Pipeline 1

Read MySQL tables using JDBC

Load `customers`, `orders`, and `order_items` from Amazon RDS MySQL into Spark DataFrames using the JDBC URL.

Perform required joins

Join `customers → orders` on `customer_id`, and `orders → order_items` on `order_id` to create a single denormalized dataset.

Select final output columns

Project the combined columns:
`customer_id, name, email, city, order_id, order_date, amount, item_id, product_name, quantity`.

Write to Amazon Keyspaces (Cassandra)

Save the final denormalized DataFrame into the table `retail.sales_data` using the Spark Cassandra Connector with `.mode("append")`.

```
racit@192 ~ % mysql -h database-1.cqr2ksiuua6t.us-east-1.rds.amazonaws.com -u admin -p
Enter password:
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 50
Server version: 8.0.43 Source distribution

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owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

mysql> create database spark
    -> ;
Query OK, 1 row affected (0.369 sec)

mysql> use spark
Database changed
mysql> -- Database: retail_db
Query OK, 0 rows affected (0.285 sec)

mysql> CREATE DATABASE IF NOT EXISTS retail_db;
Query OK, 1 row affected, 1 warning (0.381 sec)

mysql> USE retail_db;
Database changed
mysql>
mysql> CREATE TABLE customers (
    ->   customer_id INT PRIMARY KEY,
    ->   name VARCHAR(255),
    ->   email VARCHAR(255),
    ->   city VARCHAR(100)
    -> );
Query OK, 0 rows affected (0.320 sec)
```
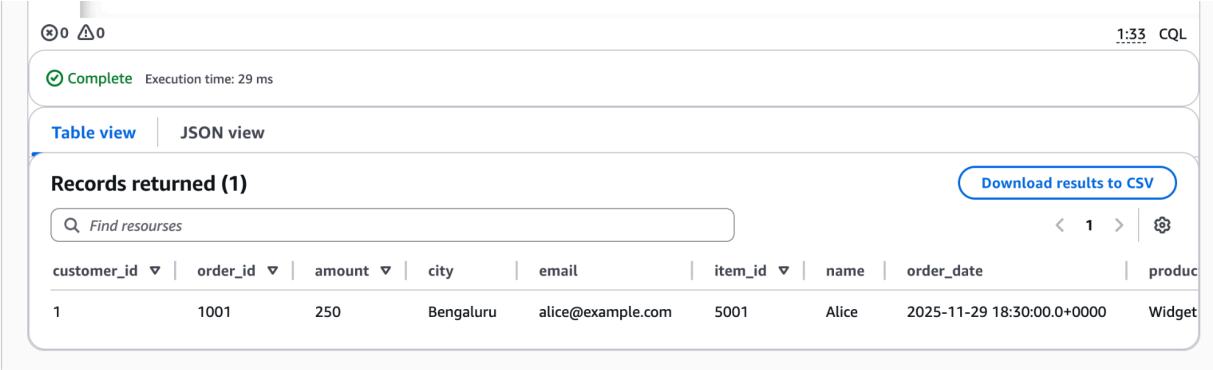



Pipeline 2

Pipeline 2 — Keyspaces → Spark → Parquet on S3

1. **Spark Session Setup**
    - Configured Spark locally with required **Amazon Keyspaces (Cassandra)** credentials and SSL settings.
    - Added **S3A configurations** with correct region, endpoint, and AWS access keys.
2. **Read from Amazon Keyspaces**

Loaded the `sales_data` table from Keyspace `retail` using the Cassandra Spark connector:

spark.read.format("org.apache.spark.sql.cassandra")

    -
3. **Select Required Columns**
    - Extracted only the necessary fields:
      `customer_id, order_id, amount, product_name, quantity`.
4. **Write to Amazon S3 as Parquet**

