUM

Overall explanation

Running the VACUUM command on a Delta table deletes the unused data files older than a specified data retention period. As a result, you lose the ability to time travel back to any version older than that retention threshold.

Reference: https://docs.databricks.com/sql/language-manual/delta-vacuum.html

Q.3. In Delta Lake tables, which of the following is the primary format for the data files?

Ans: Parquet

Overall explanation

Delta Lake builds upon standard data formats. Delta lake table gets stored on the storage in one or more data files in Parquet format, along with transaction logs in JSON format.

Reference: https://docs.databricks.com/delta/index.html

Day 07 Part 8 pynb file

Convert to Delta:

Day 8: Understanding Optimize Command – Demo

- ✓ **Optimize command in Databricks primarily reduces the number of small files and compacts data, improving query performance and storage efficiency.**
- ✓ **So on a high level, the optimize command will help us to compact multiple small files into a single file.**

Optimize in Delta lake

Operation	parquet files	_delta_log	Line number Column	State
CREATE TABLE		000.json		
WRITE	aabb.parquet	001.json	100	**Active**
WRITE	ccdd.parquet	002.json	101	Inactive
WRITE	eeff.parquet	003.json	102	Inactive
DELETE 101		004.json		
UPDATE 102	iijj.parquet	005.json	99	**Active**

- ✓ **So this is one of the optimization feature in the delta lake which the name itself indicates the optimize. Now the use of this particular command is to compact multiple files into a single file.**
- ✓ **If you are aware of the small file problem in the spark, where if you have 100 small files, where each transaction is creating a file, if you want to read the content of each and every file, the time to open each and every file is more than reading the actual file.**
- ✓ **It need to open the file, it need to read the content, and it need to close the file. So the time to open and close each and every file is more than actual content reading. So this is why the optimize command helps in a way where it can just combine all the active files into a single file.**

- ✓ **I am mentioning something like active files, because sometimes there are inactive files where. Let us try to understand what exactly is this active and what is an inactive.**

- ✓ **So let's see by taking an example. So we'll be doing some transformations on our data in our Delta lake transformations are nothing but the operations like inserts, deletes and updates and etc..**
- ✓ **So each action or a transformation will be treated as a commit and it will create the parquet file.**

UPSERT (Merge) in delta lake

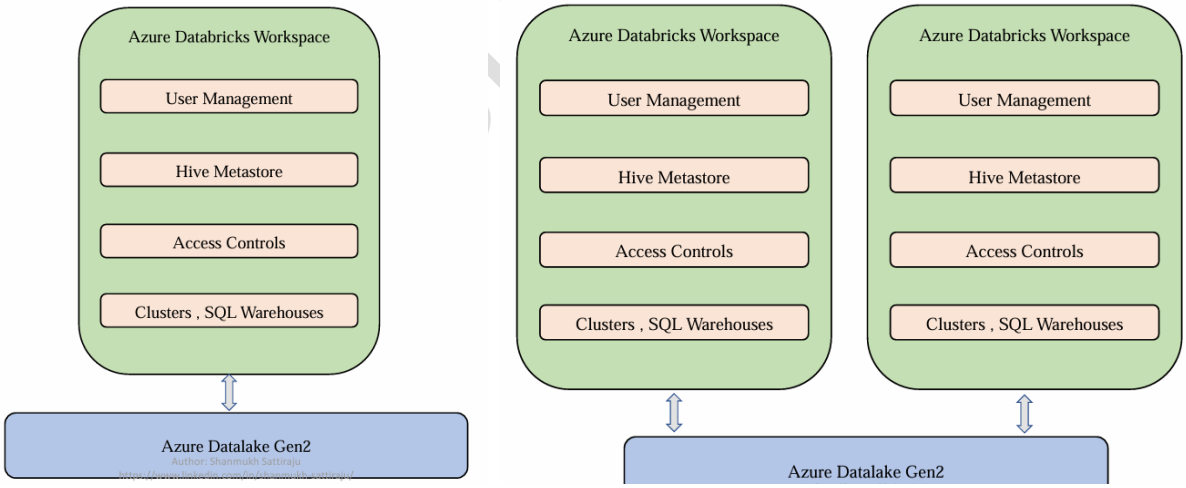
- We can UPSERT (UPDATE + INSERT) data using MERGE command.
- If any matching rows found, it will update them
- If no matching rows found, this will insert that as new row

```
MERGE INTO <Destination_Table>
USING <Source_Table>
        ON <Dest>.Col2 = <Source>.Col2
WHEN MATCHED
THEN UPDATE SET
          <Dest>.Col1 = <Source>.Col1,
          <Dest>.Col2 = <Source>.Col2
WHEN NOT MATCHED
THEN INSERT
        VALUES(Source.Col1, Source.Col2)
```

- ✓ **Along with that it will create the delta log files. So imagine we are creating a empty table because we are doing an empty table creation. It is also an operation where the operation is recorded as a create table.**
- ✓ **And it is not going to create any parquet file, but it is going to create a delta log.**

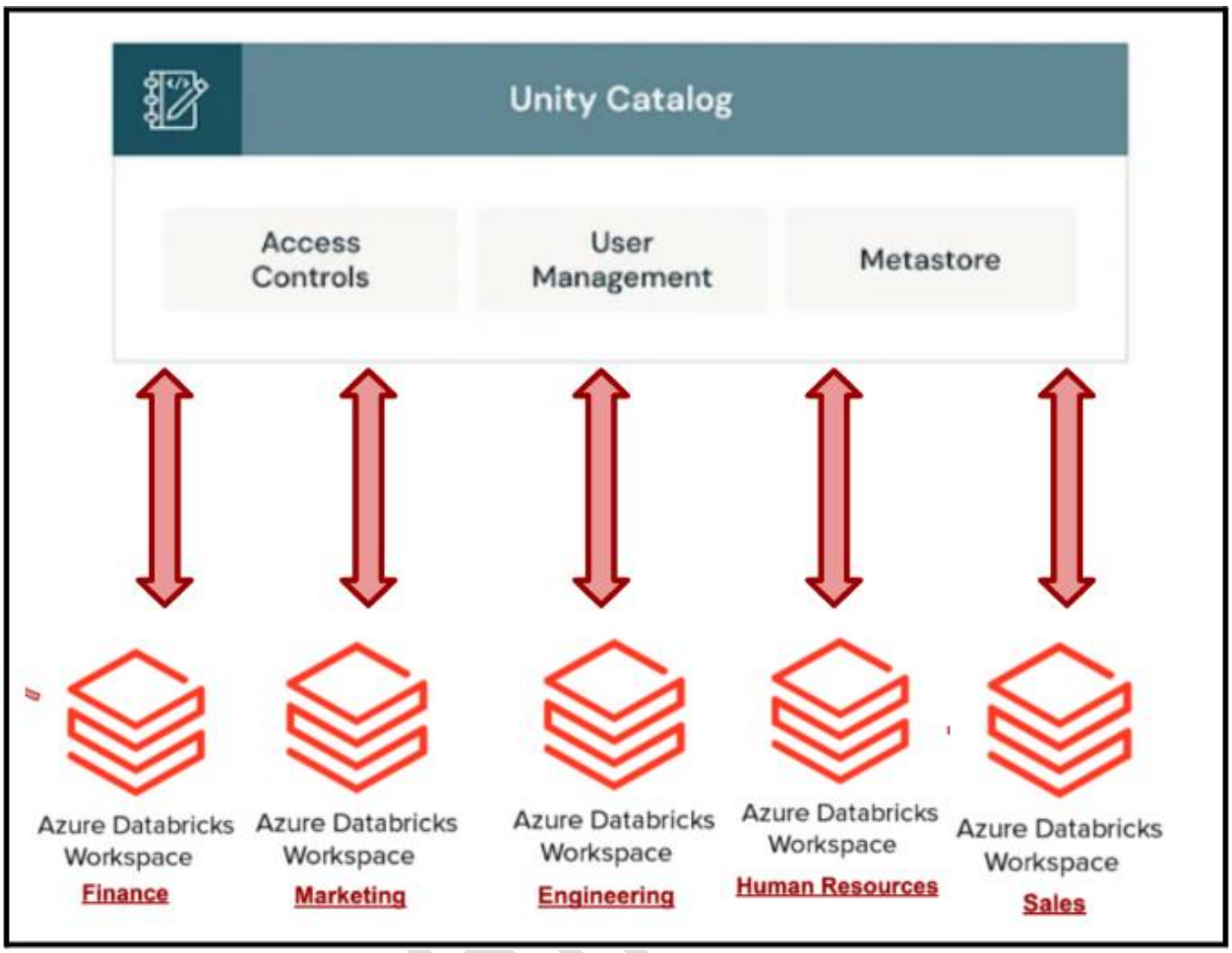
Day 9: What is Unity Catalog: Managed and External Tables in Unity Catalog

Understanding the Problem Unity Catalog Solves

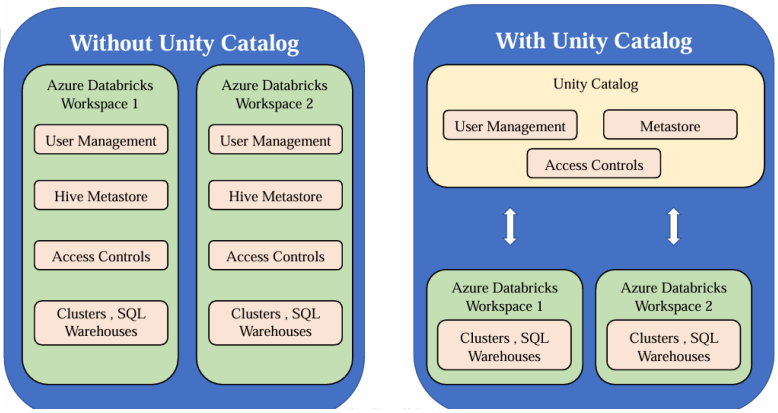


Unity Catalog: bringing order to the chaos of the cloud. It is a data governance tool that provides a centralized way to manage data and AI assets across platforms.

Unity Catalog: a powerful tool designed to centralize and streamline data management within Databricks.

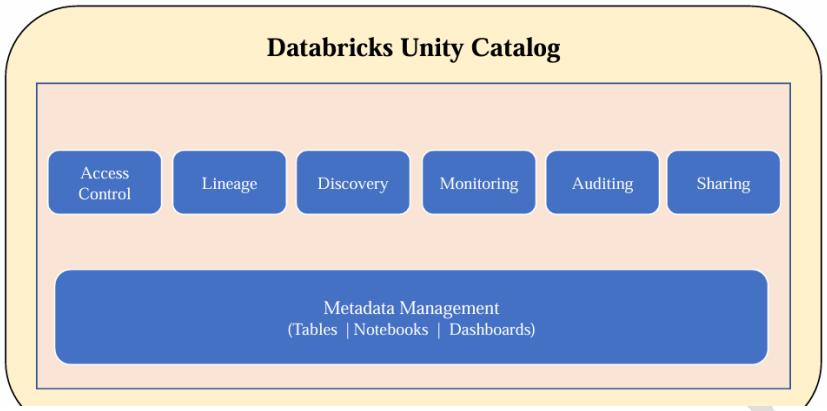


Unity Catalog centralizes all metadata, ensuring that user data definitions are standardized across the organization. This means that the marketing, customer service, and product development teams all have access to a single, consistent source of truth for user data. By providing a unified view of all data assets, **Unity Catalog** makes it easier for teams to access the information they need without having to navigate through multiple systems.

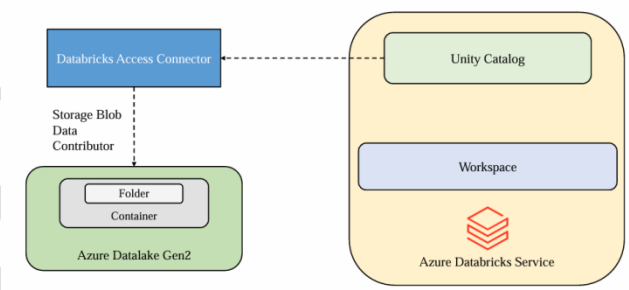


The marketing team can easily access support interaction data, and the product development team can view user engagement metrics, all from a single platform. This unified approach reduces administrative

overhead, enhances data security, and ensures that data is accurate and compliant, supporting better data-driven decision-making and driving business success.



1. **Typical Databricks Setup**
   - Organizations use Databricks workspaces for projects (e.g., Azure Databricks).
   - User management is required for assigning roles (developers, leads, managers).
   - Each workspace has a Hive metastore storing managed tables and defined access controls.



2. **Challenges in Managing Multiple Workspaces**
   - Multiple environments (dev, UAT, prod) and business units/projects require several workspaces.
   - Duplication of user management, access controls, and cluster creation policies across workspaces.
   - Lack of centralized governance for managing users, auditing, and metadata.
   - Difficult to track who has access to specific data across all workspaces.
3. **Need for a Centralized Solution**
   - A central system for governance, audit, and metadata management is required.

How Unity Catalog Solves the Problem

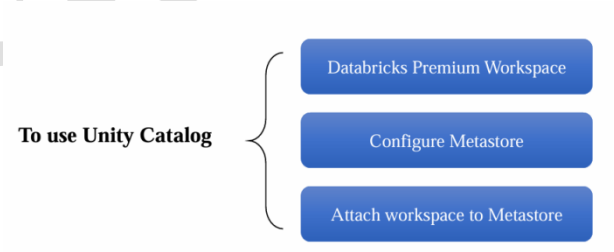
1. **Centralized Governance**
   - Manages user access, metadata, and governance for multiple workspaces centrally.
   - Provides visibility and control over access permissions across all workspaces.
2. **Unified Features**
   - **Access Controls**: Define and enforce who can access what data.
   - **Lineage**: Track how data tables were created and used.
   - **Discovery**: Search for objects like tables, notebooks, and ML models.
   - **Monitoring**: Observe and audit object-level activities.
   - **Delta Sharing**: Share data securely with other systems or users.
   - **Metadata Management**: Centralized management of tables, models, dashboards, and more.

Summary

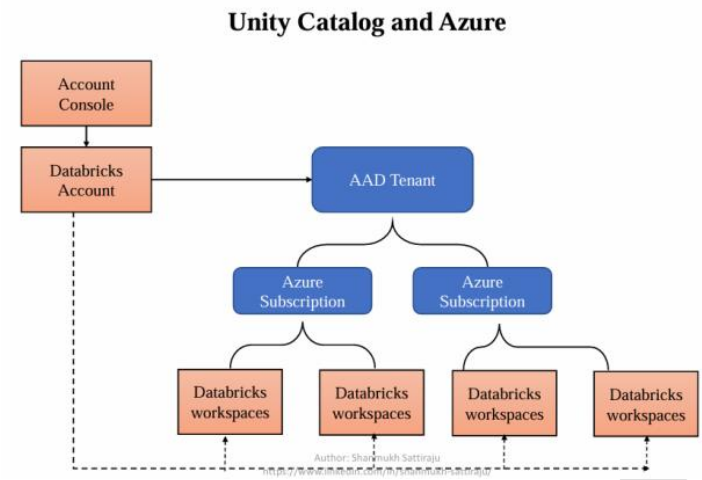
Unity Catalog is a centralized governance layer in Databricks that simplifies user and metadata management across multiple workspaces. It enables unified access control, data lineage, discovery, monitoring, auditing, and sharing, ensuring seamless management and governance in one place.

Hands-on:

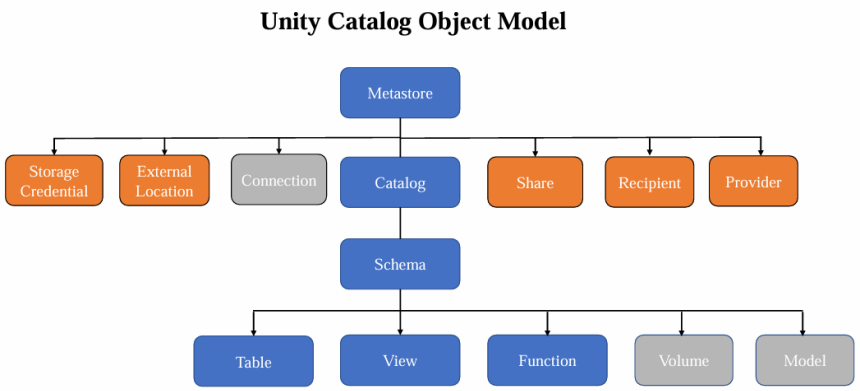
Step 1: In Azure Portal, create a Databricks workspace and ADLS Gen2, add these two Databricks workspace and ADLS Gen2 in "Favorite" section.



Step 2: search for "Access connectors for Azure Databricks", create "New", only give resource group name and Instance name "access-connectors-sachin" here, you need not to change anything here. Click on "Go to Resource". Now in "Overview", "Resource ID", can use this "Resource ID" while creating the Metastore.

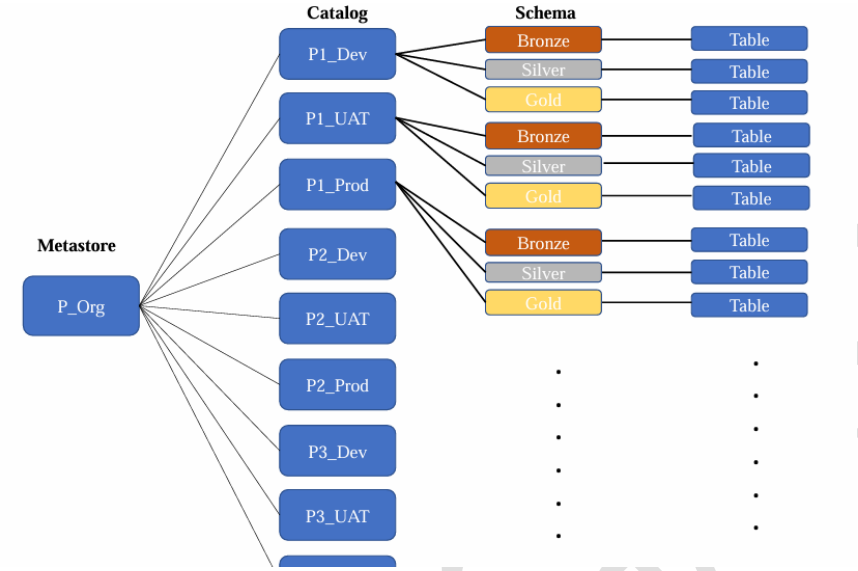


Step 3: Create ADLS Gen2, "deltadbstg"-> "test"-> "files"->"SchemaManagementDelta.csv". Now give access of this Access connectors to ADLS Gen2, go to ADLS Gen2, go to "Access Control IAM" from left pane, click on "Add"-> "Add Role Assignment"-> search for "Storage Blob Data Contributor", in "Members", select "Assign Access to"->"Managed Identity" radio button, "+Select Members"-> select "Access connectors for Azure Databricks" under "Managed identity" drop down menu-> "Select"-> "access-connectors-sachin" -> "Review+Assign".



- Now using this managed identity, our Unity catalog or Metastore can access this particular storage account. And the reason why we are doing is we need to have a container where that is going to be accessed by the unity catalog to store its managed tables, and we will see that in upcoming lectures.

Step 4: To use Unity Catalog: following are pre-requisites:



1. Must have Databricks Premium Workspace
2. Configure Metastore (Done in Step 3)
3. Attach premium workspace to Metastore
4. Note: https://accounts.azuredatabricks.net/ , in case you are not able to access "Manage Account" setting in my Azure Portal, click here:
5. a. https://learn.microsoft.com/en-us/answers/questions/1843839/not-able-to-access-manage-account-setting-in-my-az
6. b. https://learn.microsoft.com/en-us/answers/questions/1344479/unable-to-login-accounts-azuredatabricks-net-and-c
7. c. https://learn.microsoft.com/en-us/azure/databricks/admin/#account-admins

- **Solution:** Try to login using this link: https://accounts.azuredatabricks.net/login, then provide the user who is having "Global Administrator of your subscription", check this link for solution: https://learn.microsoft.com/en-us/answers/questions/1843839/not-able-to-access-manage-account-setting-in-my-az

    - Now go to Databricks, we need to start a creating a meta store, meta store is top level container in the unity catalog, go "Manage Account" under "Sachindatabricks name" from right top -> "Catalog" from left pane, "create meta store", provide "Name" as "metastore-sachin","Region"(can create one meta store in single region), "ADLS Gen2 path" (go to ADLS Gen2-> create container-> "Add Directory", paste <container_name>@<storage_account_name>.dfs.core.windows.net/<directory_Name> In the sample format of test@ deltadbstg.dfs.core.windows.net/files

- Or test@deltadbstg123456.dfs.core.windows.net/files), "Access connector ID" (go to "Access connectors"-> "access-connectors-sachin" -> copy that "resource ID")-> "Create".
- Attach with any workspaces. "Enable Unity Catalog?"-> "Enable".

Step 5: Create the required users to simulate the real time environment: go to "Microsoft Entra ID"-> "Add"-> "users" from left pane-> "new user"-> "create new user"-> give any name to "User Principal Name"-> give any display Name "Sachin_Admin" ->give custom password not "Auto generate password"-> not required to change any "Properties", "Assignments"-> click on "Create".

- Now login from https://accounts.azuredatabricks.net/ using username and password from Step 5. Using unity catalog, we can access to this user. My username is : sa******xgmail.onmicrosoft.com and password is K***r3**#

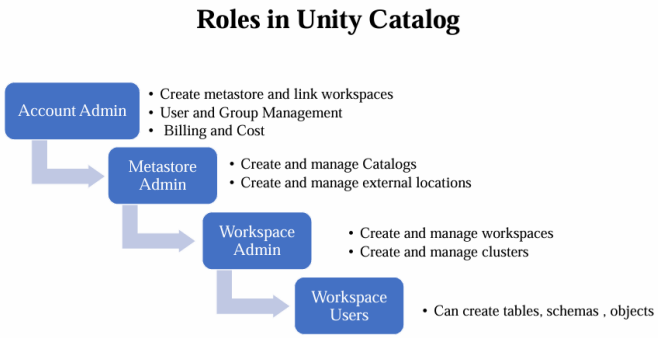
Step 6: Create one more user as in Step 5, now we two new users.

- So these are two new users we have created for this session, where we will try to simulate the real time environment by giving them required access to understand the roles and responsibilities clearly, because user management is something, if you are in a project, generally there will be an admin who can do this, but in real times they will expect you to handle this by your own. A data engineer must also be aware who can access what.
- First user will be Workspace admin and second will be developer.

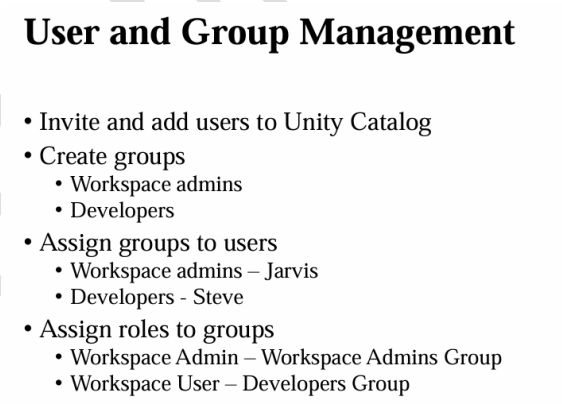
Step 7: Now in Databricks portal, click on "Manage Account", from right top, this Databricks portal is created neither by Workspace admin nor developer, in order to add user, click on "User Management" from left pane, we need to add both Workspace admin and developer.

- Click on "Add User"-> paste email id from "Microsoft Entra ID" -> "User Principal name", can give any "first name" and "last name" as "Workspace admin". Now add developer "User Principal name" in same way.
- Click on "Setting" from left, -> "User Provisioning"-> "Set up user provisioning".
- Open a "incognito window" mode to open https://portal.azure.com/#home with "admin Sachin" and "Developer Sachin" both, it will ask to create new password.

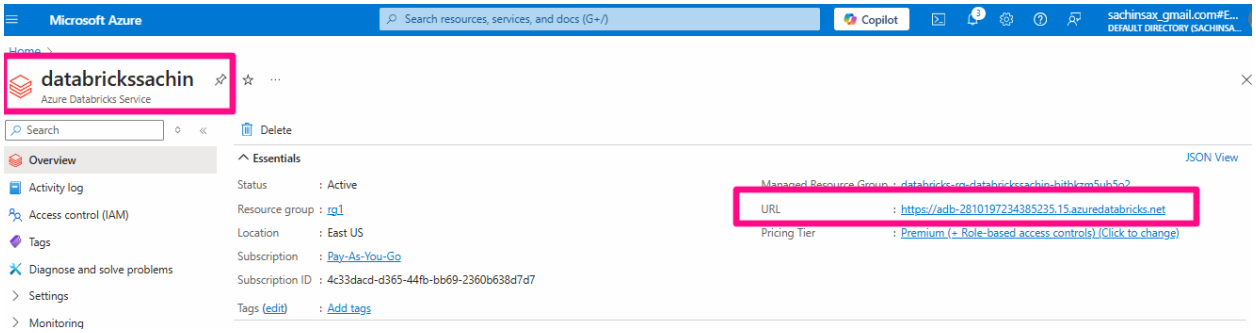
Step 8: to create group, click on “Manage Account”, from right top, this Databricks portal is created neither by Workspace admin nor developer, in order to add user, click on “User Management” from left pane-> “Groups” -> “Add Group”, we are going to create two groups, first group is “Workspace Admins”-> “Add Members” from admin only and second group is “Developer team”-> “Add Members” of developer only.



Step 9: It’s time to give permission, in Databricks portal, click on “Manage Account”, from right top, this Databricks portal is created neither by Workspace admin nor developer, in order to give permission, click on “Workspaces”, click on respective “Workspace” -> inside it “permissions”-> “Add Permissions”-> we need to add groups which we created in Step 8, to admin group assign “Permission” as “Admin” and to developer group assign “Permission” as “User”.



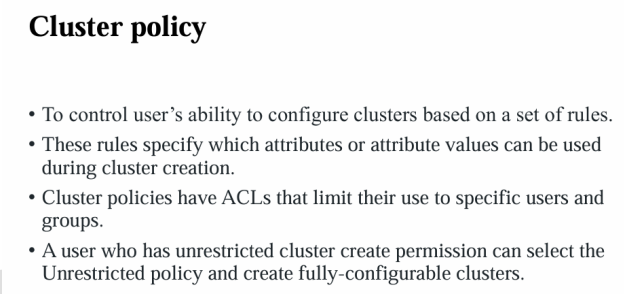
Step 10: Now login from https://portal.azure.com/signin/index/ using username and password, need to paste databricks workspace go to Databricks portal, click on “Manage Account”, from right top, this Databricks portal is created neither by Workspace admin nor developer, go to Azure portal from main where we created first Databricks workspace, copy “Workspace URL” ending with xxx.azuredatabricks.net.



Sign in with admin credentials, in similar way, go to Azure portal from main where we created first Databricks workspace, copy "Workspace URL" ending with xxx.azuredatabricks.net and sign in with user credentials.

- **Just check that in developer portal, we do not have "Manage Account" setting, also in developer portal cannot see any compute resources in "Compute" tab.**

Step 11: Create Cluster Policies: login with admin and move to databricks portal from this "sachin admin" login, go to "admin setting" from right top.



- **Click on "Identity and access" from second left pane. Click on "Manage" from "Management and Permissions" in "Users". Click on "Kumar Developer" right three dots, click on "Entitlements", check on "Unrestricted cluster creation", "Confirm" it.**
- **Now check "Compute" tab of "Kumar Developer" in databricks portal that, this "create compute " resource is now enabled.**
- **We do not want to give all kind of "Compute" resources to "Kumar Developer", so we can restrict by using create policies, otherwise,** it will result in a significantly high bill, subsequently, **and it may incur a substantial expense.**
- **(This step is for disable Compute Resource in developer portal)To create policies, click on "Kumar Developer" right three dots, click on "Entitlements", check off "Unrestricted cluster creation", "Confirm" it. Now check "Compute" tab of "Kumar Developer" in databricks portal that, this "create compute" resource is now disabled again.**

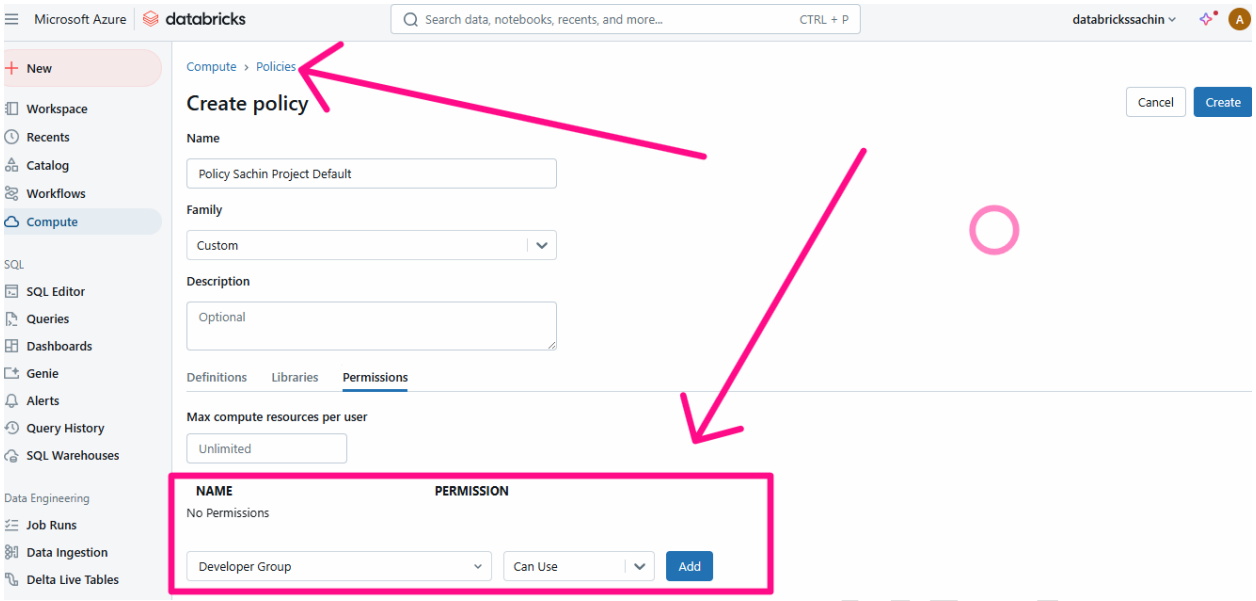
- **Compute policy reference: https://learn.microsoft.com/en-us/azure/databricks/admin/clusters/policy-definition**

- **Jump to “”Sachin Admin” databricks portal, click on “compute”, click on “Policies”: click on “create policy”-> give “Name” as “Sachin Project Default Policy” , select “Family” as “custom”->**

Change the following code:

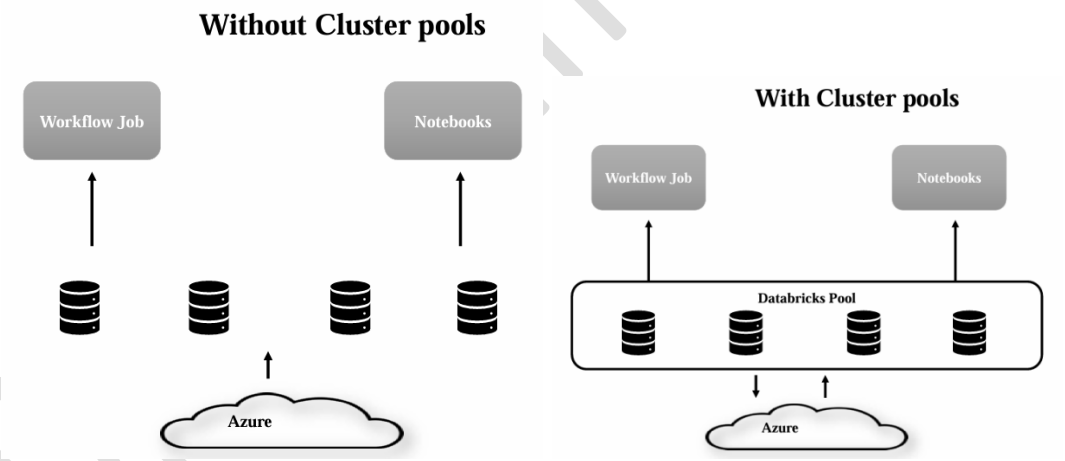
```
{
 "node_type_id": {
  "type": "allowlist",
  "values": [
   "Standard_DS3_v2"
  ]
 },
 "spark_version": {
  "type": "fixed",
  "value": "13.3.x-scala2.12"
 },
 "runtime_engine": {
  "type": "fixed",
  "value": "STANDARD",
  "hidden": true
 },
 "num_workers": {
  "type": "fixed",
  "value": 0,
  "hidden": true
 },
 "data_security_mode": {
  "type": "fixed",
  "value": "SINGLE_USER"
 },
 "cluster_type": {
  "type": "fixed",
  "value": "all-purpose"
 },
 "instance_pool_id": {
  "type": "forbidden",
  "hidden": true
 },
 "azure_attributes.availability": {
  "type": "fixed",
  "value": "ON_DEMAND_AZURE",
  "hidden": true
 },
 "spark_conf.spark.databricks.cluster.profile": {
  "type": "fixed",
  "value": "singleNode",
  "hidden": true
 },
 "autotermination_minutes": {
  "type": "fixed",
  "value": 20
 }
}
```

- **Click on “Permission” in ”Sachin Admin” databricks portal, click on “compute”, click on “Policies”: click on “create policy”-> give “Name” as “Sachin Project Default Policy”, in “Name”, select “Developers” -> “can use”, click on “Create” from right top.**



- **Now, if you jump to as "Sachin Developer" databricks portal, "Compute" tab, one "Sachin Project Default Policy" will appear at right top.**

Step 12: Cluster Pools in Databricks:



Question: What is pool? Why we use pool? How to create pool in Databricks?

- Pool is used to reduce cluster start time while auto scaling, you can attach a cluster to a predefined pool of idle instances.
- When attached to a pool, a cluster allocates its driver and worker nodes from the pool.
- If the pool does not have sufficient idle resources to accommodate the cluster's request, the pool expands by allocating new instances from the instance provider.
- When an attached cluster is terminated, the instances it used are returned to the pool and can be reused by a different cluster.

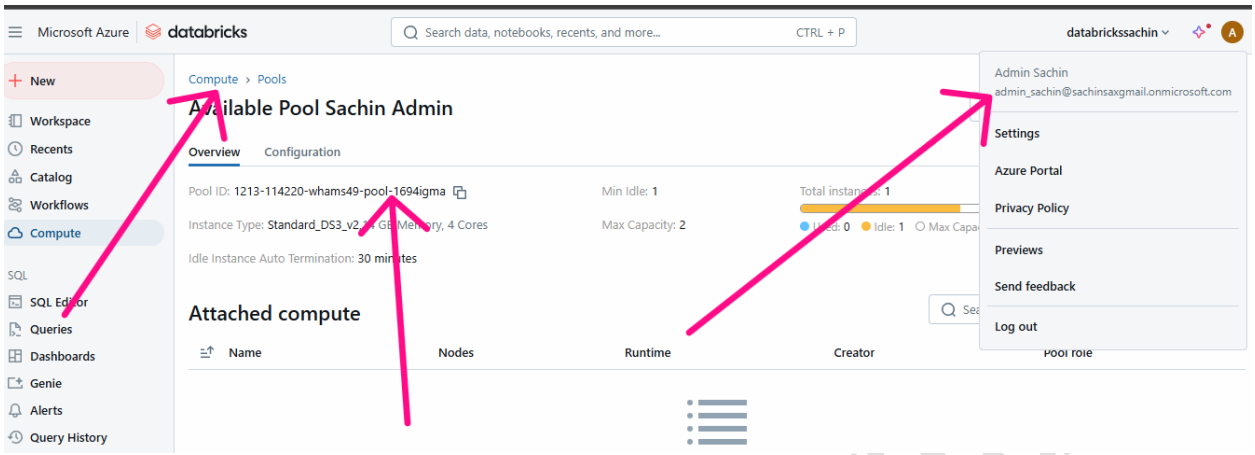
- **Purpose of Cluster Pools**:
  - Reduce cluster creation time for workflows or notebooks.
  - Enable ready-to-use compute resources in mission-critical scenarios.
- **Cluster Creation Process**:
  - Compute resources are required to run workflows or notebooks.
  - Creating a cluster involves requesting virtual machines (VMs) from a cloud service provider.
  - VM initialization takes ~3-5 minutes, which may not be ideal for real-time tasks.
- **Cluster Pool Functionality**:
  - Cluster pools pre-request VMs from the cloud provider based on configurations.
  - Keeps some VMs ready in a running or idle state.
  - Enables faster cluster creation by utilizing these pre-initialized VMs.
- **Performance and Cost Trade-Off**:
  - Performance improves as clusters are ready in reduced time (~half the usual time).
  - Databricks does not charge for idle instances not in use, but cloud provider infrastructure costs still apply.
- **Use Case**:
  - Ideal for workflows or notebooks needing rapid cluster creation.
  - Balances between cost and efficiency by keeping resources ready.
- **Key Takeaway**:
  - Cluster pools enhance performance by maintaining idle VMs for quick allocation, albeit with associated cloud costs.