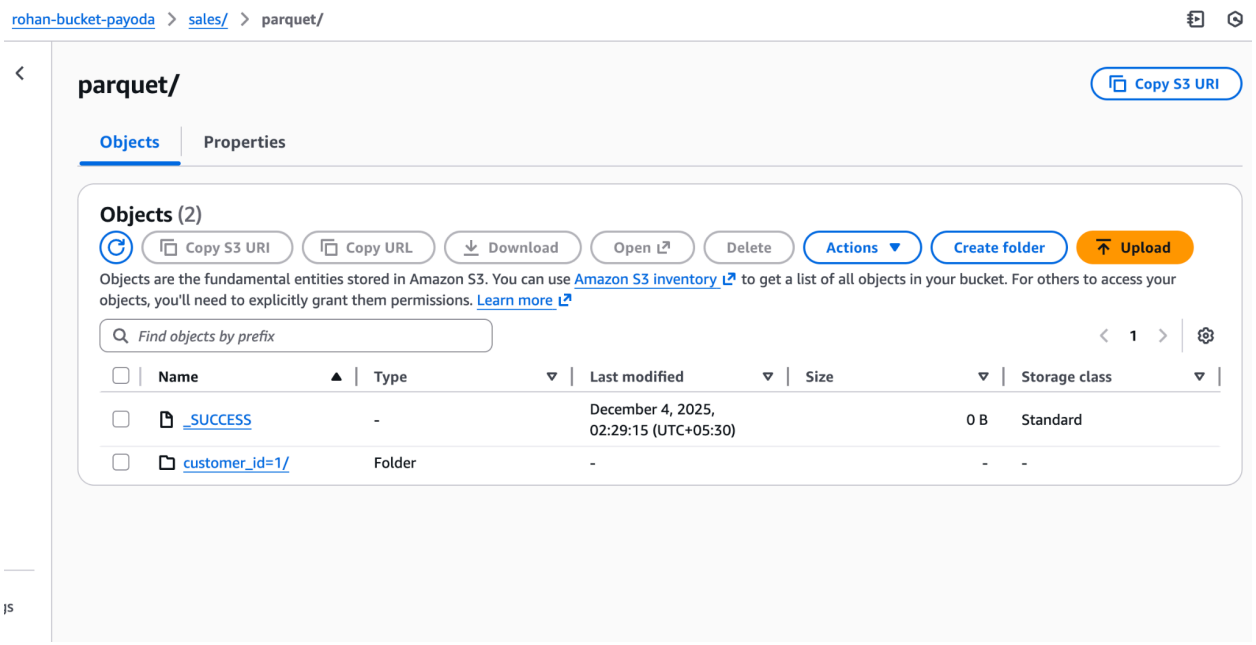
Saved the filtered data to S3 in Parquet format using:

partitionBy("customer_id")

-
- Output stored at:
  `s3a://rohan-bucket-payoda/sales/parquet/`.

5. **Result**

   - Pipeline executes successfully end-to-end:
     Keyspaces → Spark processing → S3 Parquet output, partitioned by customer ID.



Pipeline 3

Parquet → Spark Aggregation → JSON on S3 (Summary)

Spark Session Setup

- Configured Spark locally with S3A access keys and correct endpoint for S3 (ap-south-2).
- Enabled reading of Parquet files stored in your S3 bucket.

Read Parquet from S3

Loaded the Parquet data generated from Pipeline 2:

```
spark.read.parquet("s3a://rohan-bucket-payoda/sales/parquet/")
```

-

Aggregate Product Metrics

- Computed:
    - **total_quantity = SUM(quantity)**
    - **total_revenue = SUM(amount * quantity)** (rounded to 2 decimals)
- Grouped by **product_name** and sorted by **total_revenue** in descending order.

Write Aggregated JSON to S3

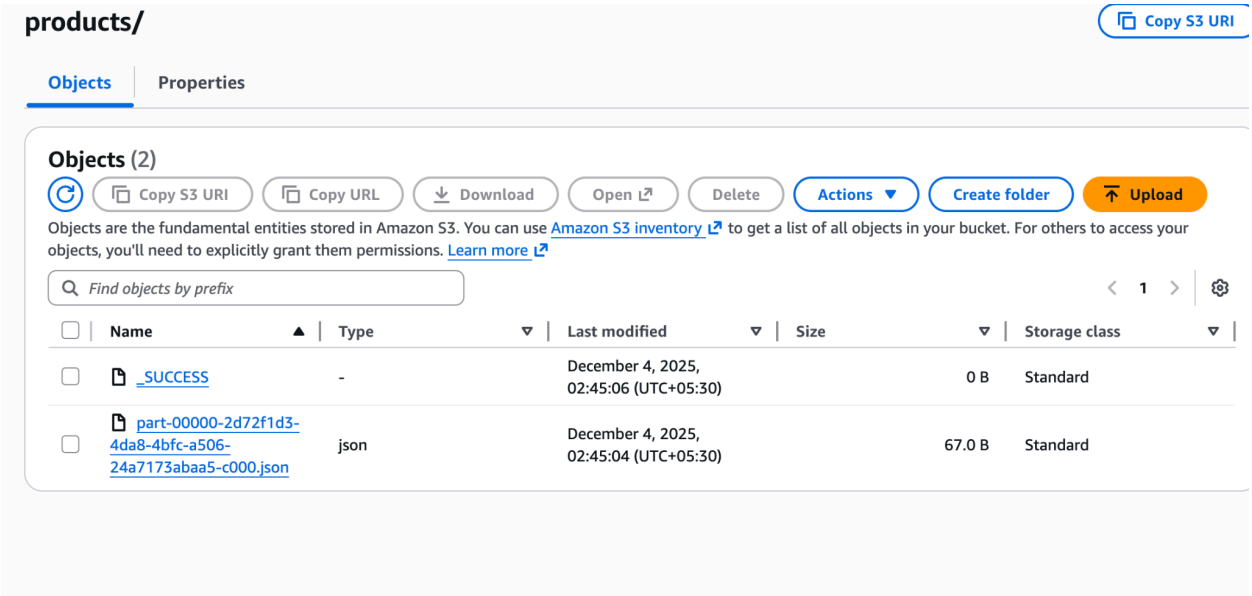
Wrote final aggregated result to S3 as JSON:

```
s3a://rohan-bucket-payoda/aggregates/products/
```