- **Cluster Pools in Databricks Hands-on: Jump to "Sachin Admin" databricks portal, click on compute, go to "Pool", click on "create pool", name as "Available Pool Sachin Admin", pool will already keep you instances in ready and running state so that we can use them while creating the cluster. And these will access the resources which are readily available.**

- **Also keep "Min Idle" as 1 and "Max Capacity" as 2. Now let me make the minimum idle instance to one and maximum two. This means all the time this one instance will be in ready and in running state. And in case if this one instance is used by any cluster, another will be in the Idle state because minimum one will be idle all the time, irrespective of the one is attached or not. So in maximum of two will be created. So one can be used by cluster and if that is already been occupied, another one will be in the idle state.**
- **Change "terminate instances above minimum tier" to 30 minutes of idle time.**
- **Change "Instance Type" to "Standard_DS3_v2"**
- **Change "On-demand/spot" to "All On-demand" radio button, bcs sometimes Spot instances are not available.**
- **Create it. It will take much time. Copy Pool ID from here.**
- **Now go to Edit Policies under "Policy tab" which was done in Step 11, make changes in:**

```
},
"instance_pool_id": {
  "type": "forbidden",
  "hidden": true
},
```

To Get Pool ID here:




```
"instance_pool_id": {
  "type": "fixed",
  "value": "1211-104550-gybed90-pool-ns7wqs2q<Your Pool ID>"
```

- **Now go to Compute Tab in "Sachin Admin" databricks, click on "Pool"->select given "availavle Pool Sachin Admin" -> click on Permission-> select "Developers group" (not individual developer) to "Can Attach to"-> "+Add", "Save" it.**

Step 13: Creating a Dev Catalogs: go to "Sachin Admin" databricks portal, go to "Catalog" tab, but "Create Catalog" is disabled now because we haven't define this permission, in order to give permission, go to "Main Datbricks" portal (neither Sachin Workspace admin nor Kumar developer), go to databricks portal, go to "Catalog" tab, "Catalog Explror" -> click on "Create Catalog" from right, name "Catalog name" as "DevCatalog", type as "Standard", skip "Storage location". Click on "Create".

Step 14: Unity Catalog Privileges:

Unity Catalog Privileges

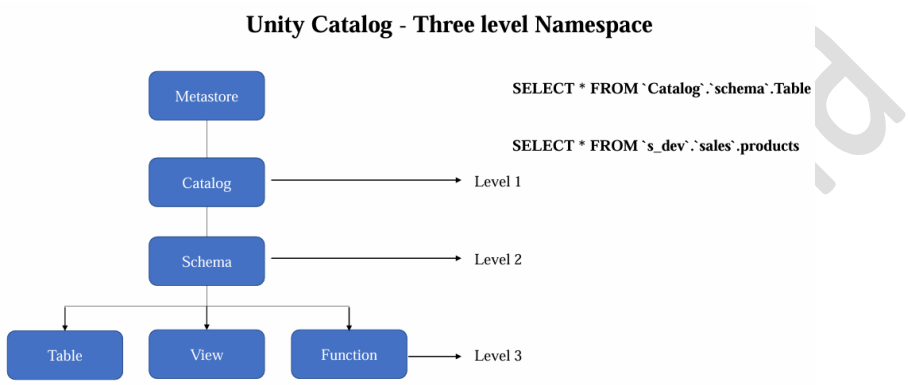
- Privileges are permissions that we assign on objects to users
- Can use SQL command or Unity Catalog UI

Eg:

GRANT **privilege_type** ON **securable_object** TO **principal**

Privilege_Type : Unity Catalog permissions like SELECT, CREATE
Securable_object: Any object like SCHEMA, TABLE , etc
Principal: Can be a user, group, etc.

- Go to “Sachin Admin” databricks portal, but still can’t see “Dev Catalog” because Sachin Admin and Kumar developer both are not having the required privileges or permission to use.
- Go to “Main Databricks” portal who is account admin (neither Sachin Workspace admin nor Kumar developer) go to “Catalog”, Click on “Dev Catalog”, then “Permissions”, then “Grant”, this screen is Unity catalog UI to grant privileges to “Sachin Admin”, then click on “Grant”, select group name “WorkSpace admins” checkbox on “create table”, “USE SCHEMA”, “Use Catalog” and “Select” in “Privileges presets”, do not check anything here. Click on “Grant”. Now, go to “Sachin Admin” databricks portal, “Dev Catalog” is showing here.

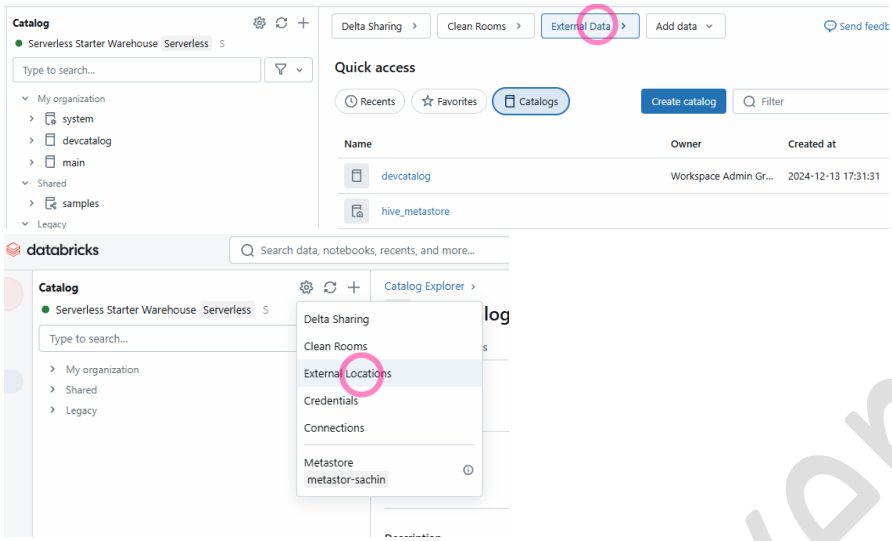


- To transfer ownership of “Dev Catalog”, go to “Main Databricks” portal who is account admin (neither Sachin Workspace admin nor Kumar developer), go to “Catalog”, Click on “Dev Catalog”, click on pencil icon from mid top near Owner: sacinsax@gmail.com, “Set Owner for Dev Catalog”, change to “Workspace admins” not to specific user, bcs if one user leave the organization then it creates havoc situations.
- Now, go to “Sachin Admin” databricks portal, “Dev Catalog” is showing here.
- Now, go to “Sachin Admin” databricks portal, create a “notebook” here, to run any cell in this notebook, we need “Compute”, select “Create with Personal compute”, “Project Defaults”.
- Go to “Sachin Admin Databricks” portal go to “Catalog”, Click on “Dev Catalog”, then “Permissions”, then “Grant”, this screen is Unity catalog UI to grant privileges to “Sachin Admin”, then click on “Grant”, select group name “WorkSpace admins” checkbox on “Use Catalog”, “USE SCHEMA”, “Create Table” and “Select” in “Privileges presets”, do not check anything here.
- Now Run SQL command, file is saved in “Day 9” folder with name “Unity Catalog Privileges.sql”. in code GRANT USE_CATALOG ON CATALOG `devcatalog` TO `Developer Group`

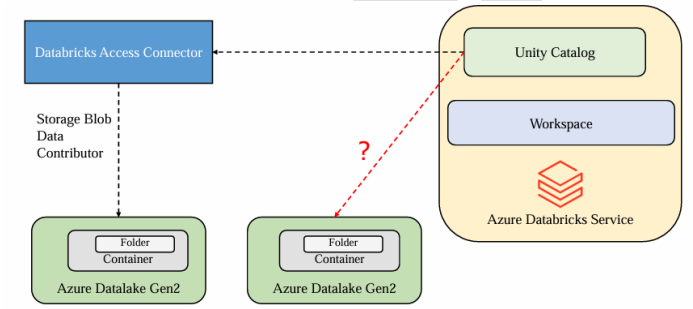
Step 15: Creating and accessing External location and storage credentials:

- Step A: Go to “Sachin Admin Databricks” portal go to “Catalog”, we do not find any external data here, to find “External Data”, go to “Main Databricks” portal who is account admin

(neither Sachin Workspace admin nor Kumar developer) go to "Catalog", in "Catalog Explorer", there is "External Data" below, click on "Storage Credentials".

- 

- **Step B: Now in ADLS Gen2, "deltadbstg"-> "test"-> "files"->"SchemaManagementDelta.csv".**
- **Now give role assignment "Storage blob Data Contributor" to "db-access-connector" from IAM role in Azure Portal of Main admin.**



- **Step C: Now go to Step A Databrick portal, click on "create credential" under "External Data" below, click on "Storage Credentials", "Storage Credentials Name" as "Deltastorage", to get "Access connector Id", go to "db-access-connector" from Azure Portal, will find "Resource ID", copy this and paste to "Access connector Id", click on "create".**
- **Step D: Go to "Main Databricks" portal who is account admin (neither Sachin Workspace admin nor Kumar developer) go to "Catalog", in "Catalog Explorer", there is "External Data" below, click on "External Data", click on "Create external location" -> "Create a new external location"click on "External location name": "DeltaStorageLocation", in "Storage credential", select "Deltastorage" which we created in Step C.**
- **To find URL: abfss://test@deltadbstg.dfs.core.windows.net/files (go to ADLS Gen2 "deltadbstg"-> "EndPoints"-> "Data Lake Storage"), click on "create".**
- **Click on "Test Connection".**
- **Step E: create a notebook in "Main Databricks" portal who is account admin (neither Sachin Workspace admin nor Kumar developer), create a compute, create with "Unrestricted", "Multi node", create a Access mode "Shared" , uncheck "Use Photon Acceleration", Min workers: 1, Max workers: 2.**
- **Run the following code in notebook in Main Databricks (Neither in Admin nor in Developer):**

```
%sql
CREATE TABLE `devcatalog`.`default`.Person_External
(
    Education_Level STRING,
    Line_Number INT,
    Employed INT,
    Unemployed INT,
    Industry STRING,
    Gender STRING,
    Date_Inserted STRING,
    dense_rank INT)
USING CSV
OPTIONS(
  'header' 'true'
)
LOCATION 'abfss://test3@deltadbstg.dfs.core.windows.net/dir'
```

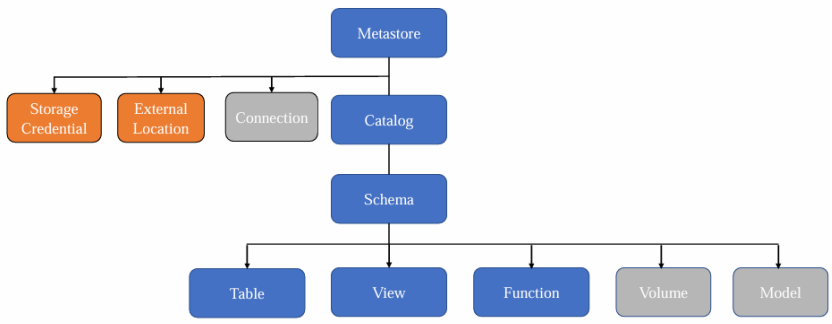
- **Df=(spark.read.format('csv').option('header','true').load('abfss://test@deltadbstg.dfs.core.windows.net/files / '))**
- **Display(Df)**

Step 16: Managed and External Tables in Unity Catalog: Do hands on also.

- Managed Tables
  - These can be defined without a specified location
  - The data files are stored within managed storage in Delta format
  - Dropping the table not only removes its metadata from the catalog, but also deletes the actual data but in Unity Catalog the underlying data will be present for 30 days.

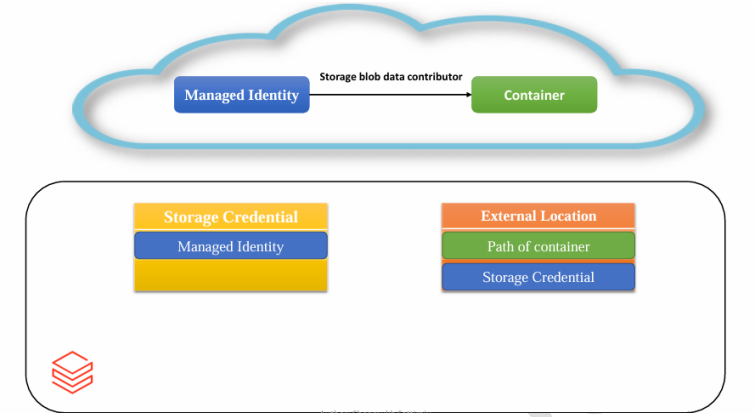
- External Tables
  - You need to have an EXTERNAL LOCATION and STORAGE CREDENTIALS created to access the external storage.
  - These can be defined for a custom file location, other than the managed storage
  - Dropping the table deletes the metadata from the catalog, but doesn't affect the data files.

Unity Catalog Object Model



Question: Which of the following is primary needed to create an external table in an Unity Catalog Enabled workspace?

Answer: You need an external location created primarily pointing out to that location , So you can get access to the path to create external table.



Question: Can managed table use Delta, CSV, JSON, avro format?

Answer: No, Managed table can use only Delta format.

Storage Credential	External Location
An authentication and authorization mechanism for accessing data stored	Serves as a reference point for External storage
Stores the access Credentials to provide access to External Location	Stores the path of the external storages that you want to access.
Credentials can be Managed Identities / Service principles	Makes use of Storage credential to get access to External Storage

Day 10: Spark Structured Streaming – basics

Note: **This hands on can be done on Databricks community addition, otherwise, it will result in a significantly high bill.**

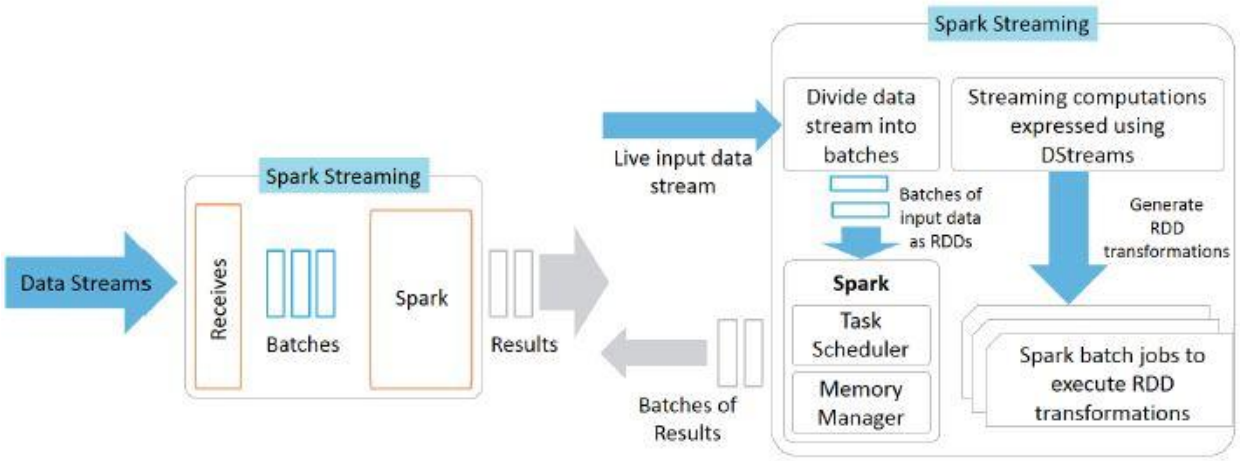
Definition: **A data stream is an unbounded sequence of data arriving continuously. Streaming divides continuously flowing input data into discrete units for further processing. Stream processing is low latency processing and analyzing of streaming data.**

In Spark Structured Streaming, in order to process data in micro-batches at the user-specified intervals, you can use processingTime keyword. It allows to specify a time duration as a string.

Reference: **https://docs.databricks.com/structured-streaming/triggers.html#configure-structured-streaming-trigger-intervals**

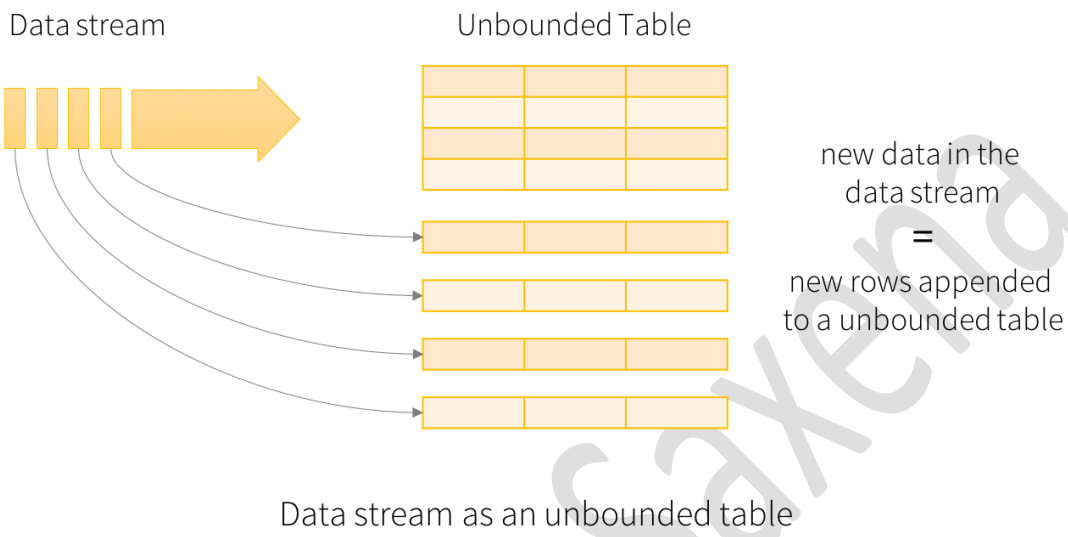
Data ingestion can be done from many sources like Kafka, Apache Flume, Amazon Kinesis or TCP sockets and processing can be done using complex algorithms that are expressed with high-level functions like map, reduce, join and window. Finally, processed data can be pushed out to filesystems, databases and live dashboards.

Firstly, streaming data is something that will never have a complete data for analysis as data is continuously coming in where there is no stop. To understand this, let's first conceptualize the structured streaming. So let's take a stream source like an IoT device which is collecting details of vehicles travelled on a road. There can be thousands of vehicles that travelled on a road or a log collecting system from an application like social media platform or e-commerce site.



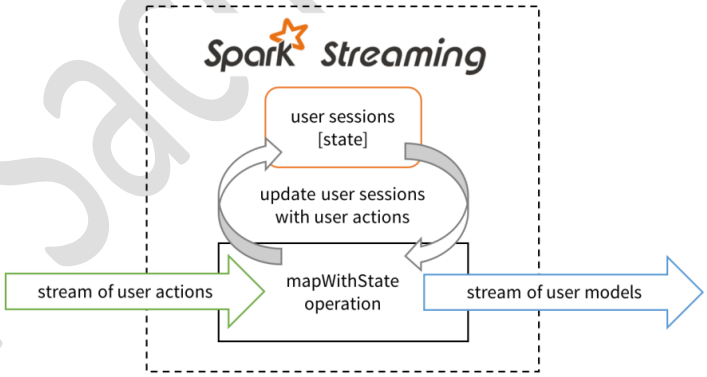
That application can be used by thousands of users, where they can be doing many clicks and you want to collect those click streams. So these are basically the endless incoming data, which is called incoming data stream or streaming data.

Why Streaming in Spark?

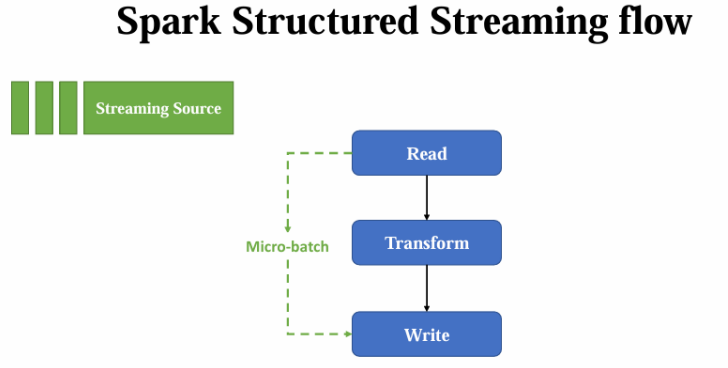


Data stream as an unbounded table

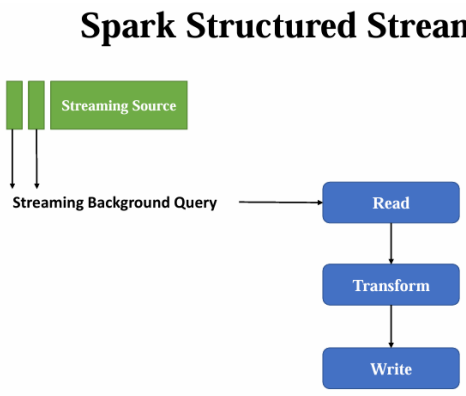
Batch processing systems like Apache Hadoop have high latency that is not suitable for near real time processing requirements.

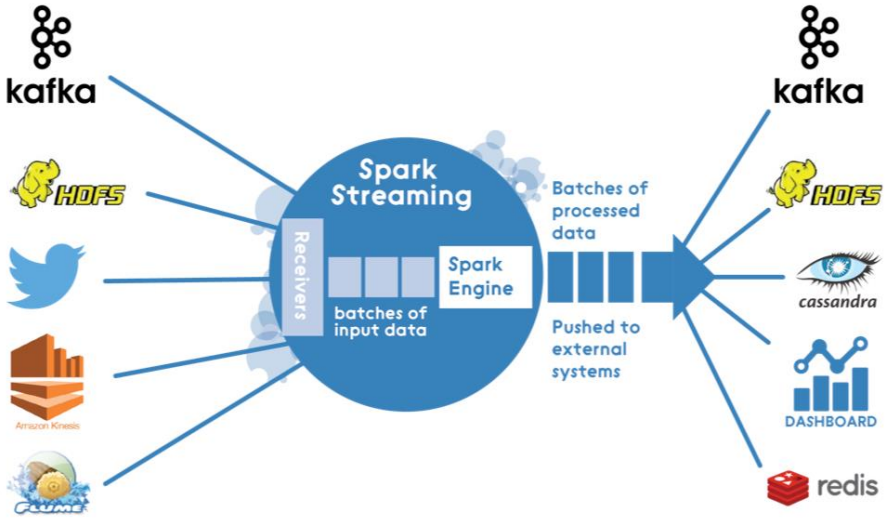


There is a set of worker nodes, each of which runs one or more continuous operators. Each continuous operator processes the streaming data one record at a time and forwards the records to other operators in the pipeline.



Data is received from ingestion systems via Source operators and given as output to downstream systems via sink operators.





- ✓ **Continuous operators are a simple and natural model. However, this traditional architecture has also met some challenges with today's trend towards larger scale and more complex real-time analytics.**

Advantages:

a) Fast Failure and Straggler Recovery

In real time, the system must be able to fastly and automatically recover from failures and stragglers to provide results which is challenging in traditional systems due to the static allocation of continuous operators to worker nodes.

b) Load Balancing

In a continuous operator system, uneven allocation of the processing load between the workers can cause bottlenecks. The system needs to be able to dynamically adapt the resource allocation based on the workload.

c) Unification of Streaming, Batch and Interactive Workloads

In many use cases, it is also attractive to query the streaming data interactively, or to combine it with static datasets (e.g. pre-computed models). This is hard in continuous operator systems which does not designed to new operators for ad-hoc queries. This requires a single engine that can combine batch, streaming and interactive queries.

d) Advanced Analytics with Machine learning and SQL Queries

Complex workloads require continuously learning and updating data models, or even querying the streaming data with SQL queries. Having a common abstraction across these analytic tasks makes the developer's job much easier.

Step 1: Understanding micro batches and background query: This hands on can be done on Databricks community addition, otherwise, it may incur a substantial expense.

Note: Each unit in streaming is called as micro-batch and it is the fundamental unit of processing.

- **Create a compute resource and create a notebook and run the file named as : "Day 10 Streaming+basics.ipynb".**

- **Upload the file "Countries1.csv" to "FileStore" in "DBFS", create a new directory named "streaming".**
- **Once we have read the data using "readStream" function, let's see what jobs it has initiated, go "Compute" resource from right top, click on "Spark UI".**

Question: What are the limitations in Jobs?

A. The number of jobs is limited to 1000.

B. A workspace is limited to 150 concurrent (running) job runs.

C. A workspace is limited to 1000 active (running and pending) job runs.

- **By observing, we can see in "Saprk UI" no job has been initiated, only jobs are created when we are trying to get some data.**
- **For streaming data frames, most of the actions are not supported, but transformations are supported.**
- **If you trying to use show method, it's not working, "df.show()".**
- **Instead, use display method, "display(df)", streaming data is something it is going to accept the files under the particular directory.**
- **Now job is still running and it is displaying the data to us, display "dashboards" which is just below "display(df)", it's showing statistic graphs.**
- **Go "Compute" resource from right top, click on "Spark UI", and see agin, there is "Executor driver added".**
- **Upload the second file "Countries2.csv" to "FileStore" in "DBFS", in "streaming" directory, .**
- **Now go to "notebook" again, observe that data is again processing in "Input vs Prcoessing Rate", there is a spike indicating new data is available.**
- **In "Spark UI", there are two jobs, means for each data there is one job it is going to read data.**
- **In "Spark UI" tab, click on "Structure Streaming" there is something called "Display Query".**
- **Upload the third file "Countries3.csv" to "FileStore" in "DBFS", in "streaming" directory, see third micro batch, this streaming query in "Structure Streaming" there is something called "Display Query", acts as a watcher.**
- **To stop this Streaming Query, you can just click on "cancel" there.**
- **Several other resources available for Live streaming: File source (DBFS), Kafka, Socket, Rate etc. , Socket, Rate Sources are useful for testing purpose not for real deployment. Several sinks are also available.**
- **WriteStream : A query on the input will generate the "Result Table". Every trigger interval (say, every 1 second), new rows get appended to the Input Table, which eventually updates the Result Table. Whenever the result table gets updated, we would want to write the changed result rows to an external sink.**


```
WriteStream = ( df.writeStream
        .option('checkpointLocation',f'{source_dir}/AppendCheckpoint')
        .outputMode("append")
        .queryName('AppendQuery')
        .toTable("stream.AppendTable"))
```

- **So coming to check pointing it is basically used to store the progress of our stream. Like having the metadata till where the data is copied. Which means if I am just telling some directory, if there is a stream that is available, it is going to read that particular stream, and it is going to write the data to a destination, and it is going to note down till where the data is been copied. It is not going to store the data; it is just going to have the metadata till where the point is copied. And what exactly is the use of this check pointing.**

StreamWriter

```
<StreamingDataframe>.writeStream
                    .option('checkpointLocation',<Location>)
                    .outputMode('append')
                    .toTable('<TableName>')
```

Checkpoint

- To develop fault-tolerant and resilient Spark applications.
- It maintains intermediate state on fault-tolerant compatible file systems like HDFS, ADLS and S3 storage systems to recover from failures.
- Must be **unique** to each stream

- Importance of Checkpoint Files: the importance of checkpoint files in Delta tables, how they are generated, and the types of information they contain. Checkpoint files help us query Delta tables efficiently, as they eliminate the need to scan the entire transaction log, which is created after every DML operation (INSERT, UPDATE, DELETE) on the Delta table. These checkpoint files store information about the latest transaction log files currently being referenced by the Delta table.

1. State Management:

Store metadata reflecting the table's state, ensuring consistency and fault tolerance.
Efficient Querying: Delta Lake uses checkpoints to avoid re-scanning the entire transaction log, improving query performance.
Fault Tolerance: Checkpoints provide a snapshot for quick recovery in case of system failures.
Optimized Performance: They keep metadata compact for faster access and minimal overhead.

2. Querying Flow:

Checkpoint Files, Transaction Logs, and Parquet Data
Checkpoint File: Delta checks the latest checkpoint to determine the table's state.
Transaction Log: Checkpoint files reference the transaction log, which contains metadata pointing to relevant Parquet data files.
Parquet Files: The transaction log provides pointers to the Parquet files holding the actual data, ensuring efficient data retrieval.

3. Parameters Controlling Checkpoint Creation

Checkpoint Interval: Defines the frequency of checkpoint creation (default is every 10 commits).
Log File Size: Large logs trigger checkpoint creation for better storage management.
Compaction: Delta Lake merges smaller transaction logs, often triggering checkpoints to optimize performance.

4. Spark Configuration to Control Checkpoint Generation

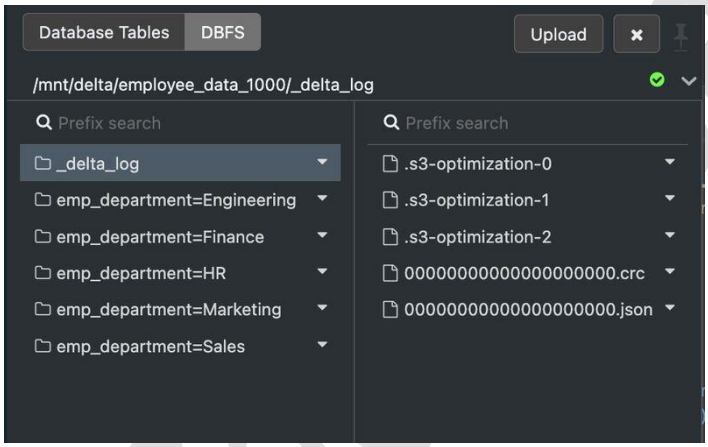
---
spark.databricks.delta.checkpointInterval: Controls the frequency of checkpoint file creation (default is 10 commits).
spark.databricks.delta.retentionDurationCheck.enabled: Enables retention policy for log and checkpoint file cleanup, ensuring efficient storage management.

5. Conclusion

Optimized Performance: Checkpoints help Delta Lake query efficiently by reducing overhead.

Data Consistency:

They maintain consistency between metadata and data files.
Scalability: Proper management of checkpoints and transaction logs ensures Delta Lake scales effectively.
I have attached a snapshot of checkpoint file also for reference.



- **So it is going to give the fault tolerance and resiliency to our streaming data. So the terms that you are seeing over there, it is to develop the fault tolerant and resilient spark applications.**
- **So to better understand the fault tolerance and the resilient terms, if there is any failure that occurs during the copy of this particular stream, spark is smart enough to start from the point of failure because it is going to store the intermediate metadata in the checkpoints. It will go to the checkpoint location, and it is going to see till where the data is copied, and it is going to begin the data copy from there.**

- **So this gives the fault tolerant to this particular spark structure streaming, where the intermediary of the state is copied to particular directory.**
- **To check "appendtable" files: got to "Database Tables"-> "Stream"-> "appendtable".**
- **To check parquet files: got to "DBFS"-> "user"->"hive"->"warehouse"-> "stream.db".**

- **In "Spark UI" tab, click on "Structure Streaming" there is something called "AppendQuery".**
- **In "DBFS", in "streaming" directory, find "AppendCheckPoint", upload file "Countries4.csv", after executing following code:**

```
WriteStream = ( df.writeStream
        .option('checkpointLocation',f'{source_dir}/AppendCheckpoint')
        .outputMode("append")
        .queryName('AppendQuery')
        .toTable("stream.AppendTable"))
```

- **Keep in mind that: the community edition was designed in a way if the cluster is been terminated, and if you try to create a new cluster, previous databases will not persist, but folder "stream.db" still exists, but "stream.db" won't show any data when run in sql query. This is not issue with Azure databricks.**
- **Now run "Day 10 outputModes.ipynb" file.**

outputModes

OutputMode	Usage	Description
Append	outputMode('append')	The records from incoming streams will be appended to destination
Complete	outputMode('complete')	All the processed rows will be displayed
Update	outputMode('update')	Spark will output only updated rows. This is valid only if there are aggregation results; otherwise, this would be similar to Append mode.

- **OutputMode: The outputMode option in Spark Structured Streaming determines how the streaming results are written to the sink. It specifies whether to append new results, complete results (all data), or update existing results based on changes in the data.**

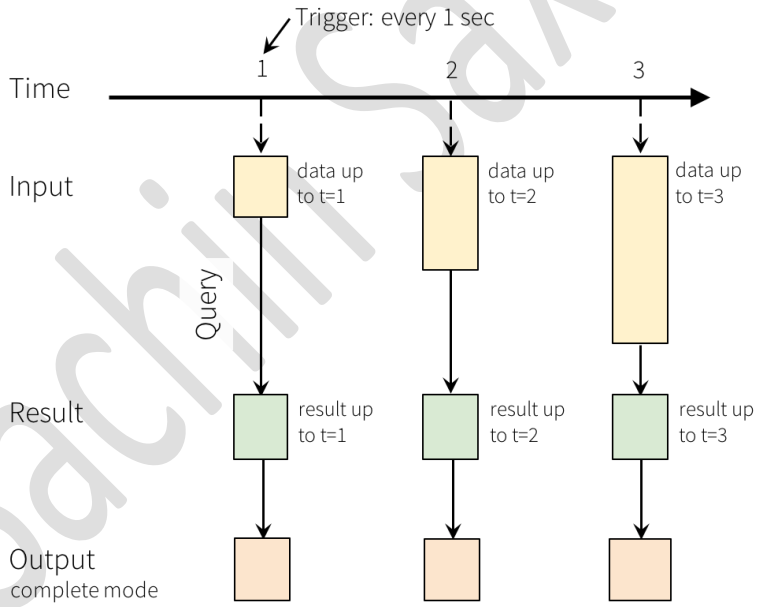
- **When defining a streaming source in Spark Structured streaming, what does the term "trigger" refer to?**
- **Answer: It triggers the start of the streaming application.**

- **Also run "Day 10 Triggers.ipynb" file, how do we know that it actually checked the input folder to know that click on click on "Structure Streaming", in "Spark UI" tab, then click on "Run ID" in "Active Streaming Queries".**

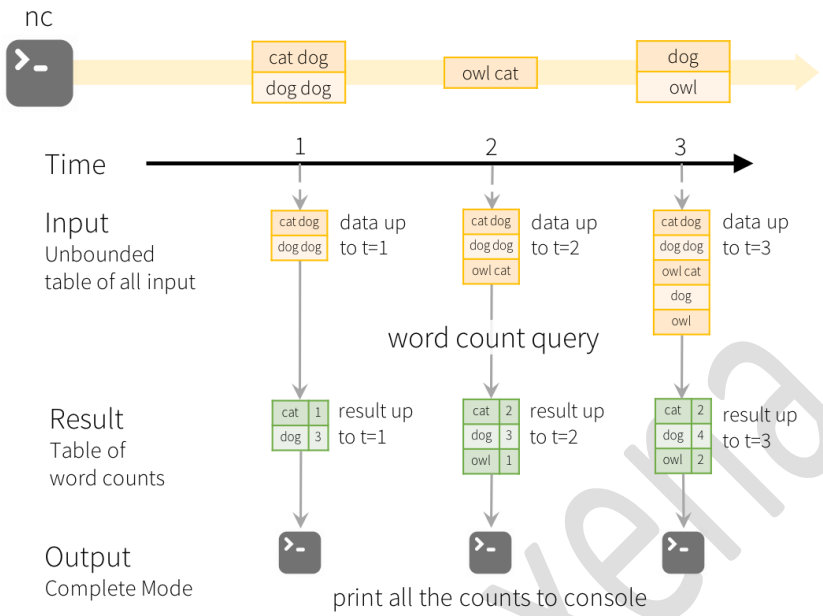
Triggers

Triggers	Usage	Description
Unspecified (default)		will trigger the microbatch for every 500 ms or half a second
processingTime (Fixed Interval)	. trigger(processingTime='2 minutes')	You can set processing time or time interval for each execution .
availableNow (OneTime)	.trigger(availableNow = True)	consumes all available records from previous execution as an incremental batch
Continuous (experimental)	.trigger(continuous = '1 second')	For ~1ms latency

- **Resource: https://spark.apache.org/docs/3.5.3/structured-streaming-programming-guide.html**
- **Resource: https://sparkbyexamples.com/kafka/spark-streaming-checkpoint/**



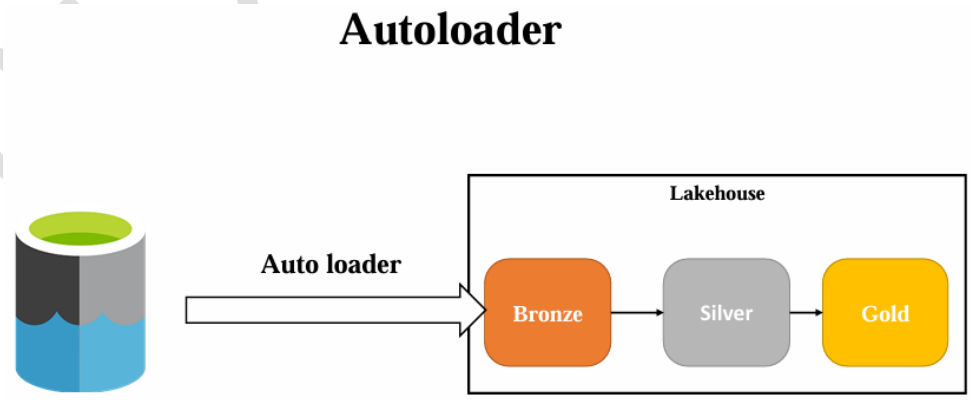
Programming Model for Structured Streaming



Model of the Quick Example

Day 11: Autoloader – Intro, Autoloader - Schema inference: Hands-on

Note: This hands on can be done on Databricks community addition, otherwise, it will result in a significantly high bill.