-
- Used `coalesce(1)` to generate a single JSON output file.

Result

- Pipeline runs successfully end-to-end:
  S3 Parquet → Spark Aggregation → Final JSON output stored on S3.



Pipeline 4

- Spark Structured Streaming **polls the `new_orders` MySQL table every 5 seconds** using `order_id` to detect new rows.
- Any **newly added orders** are captured in real-time.
- Each record is **converted into Avro format** using the provided `orders.avsc` schema.
- The **Avro-encoded records are sent to the Kafka topic** `orders_avro_topic`.
- This enables a **streaming pipeline** from MySQL → Spark → Kafka in near real-time.

```
racit@192 kafka_2.13-3.5.1 % kafka-topics.sh --list --bootstrap-server localhost:9092

__consumer_offsets
orders_avro_topic
visitor.checkin
racit@192 kafka_2.13-3.5.1 % bin/kafka-console-consumer.sh \
  --bootstrap-server localhost:9092 \
  --topic orders_avro_topic \
  --property print.key=true \
  --from-beginning

2001    ?Y@02025-12-03T10:00:00.000Z
2006    ??i@02025-12-04T07:08:26.000Z
2007    ???b@02025-12-04T07:08:26.000Z
2008    ???t@02025-12-04T07:08:26.000Z
2009    ???y@02025-12-04T07:08:26.000Z
2010    ?????(\?X@02025-12-04T07:08:26.000Z
```

```
mysql> select * from new_orders
    -> ;
+----------+-------------+--------+---------------------+
| order_id | customer_id | amount | created_at          |
+----------+-------------+--------+---------------------+
|     2001 |           1 |    100 | 2025-12-03 10:00:00 |
|     2006 |         106 |  200.5 | 2025-12-04 07:08:26 |
|     2007 |         107 | 150.75 | 2025-12-04 07:08:26 |
|     2008 |         108 |    330 | 2025-12-04 07:08:26 |
|     2009 |         109 | 410.25 | 2025-12-04 07:08:26 |
|     2010 |         110 |  99.99 | 2025-12-04 07:08:26 |
+----------+-------------+--------+---------------------+
6 rows in set (0.248 sec)

mysql>
```


```
mysql> select * from new_orders
    -> ;
+----------+-------------+--------+---------------------+
| order_id | customer_id | amount | created_at          |
+----------+-------------+--------+---------------------+
|     2001 |           1 |    100 | 2025-12-03 10:00:00 |
|     2006 |         106 |  200.5 | 2025-12-04 07:08:26 |
|     2007 |         107 | 150.75 | 2025-12-04 07:08:26 |
|     2008 |         108 |    330 | 2025-12-04 07:08:26 |
|     2009 |         109 | 410.25 | 2025-12-04 07:08:26 |
|     2010 |         110 |  99.99 | 2025-12-04 07:08:26 |
+----------+-------------+--------+---------------------+
6 rows in set (0.248 sec)

mysql>
```


Pipeline 5

Spark Streaming Setup: A Spark Structured Streaming job reads messages from the Kafka topic `orders_avro_topic` using `readStream` with proper Kafka options (`bootstrap.servers`, `startingOffsets`, etc.).

Avro Decoding: Each Kafka message in Avro format is decoded into a DataFrame with proper columns (`order_id`, `customer_id`, `amount`, `created_at`) using `from_avro` and an Avro schema.

Data Transformation: A `processing_time` column is added to track ingestion, and the DataFrame schema is printed for verification.

JSON Write to S3: Using `foreachBatch`, each micro-batch is written to the configured S3 path in JSON format with `batchDF.write.json(...)`, optionally coalescing files to reduce small files.

Reliability: S3 Hadoop configurations and checkpointing are configured to ensure continuous streaming and fault tolerance, so every batch of Kafka messages is successfully persisted as JSON in S3.