Why Autoloader?: In this session, let us now see about the auto loader, Let us first understand what exactly is the need of the auto loader before directly going to the definition.

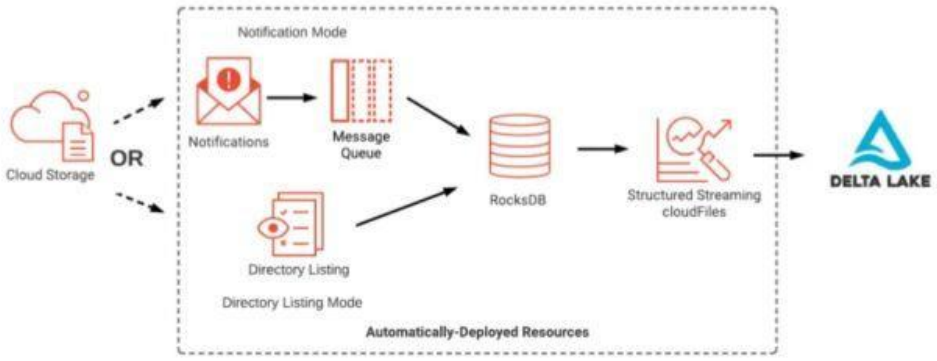
- **So in the real time project we will always have cloud storage where it is going to store our files. So in order to implement medallion architecture or Lakehouse architecture, we will generally read these files from cloud storage to a bronze layer.**

- **Ever Worked with Autoloader??**

Data Handling is one of the crucial segment of any Data related job as proper data planning drives into results which led to efficient and economical storage, retrieval, and disposal of data. When it comes to Data Engineering profile, Data Loading (ETL) plays an equivalent role too.

Data Loading can be done in 2 ways — Full Load or Incremental Load. Databricks provide a great feature with Auto Loader to handle the incremental ETL and taking care of any data that might be malformed and would have been ignored or lost.

Auto Loader supports both Python and SQL in Delta Live Tables and can be used to process billions of files to migrate or backfill a table. Auto Loader scales to support near real-time ingestion of millions of files per hour.



Auto Loader Working

Autoloader

- Autoloader is an **optimized data ingestion tool** that incrementally and efficiently processes new data files as they arrive in the cloud storage built into the Databricks Lakehouse.
- Auto Loader incrementally and efficiently processes new data files as they arrive in cloud storage without any additional setup.
- Auto Loader can load data files from Cloud Storages without being vendor specific (AWS S3 , Azure ADLS , Google Cloud Storage, DBFS).
- Auto Loader can ingest JSON, CSV, PARQUET, AVRO, ORC, TEXT, and BINARYFILE file formats
- This Auto loader is beneficial when you are ingesting data into your lakehouse particularly into bronze layer as a streaming query.

- **Auto Loader is based on Spark Structured Streaming. It provides a Structured Streaming source called cloudFiles.**
- **Reference: https://docs.databricks.com/ingestion/auto-loader/index.html**

- ✓ **Auto Loader Definition: Auto loader monitors a source location, in which files accumulate, to identify and ingest only new arriving files with each command run. While the files that have already been ingested in previous runs are skipped.**
- ✓ **Auto Loader incrementally and efficiently processes new data files as they arrive in cloud storage.**
- ✓ **Reference: https://docs.databricks.com/ingestion/auto-loader/index.html**

- **And from the bronze layer we are going to do the silver and gold and the downstream transformations in a medallion or a lake house project.**
- **Now, in order to get these files from cloud storage, which is like Azure Data Lake in Azure or a lake house project, and we need to ingest the cloud files or the files available in the cloud storage to bronze layer.**
- **So in order to ingest these files, you need to take care of many things. We need to ingest these files incrementally. And there can be billions of files inside the cloud storage. So you need to build a custom logic to handle the incremental loading.**

- **And also this would be quite complex task for any data engineer to set up an incremental load.**
- **Now we also need to handle the bad data. When you are trying to load this to the bronze layer, you need to handle the schema changes and things, etc. all these needs a complex logic to customize and handle these while reading the data from the data lake to bronze layer. So**

all these can be supported without explicitly defining any custom logic by making use of auto loader.

- So auto loader is a feature in the spark streaming, which can handle billions of data incrementally, and it is the best suited auto loader tool to load the data from the files in the cloud storage to bronze layer.

Implementing Autoloader

```
df_str = (spark.readStream
          .format("cloudFiles")     ## This will tell the spark to use AutoLoader.
          .option("cloudFiles.format","csv")  ## Tells Autoloader to expect csv files
          .option('header','true')
          .schema(schema)
          .load(f'{source_dir}')
)
```

- So this is the best beneficial tool when you are trying to ingest the data into your lake house, particularly into the bronze layer as a streaming query, where you can also benefit by making use of triggers. And you can implement this auto loader as a tool, which it can take care of everything for you.

Hands-on: run "Day 11 Autoloader+-+Schema+Evolution.ipynb" file

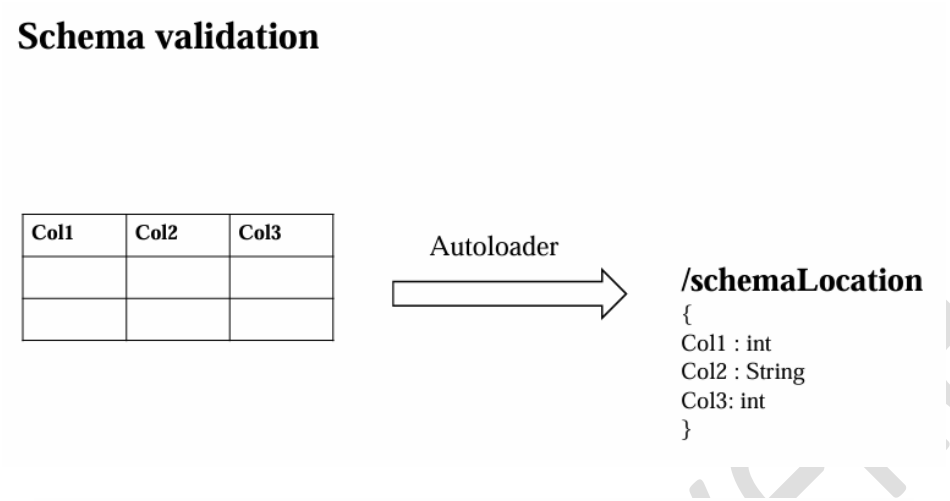
- Inside this file, .format('cloudFiles'), this will tell the spark to use the auto loader here, Cloud files is kind of an API that spark uses to use the auto loader feature.

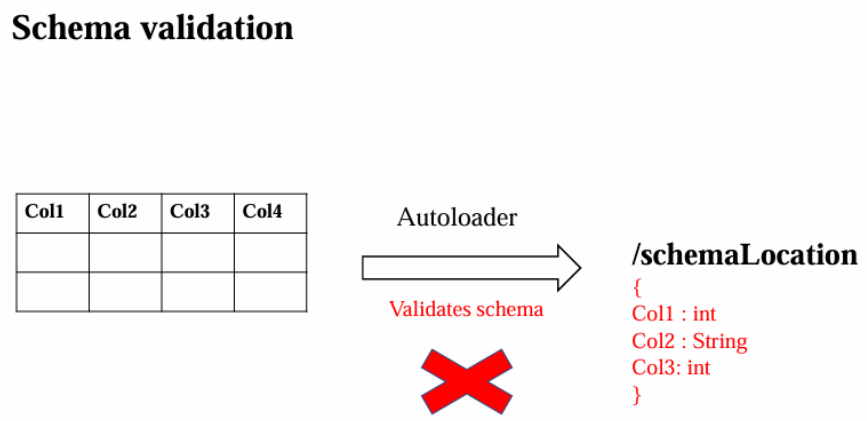
Schema evolution

- Schema evolution is the process of managing changes in data schema as it evolves over time, often due to updates in software or changing business requirements, which can cause schema drift

- Ways to handle schema changes
  - Fail the stream
  - Manually change the existing schema
  - Evolve automatically with change in schema

- **Now we have something called schema where we are trying to define the explicit schema. Now auto loader is smart enough to identify the schema of our source.**





- **So you can just feel free to remove this. And all you need to do is you just need to add something called schema location.**
- **So the schema location path is required because first when it is trying to read the file, it is going to understand the schema of this particular data frame.**
- **"schemaInfer": So auto loader will first try to read the 100 files or the first 50 GB files. And it is going to conclude that this is the schema which it is going to expect. Now that schema will be written to a path where for the further reading, it is going to refer to that particular schema location.**

Schema Evolution: if you are having data ingestion with four columns today and tomorrow, due to some business requirements, there could be a new column to be introduced.

Schema Evolution

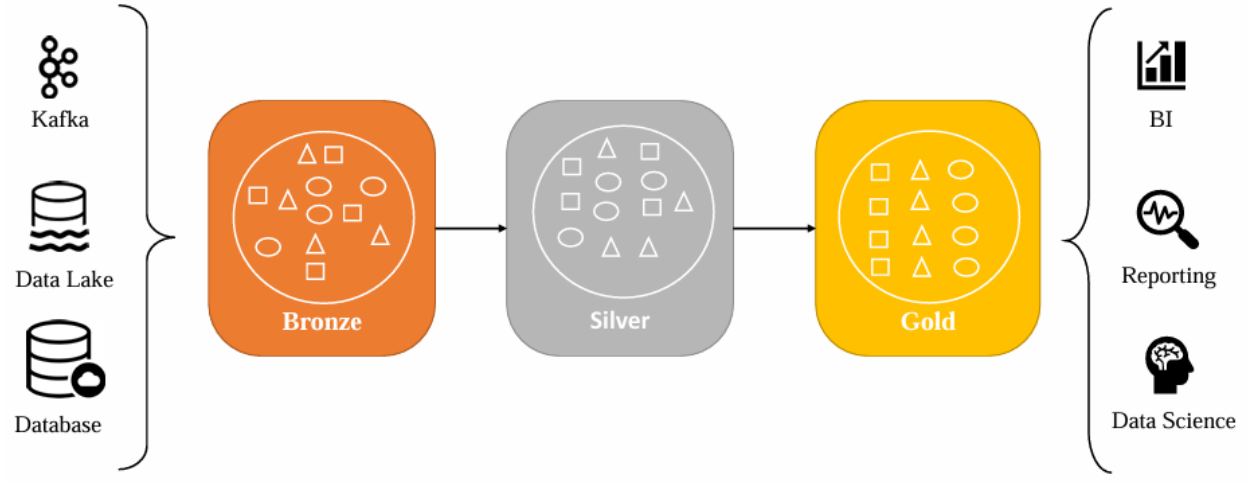
- **addNewColumns** = Stream fails. New columns are added to the schema. Existing columns do not evolve data types.
- **failOnNewColumns** = Stream fails. Stream does not restart unless the provided schema is updated, or the offending data file is removed
- **rescue** = Schema is never evolved and stream does not fail due to schema changes. All new columns are recorded in the rescued data column.
- **none** = ignore any new columns (Does not evolve the schema, new columns are ignored, and data is not rescued unless the rescuedDataColumn option is set. Stream does not fail due to schema changes.)

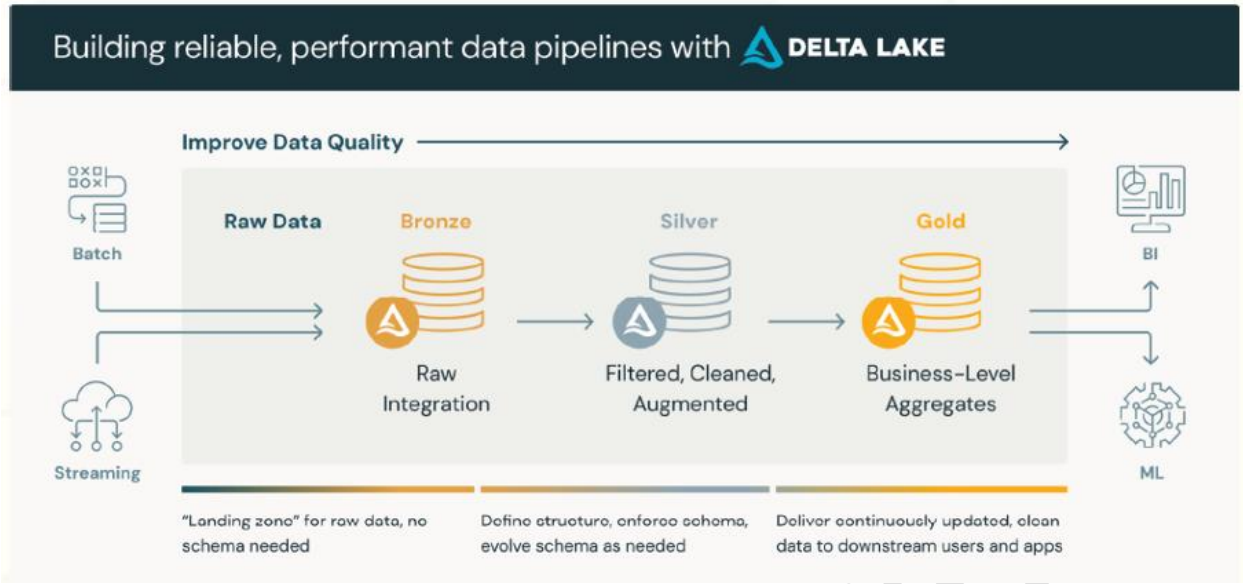
➢ **This will cause a change in the existing schema where we need to evolve our schema, which is called the schema evolution.**

Day 12: Project overview: Creating all schemas dynamically

Medallion Architecture: Let us understand about the medallion architecture. So data engineering is all about quality.

Medallion Architecture





- The goal of the modern data engineering is to distill data with a quality that is fit for downstream analytics and AI. With the Lakehouse, the data quality is achieved on three different levels.
- On a technical level, data quality is guaranteed by enforcing and evolving schemas for data storage and ingestion.
- On an architectural level, the data quality is often achieved by implementing the medallion architecture, where the data that is flowing on through each and every layer in the medallion architecture increases the quality.

- The Databricks Unity Catalog comes with the robust data quality management, with built in quality controls, testing, monitoring, and enforcement to ensure accurate and useful data is available.
- Now with all this, let's understand and implement the medallion architecture.
- This architecture is often referred as a multi-hop architecture. Medallion architecture is a data design pattern used to logically organize the data in a Lakehouse, with the goal of increasingly and progressively improving the structure and quality of the data as it flows through each layer of the architecture.

- Typically we will have three layers bronze, silver, and gold.
- So let's understand this architecture end to end, starting from the data sources. So the data sources can be Kafka streaming data lakes which we will generally use it.
- Or it can be databases where your data is generally getting ingested. All these will be where the data is coming from.
- You can use any of the ETL tool to get this data ingested from an external system. So this generally sits in a data lake folder which we will use in our project. So being specific with Azure we have an Azure Data Factory which is an ETL tool to ingest the data.

- There are 90 plus sources which are supported. And it is going to do some initial loading or the copying of the data to a certain folder, where we often call it as a landing zone.

- Bronze Layer: Now there comes some medallion architecture and that starts with the bronze layer.
- So this bronze layer typically also called as a raw layer. In this the data is first ingested into the system, as is usually in the bronze layer. The data will be loaded incrementally and this will grow in time. The ingested data into the bronze layer can be a combination of batch and streaming, although the data that is kept here is mostly raw. The data in the bronze layer should be stored in a columnar format, which can be a parquet or delta. The columnar storage is great because it stores the data in columns rather than rows. This can provide more option for compression, and it will allow for more efficient querying of the subset of data.
- So this is the primary zone where we will have the exact same data that we receive from our sources without having any modification.
- So this is going to serve as a single source of truth for the downstream transformations.

- Silver Layer: Now next comes would be the silver layer or the curator layer. So this is the layer where the data from the bronze is matched, merged and conformed, or just cleans just enough so that the silver layer can provide the enterprise view.
- So all the key business entities, concepts and transactions will be applied here. So basically we perform the required transformations to the data which can give some basic business value and a quality data where we apply our data quality rules to bring some trustworthiness to the data.
- Also, few transformations on top of like joining merging the data to bring some sense of it. By the end of this silver layer, we can have multiple tables which are generated in the process of transformation.
- And there comes the business level aggregation.

- Golden layer: And the next level would be having this data in a gold layer or a processed layer of the lake house. This is typically organized in a consumption ready project. Specific databases.
- The golden layer is often used for reporting and uses more denormalized and the read optimized data models with fewer joints. This is where the specific use cases and the business level aggregations are applied. So we mentioned the data will flow through this layer.
- And for each and every layer the quality will be increased.

- Coming to bronze the data can be raw and completely unorganized. Whereas for silver we are giving some structure by applying some business level transformations. And there can be a situation you can have completely transformed and ready available data in the silver. And sometimes gold is just for having the views where we have the exact data in silver, and in cases there are some times where the gold layer will have a minimal transformations where we will have the completely organized data.
- Now this organized data is ready for consumption. So data consumers are the one who use this data to drive the business decisions. It can be like by reporting in the data science. So this is on a typical the medallion architecture where this can be used in the projects like they want with different data sources and the data consumers.

- The basic idea is you will have the data flowing throughout these layers, where each layer will have more quality than the previous layer.
- And in our project, also, we will implement this architecture by making use of the data bricks.

Project Details: Hands-on

Step 1: Create Storage account and directories
Step 2: Create Azure Databricks Resource
Step 3: Access Connector for Azure Databricks
Step 4: Add role assignment in Access Control (IAM)
Step 5: Create Metastore from Databricks Notebook
Step 6: create a dev-catalog
Step 7: Create a Compute Resource
Step 8: Create External Storages
Step 9: Part 0 Medallion Architecture Project overview
Step 10: Part 1 Project set up Creating bronze Tables Dynamically
Step 11: Load to Bronze
Step 12: Silver Traffic Transformations
Step 13: To re-use common functions and variables
Step 14: Silver - Roads Transformation

① create storage acnt in sachinsax-gmail (Ext # sachinsax@gmail.onmicrosoft.com (master) admin) "databricksdevstg"

② create ~~three~~ Four containers "landing", "medallion" and "checkpoints". and "metastoretest".

③ Inside "landing" create two directories "raw_roads" & "raw_traffic".

④ Inside "mediallion" create three directories "bronze", "silver", "gold".

⑤⑦ Go to storage account "databricksdevstg" → "Access Control (IAM)" → "Add" → "Add role assignment" → search for "storge blob data contributor" → "Magaged identity" → "select members" → "Access Connectors for Azure Databricks(2)" → "access controllersachin" → "review + assign".

⑤ Create databricks notebook "data-bricks-dev-ws"

⑥ "Access Connectors for Azure Databricks" create a new with name "accesscontrollersachin"

⑧ Go to "Databricks portal" → "Manage account" from right top → "Catalog" → "Create metastore" → Name → meta-store-sachin (जो की metastore successfully connect होगा और External resource का option दिखाई देगा।)
Make sure you are providing different holder name.

⑨ Add a catelog "Dev-catlog" :- "Databricks portal"

"Catalog" → "Add a Catalog" → Dev Catalog
Catalog Name

→ Type "Standard"

⑩ Inside "Databricks" → "Catalog" → "Catalog Explorer" → "External Location"

⑪ Create 5 External locations :- in URL give path

Ⓐ like :- Landing :-

abfss://landing@databricksdustg.dfs.core.windows.net/

storage credinal :- select that big one (manage identity)

checkpoints :-

Ⓑ abfsss://checkpoints@dd.————————

bronze :-

Ⓒ dbfss://medallion@———— net/bronze

silver

Ⓓ "————————/silver

gold

abfss//medillion@———— /gold

(12) Create a schema → from Catalog tab

Schema Name [bronze]

storage location [bronze] (which we defined in external location)

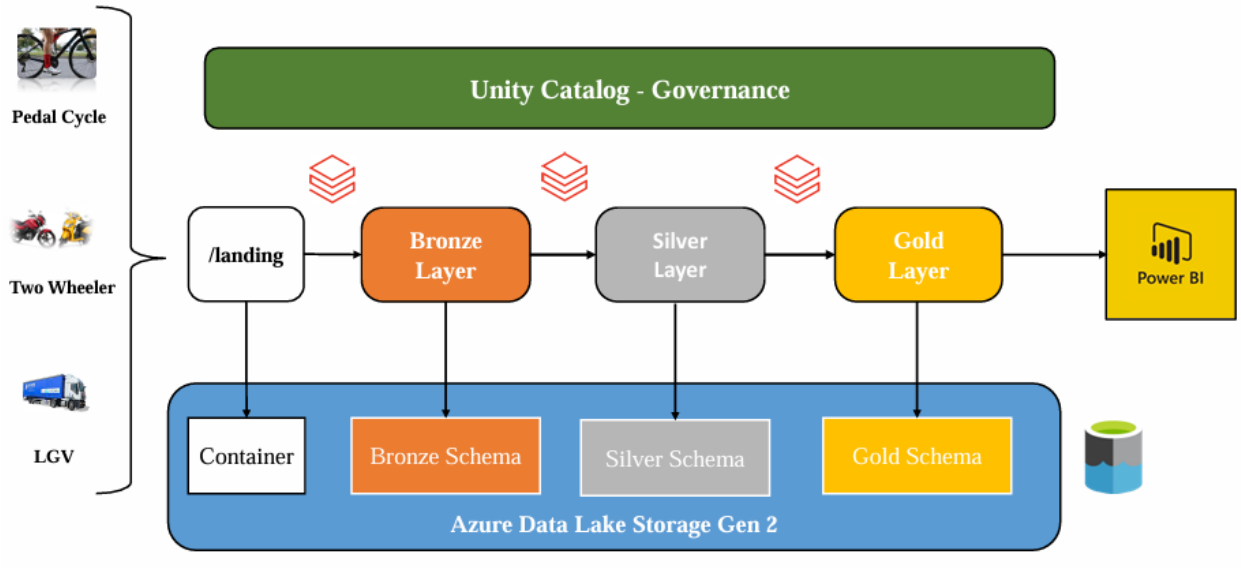
[bronze] → sub path give name here.

→ This is UI based method but we will use code.

(13) create a group and assign this users to this workspace.

(14) give permissions to them.

Project Architecture



Project Architecture Script (Main Points)

1. **Introduction**
   - Recap: Medallion architecture overview from the previous video.
   - Current video focus: Specific project implementation of the architecture.
2. **Data Sources**
   - Use **traffic and roads data** as input.
   - Data will be loaded into a **landing zone** (a container in the data lake).
3. **ETL and Data Ingestion**
   - Typical projects use ETL tools like **Azure Data Factory** for incremental data ingestion.
   - For this course: Manual data input into the landing zone to focus on **Databricks learning**.
   - Multiple approaches exist for ingestion pipelines (not the main focus here).
4. **Landing Zone**
   - Located in **data lake storage** under a specific container.
   - Data manually uploaded for simplicity.
5. **Bronze Layer**
   - Purpose: Store raw data from the **landing zone**.
   - Implementation:
     - Use **Azure Databricks notebooks** to ingest data incrementally.
     - Store data in tables under the **bronze schema** (backed by Azure Data Lake).
   - Transformations: Perform on **newly added records only**.
6. **Silver Layer**
   - Purpose: Perform transformations to refine data.
   - Implementation:
     - Create **silver tables** stored under the **silver schema** in Azure Data Lake.
     - Apply detailed transformations on bronze layer data.
7. **Gold Layer**
   - Purpose: Provide **clean and minimal-transformed data**.
   - Implementation:
     - Create **gold tables** under the **gold schema** in Azure Data Lake.
8. **Data Consumption**

- Final output used by:
  - **Analytics teams**, **data scientists**, and others.
- Data visualization: Import into **Power BI** for insights.

9. **Governance**
   - Govern and back up the entire pipeline with **Unity Catalog**.
10. **Conclusion**
    - Recap of the end-to-end implementation and project focus on Databricks.

Raw Traffic counts dataset

Pedal Cycle

Two Wheeler motor vehicles

Buses and coaches

LGV (Large Goods Vehicle)

HGV (Heavy Goods Vehicle)

Electric Vehicles

Data Dictionary

1. Record ID 2. Count point id 3. Direction of travel 4. Year 5. Count date	Vehicle flow point
6. hour 7. Region id 8. Region name 9. Local authority name 10. Road name 11. Road Category ID 12. Start junction road name 13. End junction road name 14. Latitude 15. Longitude 16. Link length km	Travel info of vehicle
17. Pedal cycles 18. Two wheeled motor vehicles 19. Cars and taxis 20. Buses and coaches 21. LGV Type 22. HGV Type 23. EV Car 24. EV Bike	Count of types of vehicle

Data Dictionary

1. Record ID	=	Uniquely identifies a record
2. Count point id	=	A unique reference for the road link
3. Direction of travel	=	Direction of travel
4. Year	=	Year it happened
5. Count date	=	The date when the actual count took place
6. hour	=	Hour 7 represents from 7am to 8am, and 17 tells from 5pm to 6pm.
7. Region id	=	Website region identifier
8. Region name	=	The name of the Region that travel took place
9. Local authority name	=	Local authority that region
10. Road name	=	This is the road name (for instance M25 or A3).
11. Road Category ID	=	Uniquely identifies road ID
12. Start junction road name	=	The road name of the start junction of the link
13. End junction road name	=	The road name of the end junction of the link
14. Latitude	=	Latitude of the Location
15. Longitude	=	Longitude of the Location
16. Link length km	=	Total length of the network road link
17. Pedal cycles	=	Counts for pedal cycles
18. Two wheeled motor vehicles	=	Counts of Two wheeled motor vehicles
19. Cars and taxis	=	Counts of Cars and taxis
20. Buses and coaches	=	Counts of Buses and coaches
21. LGV Type	=	Counts of LGV Type
22. HGV Type	=	Counts of HGV Type
23. EV Car	=	Counts of EV Car
24. EV Bike	=	Counts of EV Bike

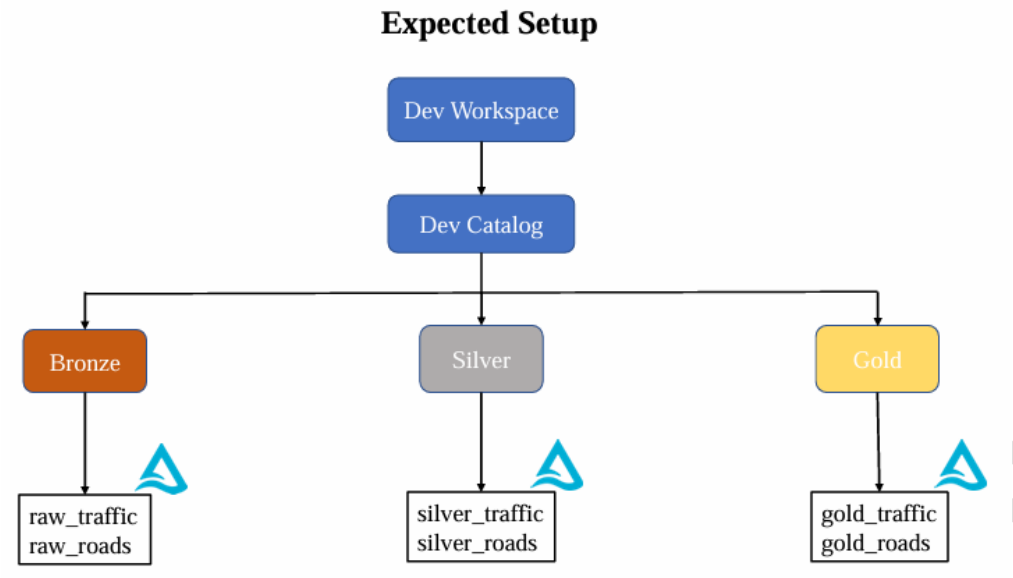
Raw Roads dataset

Road Category

Road Types

Dr Sachin Saxena
Follow on LinkedIn

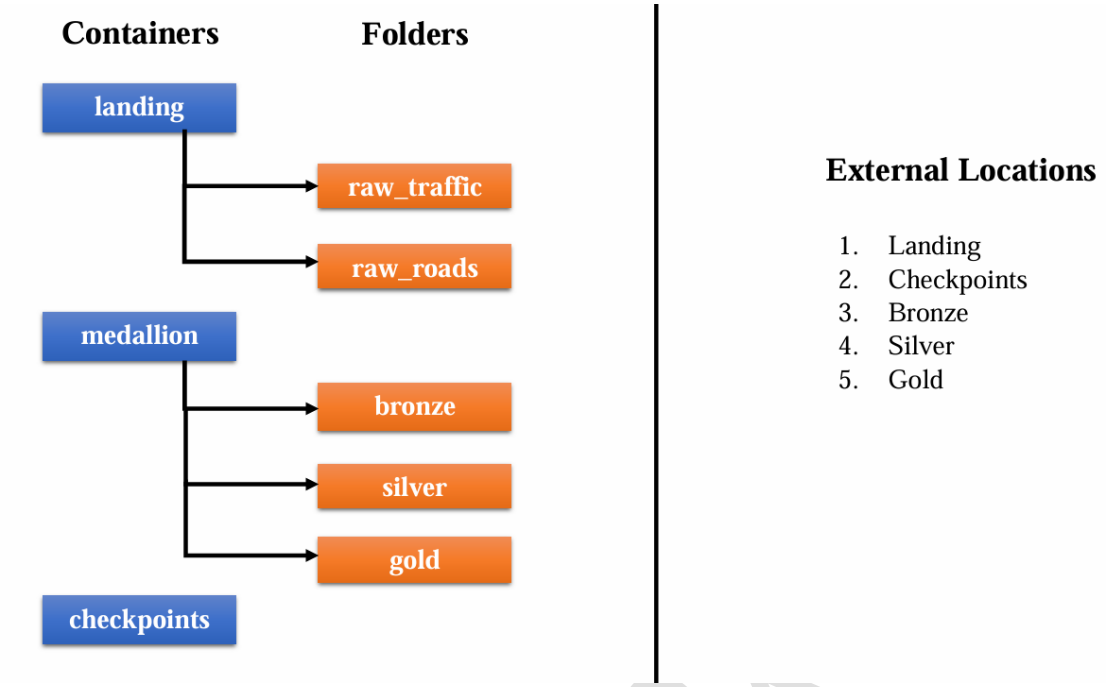
- **Expected Setup pre-requisitive:** **We need to set up a multi-hop architecture setup. In lack house architecture, we have Bronze, Silver and Golden Layers.**



- **And we are going to create the two tables which are raw traffic and the raw roads. But let us now see the complete setup so that you can get an idea on what are the tables we are going to create and what format they should be in.**
- **So once these tables are created and once these are having the data, like taking the data from the landing to bronze, so the raw traffic and the raw Rhodes will have the data and we will perform the required transformations on them.**

⇨

- **Hands-on Activity in Azure portal: Create three containers, first container will be "Landing container", which will consist both "traffic" and "roads" datasets.**



- Hands-on Activity in Azure portal: Create three containers, “landing”, “medallion”, and ”checkpoints”.
- In “landing” containers, create two directories: “raw_roads” and “raw_traffic”.
- Now in “medallion” conatiner, create three directories: “Bronze“,“Silver“ and “Golden“.
- Hands-on Activity in Databricks portal (which is created through super Admin): inside “Catalog Explorer” click on “External Locations” -> check “Storage Credentials” (you need to create the storage credentials here, because we already have the Databricks Access connector that is having the required role in this particular storage account. So the credentials are already stored by the storage credential. Now you just need to create the external locations.).

Create Five “External locations”:

- Create External Locations through “Create Location” button: first “External location name” is “landing”, select “Storage Credential” from default (which is having very big name), provide the link accordingly. “Test Connection”, it must be green for all checks.
- Similarly, Create second External Locations through “Create Location” button: “External location name” is “checkpoints”, select “Storage Credential” from default (which is having very big name), provide the link accordingly. “Test Connection”, it must be green for all checks.
- Similarly, Create third External Locations through “Create Location” button: “External location name” is “bronze”, select “Storage Credential” from default (which is having very big name), provide the link accordingly. “Test Connection”, it must be green for all checks. Give extra path at the end of “URL” “/bronze”, bcs we have extra directory there.
- Similarly, Create forth External Locations through “Create Location” button: “External location name” is “silver”, select “Storage Credential” from default (which is having very big name),

provide the link accordingly. “Test Connection”, it must be green for all checks. Give extra path at the end of “URL” “/silver”, bcs we have extra directory there.

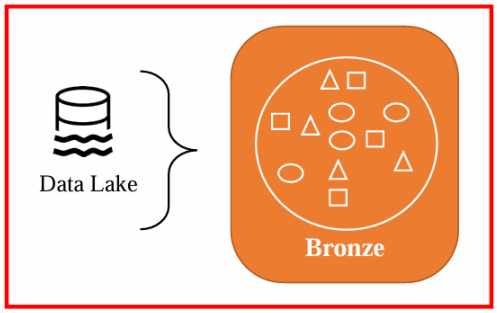
- Similarly, Create fifth External Locations through “Create Location” button: “External location name” is “gold”, select “Storage Credential” from default (which is having very big name), provide the link accordingly. “Test Connection”, it must be green for all checks. Give extra path at the end of “URL” “/gold”, bcs we have extra directory there.
-
-

Day 13: Ingestion to Bronze: raw_roads data to bronze Table

Reference: To be published

Details: to be added

Ingesting data to Bronze Layer



Schema: bronze

Tables:

1. raw_traffic
2. raw_roads

Day 14: Silver Layer Transformations: Transforming Silver Traffic data

Reference:

Renaming Columns

1. Record ID	Record_ID
2. Count point id	Count_point_id
3. Direction of travel	Direction_of_travel
4. Year	Year
5. Count date	Count_date
6. hour	hour
7. Region id	Region_id
8. Region name	Region_name
9. Local authority name	Local_authority_name
10. Road name	Road_name
11. Road Category ID	Road_Category_ID

Details:

Creating Electric_Vehicles_Count

1. Record_ID	1. Record_ID
2. Count_point_id	2. Count_point_id
3. Direction_of_travel	3. Direction_of_travel
4. Year	4. Year
5. Count_date	5. Count_date
6. hour	6. hour
7. Region_id	7. Region_id
.	.
.	.
24. EV_Bike	24. EV_Bike
	25. Electric_Vehicles_Count

Creating Motor_Vehicles_Count

1. Record_ID
2. Count_point_id
3. Direction_of_travel
4. Year
5. Count_date
6. hour
7. Region_id
.
.
25. Electric_Vehicles_Count

1. Record_ID
2. Count_point_id
3. Direction_of_travel
4. Year
5. Count_date
6. hour
7. Region_id
.
.
25. Electric_Vehicles_Count
26. Motor_Vehicles_Count

Two_wheeled_motor_vehicle + Cars_and_taxis + Buses_and_coaches + LGV_Type + HGV_Type + Electric_Vehicle_Count

Transforming Raw Roads dataset:

Renaming Columns

1. Road ID
2. Road category id
3. Road category
4. Region id
5. Region name
6. Total link length km
7. Total link length miles
8. All motor vehicles

1. Record_ID
2. Road_category_id
3. Road_category
4. Region_id
5. Region_name
6. Total_link_length_km
7. Total_link_length_miles
8. All_motor_vehicles

Creating Road_Category_Name

1. Record_ID
2. Road_category_id
3. Road_category
4. Region_id
5. Region_name
6. Total_link_length_km
7. Total_link_length_miles
8. All_motor_vehicles

1. Record_ID
2. Road_category_id
3. **Road_category**
4. Region_id
5. Region_name
6. Total_link_length_km
7. Total_link_length_miles
8. All_motor_vehicles
9. Road_Category_Name

When **Road_Category** = TA THEN Class A Trunk Road
When **Road_Category** = TM THEN Class A Trunk Motor
When **Road_Category** = PA THEN Class A Principal road
When **Road_Category** = PM THEN Class A Principal Motorway
When **Road_Category** = M THEN Class B road

Creating Road_Type

1. Record_ID
2. Road_category_id
3. Road_category
4. Region_id
5. Region_name
6. Total_link_length_km
7. Total_link_length_miles
8. All_motor_vehicles
9. Road_Category_Name

1. Record_ID
2. Road_category_id
3. Road_category
4. Region_id
5. Region_name
6. Total_link_length_km
7. Total_link_length_miles
8. All_motor_vehicles
9. **Road_Category_Name**
10. Road_Type

WHEN **Road_Category_Name** Contains Class A THEN Major
WHEN **Road_Category_Name** Contains Class B THEN Minor

Transforming & Loading Silver datasets:

Creating Vehicle_Intensity

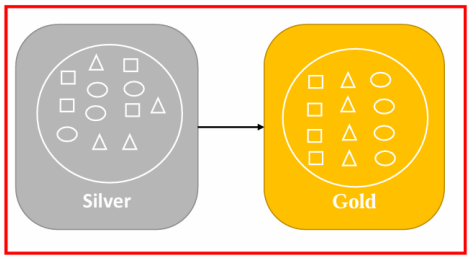
1. Record_ID
2. Count_point_id
3. Direction_of_travel
4. Year
5. Count_date
6. hour
7. Region_id
.
.
26. Motor_Vehicles_Count

1. Record_ID
2. Count_point_id
3. Direction_of_travel
4. Year
5. Count_date
6. hour
7. Region_id
.
.
26. Motor_Vehicles_Count
27. Vehicle_Intensity

Vehicle Intensity = Motor_Vehicles_Count / Link_length_km

Day 15: Golden Layer: Getting data to Gold Layer

Loading data to Gold Layer



Schema: Gold

Tables:

1. gold_traffic
2. gold_roads

Reference:

Details: to be added

Orchestrating with WorkFlows: Adding run for common notebook in all notebooks

Simplify Your Data Pipeline with Databricks Workflows:

Imagine managing complex data workflows, scheduling tasks, and integrating seamlessly across tools—all in one platform. That's Databricks Workflows for you! But when should you use it, and how? Let's break it down.

🛠️ **When to Use Databricks Workflows:**
- **Automating ETL Pipelines: For transforming large datasets across stages with reliability.**
- **Orchestrating Machine Learning Models: To train, validate, and deploy models at scale.**
- **Managing Cross-Team Collaboration: Ideal for teams managing shared resources and dependencies.**

🌟 **Key Use Cases & Examples:**

1. Data Ingestion Pipelines
Use case: Automate ingestion of streaming or batch data from multiple sources like Azure Event Hub.
Example: A retail company importing transactional data for real-time analytics.

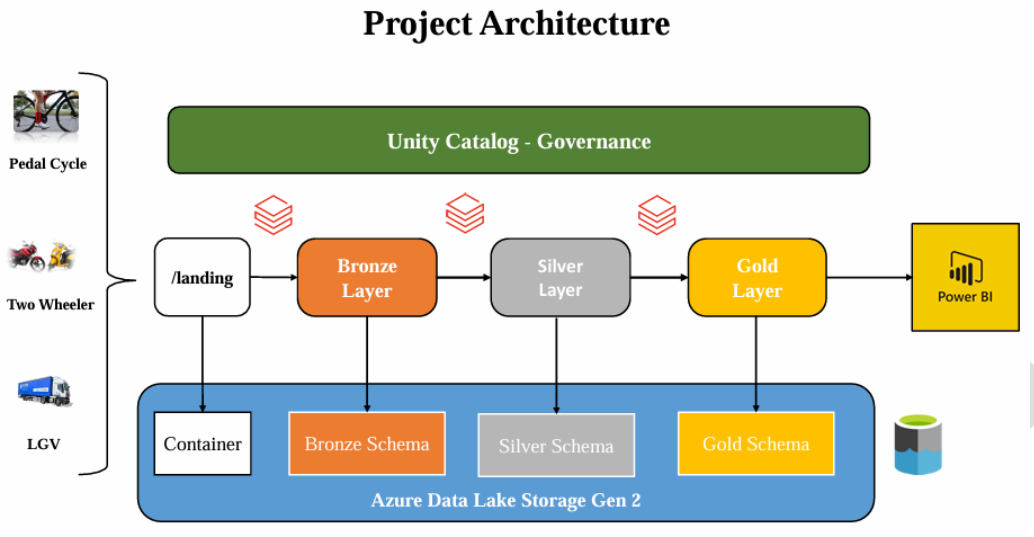
2. ML Workflow Automation
Use case: Training a customer churn prediction model on a nightly basis.
Example: Trigger preprocessing, training, and model evaluation tasks in sequence.

3. Cost Optimization
Use case: Dynamically manage jobs based on demand.
Example: Scale compute resources for ad-hoc analytics during peak hours.

4. End-to-End Data Ops
Use case: Schedule workflows that combine SQL queries, Python scripts, and Spark jobs.
Example: Finance team running daily reconciliation and compliance checks.

🎯 **Why It's a Game-Changer**
-Simplified Orchestration: No need for separate schedulers. Manage everything in Databricks.
- Built-in Monitoring: Get real-time visibility into job runs and logs.
- Flexible Triggers: Schedule, event-based, or manual. You choose.

Day 16: Reporting with PowerBI



Step 1: Login with sachinsax_gmail.com#EXT#@sachinsaxgmail.onmicrosoft.com who is having "Global Administrator" role.

Step 2: Create ADLS Gen 2 instance: Inside ADLS Gen 2, create a ADLS Gen 2 with name "deltadbstg", create a container with name "test", inside this container add a directory with name "sample", upload a csv file name "countires1.csv".

Step 3: Databricks instances and Compute resource: Inside Databricks instances: Create a compute resource with Policy: "Unrestricted", "Single node", uncheck "Use Photon Acceleration", select least node type.

Step 4: "Access connectors for Azure Databricks": search for "Access connectors for Azure Databricks", create "New", only give resource group name and Instance name "access-connectors-sachin" here, you need not to change anything here. Click on "Go to Resource". Now in "Overview", "Resource ID", can use this "Resource ID" while creating the Metastore.

Step 5: Now give access of this Access connectors to ADLS Gen2, go to ADLS Gen2, go to "Access Control IAM" from left pane, click on "Add"-> "Add Role Assignment"-> search for "Storage Blob Data Contributor", in "Members", select "Assign Access to"->"Managed Identity" radio button, "+Select Members"-> select "Access connectors for Azure Databricks" under "Managed identity" drop down menu-> "Select"-> "access-connectors-sachin" -> "Review+Assign".

Step 6: Create a catalog with name 'test-catalog': Go to "Catalog" tab, "Catalog Explorer" -> click on "Create Catalog" from right, name "Catalog name" as "test-catalog", type as "Standard", skip "Storage location". Click on "Create". Create a catalog with name 'test-catalog' inside Databricks instances.

Step 7: It's time to give permission, in Databricks portal, click on "Manage Account", from right top, this Databricks portal is created neither by Workspace admin nor developer, in order to give permission, click on "Workspaces", click on respective "Workspace" -> inside it "permissions"-> "Add Permissions"-> we need to add groups which we created in Step 8, to admin group assign "Permission" as "Admin" and to developer group assign "Permission" as "User".

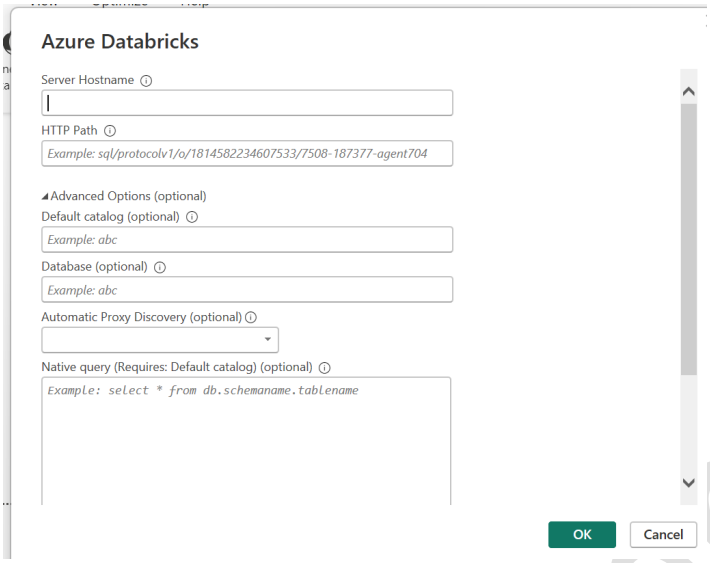
Step 8: Grant Permission: Click on "test-catalog", then "Permissions", then "Grant", this screen is Unity catalog UI to grant privileges to "Sachin Admin", then click on "Grant", select group name "WorkSpace admins" checkbox on "create table", "USE SCHEMA", "Use Catalog" and "Select" in "Privileges presets", do not check anything here. Click on "Grant". Now, go to "Sachin Admin" databricks portal, "test-catalog" is showing here.

Step 9: Enable and creating Metastore: Now go to Databricks, we need to start a creating a meta store, meta store is top level container in the unity catalog, go "Manage Account" under "Sachindatabricks name" from right top -> "Catalog" from left pane, "create meta store", provide "Name" as "metastore-sachin","Region"(can create one meta store in single region), "ADLS Gen2 path" (go to ADLS Gen2-> create container-> "Add Directory", paste <container_name>@<storage_account_name>.dfs.core.windows.net/<directory_Name> In the sample format of test@ deltadbstg.dfs.core.windows.net/files

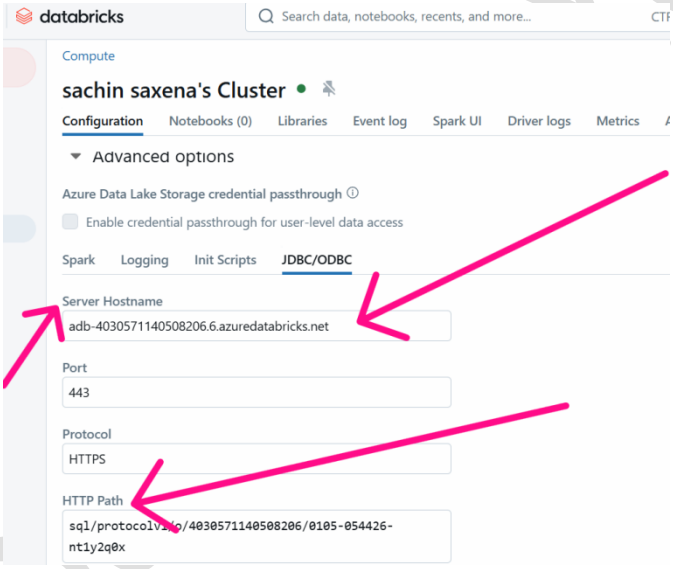
- **Or test@deltadbstg123456.dfs.core.windows.net/files), "Access connector ID" (go to "Access connectors"-> "access-connectors-sachin" -> copy that "resource ID")-> "Create".**
- **Attach with any workspaces. "Enable Unity Catalog?"-> "Enable".**

Step 10: Run "Day 13 Databricks to PowerBI.ipynb" file to create tables using Pyspark code.

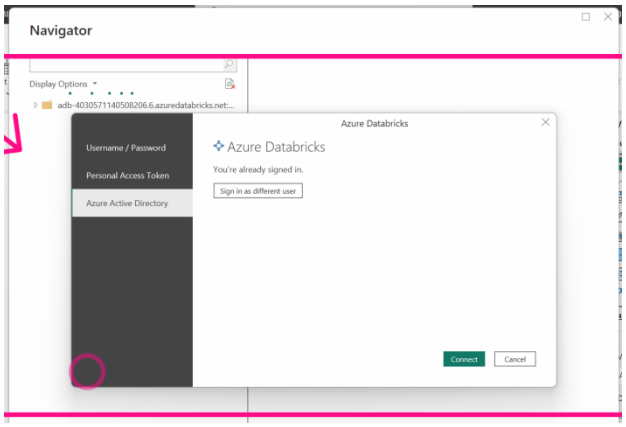
Step 11: Connect to PowerBI, open Power BI dashboard, open "Get Data", search for "Azure Databricks",

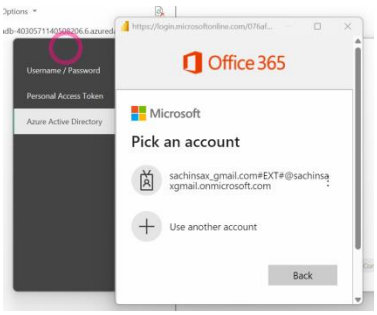


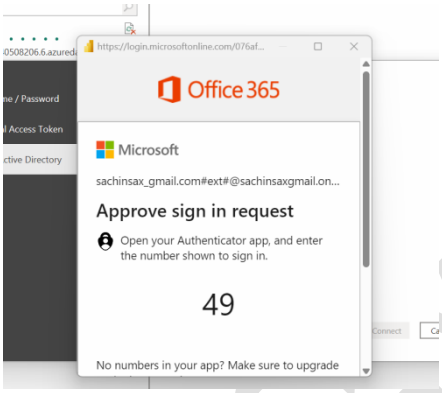
Server Hostname and HTTP path is given in Databricks's compute resource under JDBC/ODBC tab,

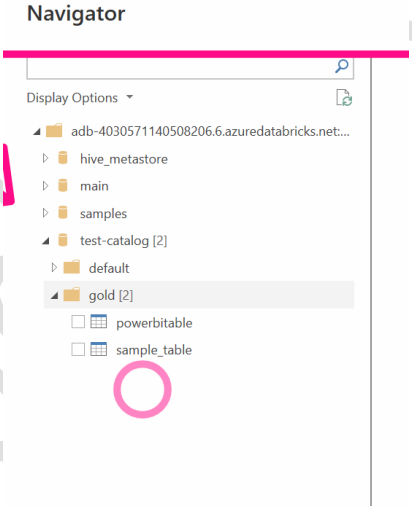


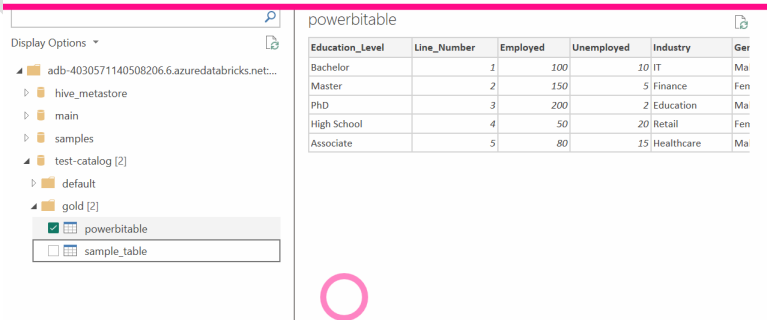
Now, connect using "Azure Active ID", sign-in with your credentials.



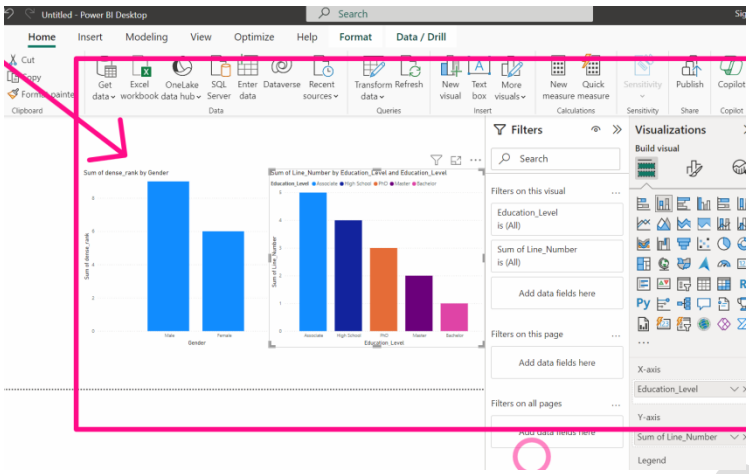








Education_Level	Line_Number	Employed	Unemployed	Industry	Ge
Bachelor	1	100	10	IT	Ma
Master	2	150	5	Finance	Fen
PhD	3	200	2	Education	Ma
High School	4	50	20	Retail	Fen
Associate	5	80	15	Healthcare	Ma



Question: does it necessary to connect every unity catalog with any ADLS gen2?

Answer: Yes, it is necessary to connect Unity Catalog with Azure Data Lake Storage Gen2 (ADLS Gen2) when using Azure Databricks. Unity Catalog requires ADLS Gen2 as the storage service for data processed in Azure Databricks. This setup allows you to leverage the fine-grained access control and governance features provided by Unity Catalog.

Here are the key references: How does Unity Catalog use cloud storage?

https://learn.microsoft.com/en-us/azure/databricks/connect/unity-catalog/

Therefore, to use Unity Catalog effectively with Azure Databricks, you must connect it to ADLS Gen2.

Details:

Day 17: Delta Live Tables: End to end DLT Pipeline

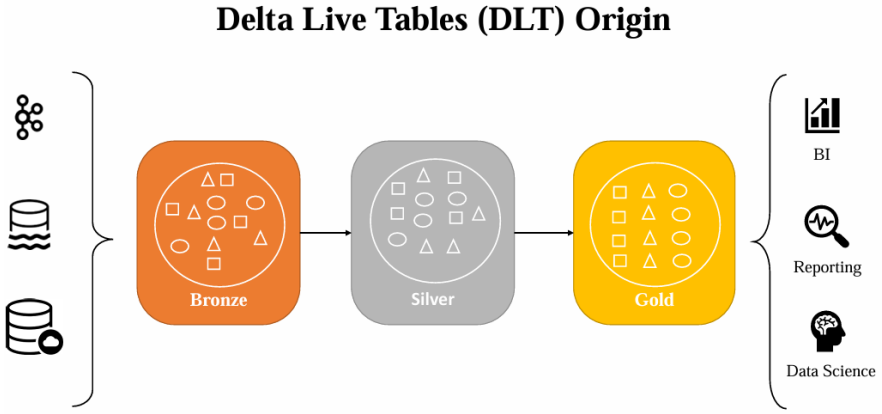
Reference: Unlock the Power of Delta Live Tables (DLT) in Databricks!

Delta Live Tables (DLT) revolutionizes the way you build and manage data pipelines. With a declarative approach, you can define transformations in simple SQL or Python while ensuring data quality and automating operations seamlessly.

What's inside this guide?

✔ Overview of the Databricks Lakehouse platform
✔ Key differences between Data Warehouses and Data Lakes
✔ Building ETL pipelines with DLT
✔ Automating data ingestion using Auto Loader
✔ Implementing Change Data Capture (CDC) with DLT

This comprehensive guide is perfect for anyone looking to streamline their data engineering workflows using Databricks and DLT.



Step 1: Create Databrick Workspace from Azure Portal.

Step 2: Create ADLS Gen 2 Storage-> container with name 'sachinstorage' -> Directory with name 'landing' -> two directory with names 'raw_traffic' and 'raw_roads', upload all 6 csv files in both these directories.

Step 3: search for "Access connectors for Azure Databricks", create "New", only give resource group name and Instance name "access-connectors-sachin" here, you need not to change anything here. Click on "Go to Resource". Now in "Overview", "Resource ID", can use this "Resource ID" while creating the Metastore.

Step 4: Now give access of this Access connectors to ADLS Gen2, go to ADLS Gen2, go to "Access Control IAM" from left pane, click on "Add"-> "Add Role Assignment"-> search for "Storage Blob Data Contributor", in "Members", select "Assign Access to"->"Managed Identity" radio button, "+Select Members"-> select "Access connectors for Azure Databricks" under "Managed identity" drop down menu-> "Select"-> "access-connectors-sachin" -> "Review+Assign".

Step 5: No need of any Unity catalog or External Storage but we require 'Metastore', make path to your metastore as 'landing@ sachinstorage.dfs.core.windows.net' bcs ur data is at same path

Step 6: Create Delta Live table and keep change all the setting, however also switch to JSON view and insert code:

- **"label": "default", //in between this line**
- **"node_type_id": "Standard_DS3_v2", // Insert this code**
- **"num_workers": //in between this line**

Step 7: Insert code file 'Day 14 DLT_Databricks.ipynb' but don't run it.

Step 8: Create 'dev-catlog' from 'catalog' pane also grant relevant permissions to this catalog.

Step 9: First run first two cells and then run DLT Pipeline to initiate first create two tables in dev-catlog and then DLT Pipeline will automatically create relationship or dependencies, Secondly run Third and Forth cells and then run DLT Pipeline to initiate relationship, Thirdly fifth cell in third run of DLT pipeline.

Step 10: Also create 'Job' and instead of 'Notebook', select existing 'Delta Live Table'.

Question: What is DLT in Databricks and How Can It Simplify Your Data Pipelines?

Managing data can be tricky, but Delta Live Tables (DLT) in Databricks is here to help. Let's break down what it is and how it can make your life easier.

What is DLT?

DLT (Delta Live Tables) is a tool in Databricks that helps you easily build and manage data pipelines.

It automates data tasks, ensuring your data is always clean, up-to-date, and ready for analysis.

Whether you're working with large data sets or just a few tables, DLT simplifies the process.

How does DLT work?

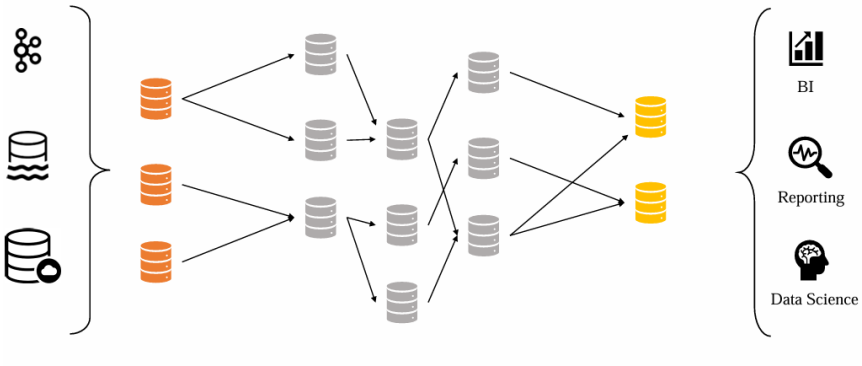
Simple Setup: Use basic SQL or Python to define your data pipelines. No complex coding required.

Automated Data Management: DLT takes care of cleaning, organizing, and updating your data without you having to lift a finger.

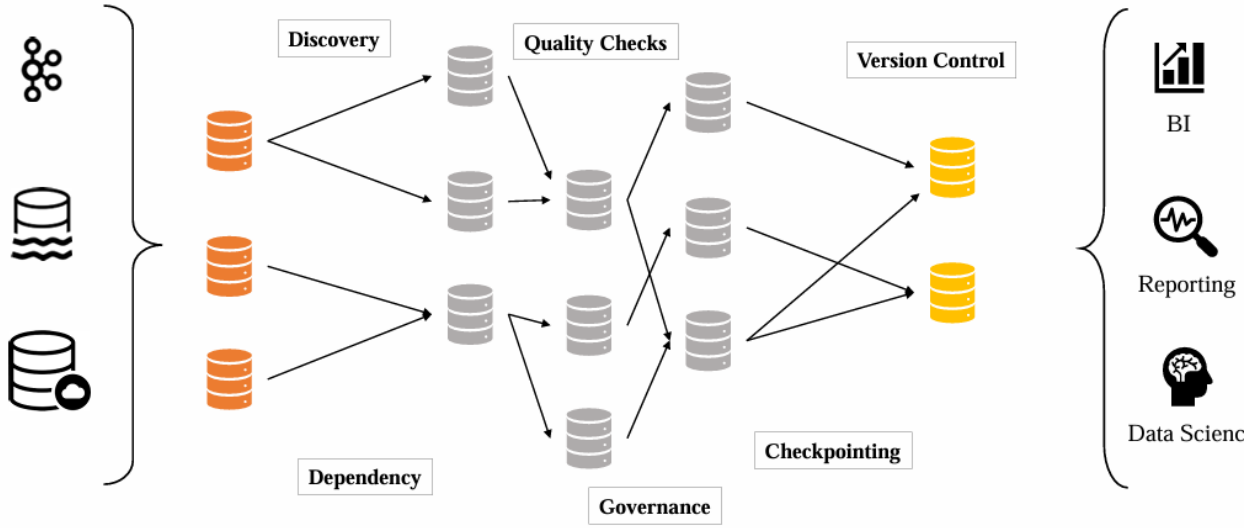
Built-in Data Checks: It ensures your data meets quality standards by running checks automatically.

Data Versioning: Easily track changes in your data and see how it has evolved over time.

Medallion/Lakehouse Architecture Tables



Considerations in Lakehouse Architecture



Declarative programming

Declarative programming say **what should be done ,** not **how to do it**

Procedural programming

```
Numbers = [..]

Sum = 0

For n in numbers:
        sum = sum + n

Print (n)
```

Declarative programming

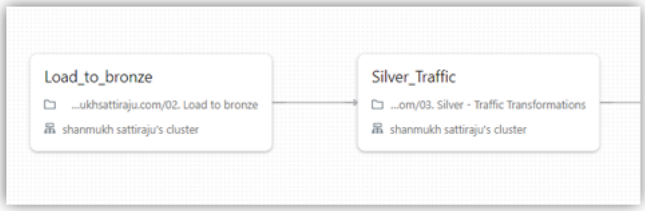
```
SELECT SUM(n)
FROM numbers
```

Declarative ETL with DLT

Declarative programming say **what should be done ,** not **how to do it**

Procedural ETL

- Apache Airflow
- Azure Data Factory



Declarative ETL

Delta live tables

Delta Live Tables (DLT)

Delta Live Tables (DLT) is **a declarative ETL framework** for the Databricks Data Intelligence Platform that helps data teams simplify streaming and batch ETL cost-effectively.

Simply define the transformations to perform on your data and let DLT pipelines automatically manage task orchestration, cluster management, monitoring, data quality and error handling.

Delta Live Table Execution

- Requires premium workspace
- Supports only Python and SQL languages
- Can't run interactively
- No support for magic commands like %run

✓ In DLT pipelines, we use the CREATE LIVE TABLE syntax to create a table with SQL. To query another live table, prepend the LIVE. keyword to the table name.

```
CREATE LIVE TABLE aggregated_sales

AS

SELECT store_id, sum(total)

FROM LIVE.cleaned_sales

GROUP BY store_id
```

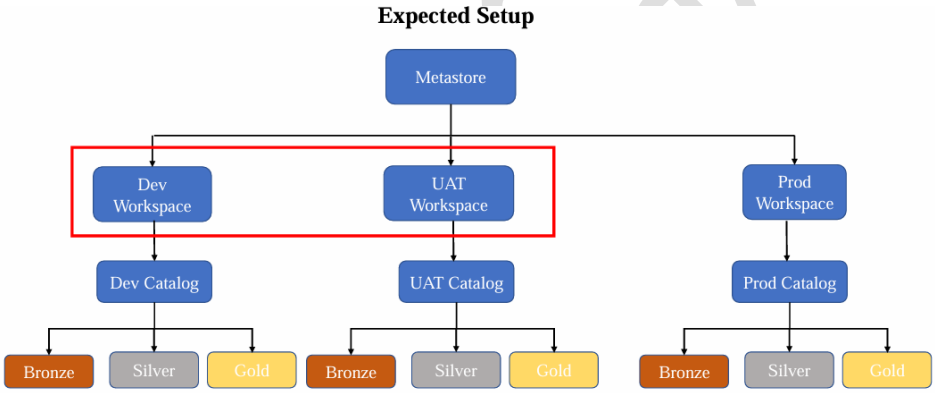
Reference: https://docs.databricks.com/workflows/delta-live-tables/delta-live-tables-sql-ref.html

Expectations in DLT pipeline

Action	Result	Usage
warn (default)	Invalid records are written to the target; failure is reported as a metric for the dataset.	--
drop	Invalid records are dropped before data is written to the target; failure is reported as a metrics for the dataset.	On Violation Drop Row
fail	Invalid records prevent the update from succeeding. Manual intervention is required before	On Violation Fail Update

Day 18: Capstone Project I

Reference:



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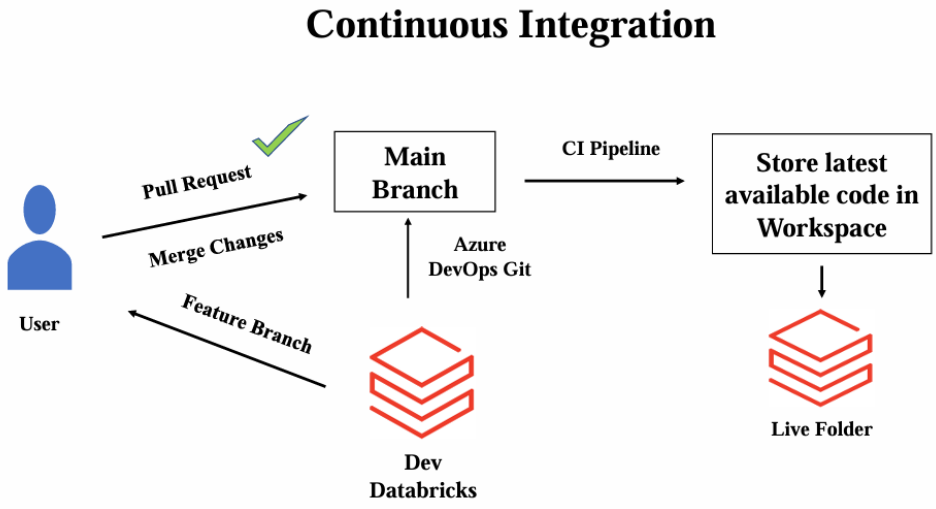
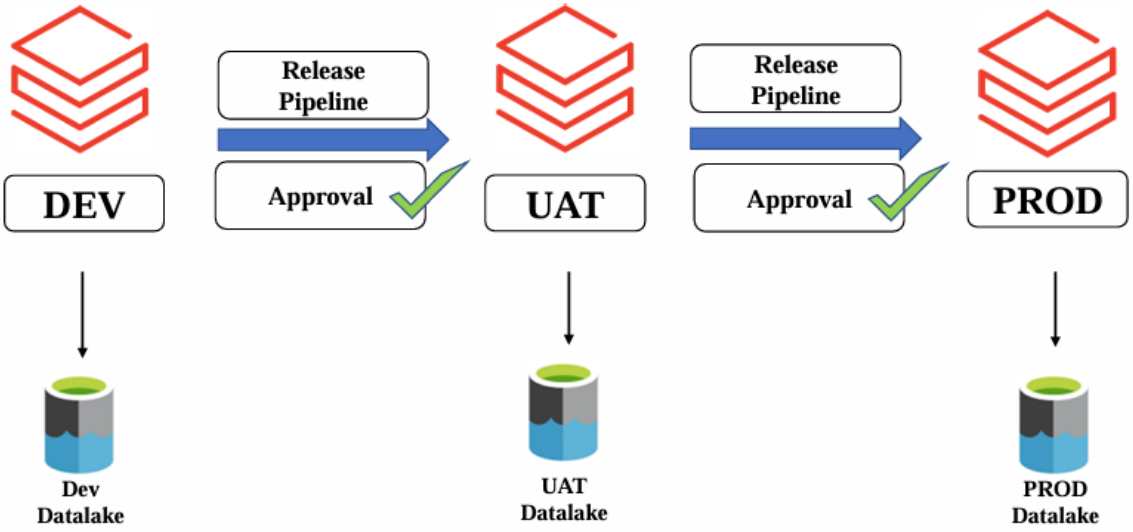


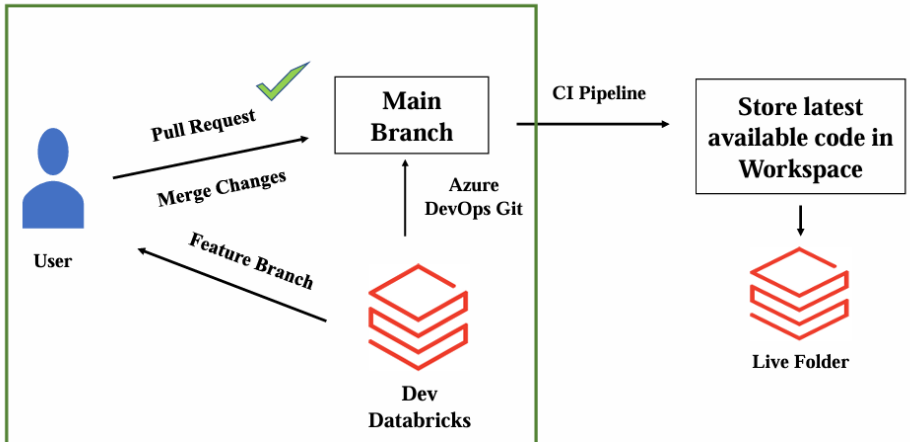
Continuous Deployment



Creating UAT resources in Azure

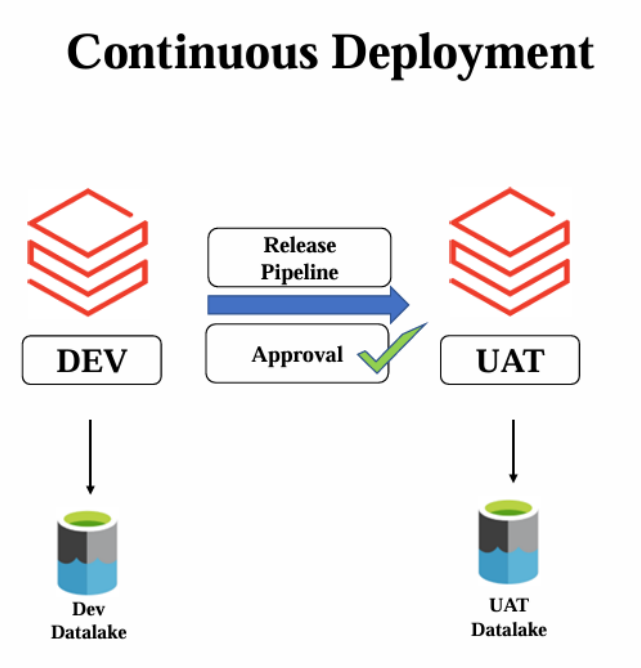
- **Resource Group:** databricks-uat-rg
- **Databricks workspace:** databricks-uat-ws
- **Storage Account:** databricksuatstg

Continuous Integration



Day 19: Capstone Project II

Reference:



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