**Databricks Auto Loader : Best Practices & Learning Story**

This document outlines best practices for using **Auto Loader** in Databricks, based on practical exercises and real-world examples.

## Purpose of Auto Loader

Auto Loader is a high-performance, incremental ingestion tool in Databricks designed to:

* Automatically detect and load **new files** from cloud storage (e.g., ADLS, S3, GCS).
* Efficiently handle **millions of files**.
* Track progress using **checkpoints** and **schema inference**.

## Real-Time Use Case: HR Employee Data Ingestion

**Scenario**:

* Files like employee\_1.csv, employee\_2.csv, etc., land in /mnt/data/autoloader/incoming/
* They contain HR records: id, FirstName, Department
* Objective: Load them into a **Delta Bronze table** with proper tracking and transformation

## Setup Configuration

source\_path = "/mnt/data/autoloader/incoming/"

schema\_path = "/mnt/data/autoloader/schema/people/"

checkpoint\_path = "/mnt/data/autoloader/checkpoints/people/"

target\_path = "/mnt/data/bronze/people/"

## Auto Loader Pipeline with Error Handling

from pyspark.sql.functions import current\_timestamp, input\_file\_name, upper, col

from pyspark.sql.streaming import StreamingQueryListener

class AutoLoaderErrorListener(StreamingQueryListener):

def onQueryProgress(self, event):

print("✅ Batch processed:", event.progress.batchId)

def onQueryTerminated(self, event):

if event.exception:

print("🚨 Stream failed:", event.exception)

spark.streams.addListener(AutoLoaderErrorListener())

try:

df = spark.readStream.format("cloudFiles") \

.option("cloudFiles.format", "csv") \

.option("cloudFiles.inferColumnTypes", "true") \

.option("cloudFiles.schemaLocation", schema\_path) \

.load(source\_path)

df\_transformed = df.withColumn("Department", upper(col("Department"))) \

.withColumn("ingestion\_timestamp", current\_timestamp()) \

.withColumn("source\_file", input\_file\_name())

df\_transformed.writeStream.format("delta") \

.option("checkpointLocation", checkpoint\_path) \

.outputMode("append") \

.start(target\_path)

except Exception as e:

print("Stream failed to start:", e)

## How to Reset Auto Loader (If Needed)

1. **Stop the stream**:

query.stop()

1. **Delete checkpoint**:

dbutils.fs.rm(checkpoint\_path, recurse=True)

1. **(Optional) Delete target path**:

dbutils.fs.rm(target\_path, recurse=True)

## Best Practices Checklist

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| --- | --- |
| **Area** | **Best Practice** |
| Schema Inference | Use schemaLocation to avoid repeated inference |
| Checkpointing | Always configure checkpointLocation for fault tolerance |
| Transformations | Add input\_file\_name() and timestamps for traceability |
| Error Logging | Use StreamingQueryListener and custom logs |
| Deduplication | Add dropDuplicates() or business keys if resetting |
| Trigger | Use .trigger(processingTime="10 seconds") for batch control |
| Table Registration | Register Delta tables for SQL access and lineage |

## Sample Deduplication

df\_deduped = df\_transformed.dropDuplicates(["id", "source\_file"])

## Table Metadata

To register a Delta table:

CREATE TABLE bronze\_people

USING DELTA

LOCATION '/mnt/data/bronze/people/'

## Monitoring

* Use Spark UI or spark.streams.active to monitor status
* In production, use **Databricks Workflows** for retry, alert, and orchestration

## Summary

Auto Loader enables smart, scalable, fault-tolerant ingestion of files into your lakehouse. With schema inference, checkpointing, and built-in cloud integration, it simplifies Bronze layer development.

**Learn it once. Automate forever.**

## ****Cost Perspective: Auto Loader Best Practices****

Auto Loader is designed for cost-efficient ingestion at scale, but improper configuration can lead to unexpected compute or storage costs. Below are key recommendations:

**Best Practices for Cost Optimization**

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| **Area** | **Best Practice** | **Why It Helps** |
| **Trigger Interval** | Use .trigger(processingTime="30 seconds") or longer in low-latency environments | Reduces the number of micro-batches and compute overhead |
| **File Notification Mode** | Use **cloudFiles.useNotifications = true** (S3, GCS, ADLS Gen2) | Avoids expensive directory listing scans |
| **Schema Inference** | Persist schema with cloudFiles.schemaLocation | Prevents re-inferring schema (expensive for large files) |
| **Partitioning** | Write data with proper partitionBy() | Reduces file scan time and speeds up downstream queries |
| **Cluster Sizing** | Use auto-scaling or small spot clusters for ingestion jobs | Right-size resources based on load volume |
| **Compaction Jobs** | Periodically compact small files into larger ones | Reduces storage cost and speeds up reads (see Delta Optimize) |
| **File Format Choice** | Prefer **Parquet or Delta** over CSV for long-term ingestion | Smaller size = lower I/O and faster parsing |
| **Inactivity Timeout** | Set spark.databricks.streaming.stopActiveRunOnMaxIdleTime | Automatically stops idle streaming jobs |

**Practical Scenario: File Notification Saves Money**

**Without notifications**:

* Auto Loader lists millions of files in the directory each time.
* Costs go up due to repeated API calls and metadata operations.

**With notifications** (via GCS Pub/Sub, S3 EventBridge, ADLS Gen2 events):

* Only new files are picked up with minimal overhead.

**Savings**: 50–80% on compute time and file system I/O.

**Example: Cost-Smart Trigger**

python

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df.writeStream \

.format("delta") \

.option("checkpointLocation", checkpoint\_path) \

.trigger(processingTime="60 seconds") \

.start(target\_path)

* One batch per minute = lower load on cluster
* Ideal for non-latency-critical pipelines (e.g., hourly reports)

**What to Avoid**

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| **Pitfall** | **Impact** |
| Triggering every 1 second | Excessive micro-batches, wasteful compute |
| No schemaLocation | Re-inferring schema every time = costly |
| Writing many small files | Inefficient storage & slower reads |
| Not stopping idle jobs | Costs continue even without new data |

**Operational Excellence**

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| **Focus Area** | **Best Practice** |
| **Observability** | Integrate StreamingQueryListener, use logs and metrics dashboard |
| **Resilience** | Use checkpointing, trigger retries on failure via Workflows |
| **Recoverability** | Design for full or partial reprocess with deduplication logic |
| **Maintainability** | Store configurations in centralized configs or Delta tables |
| **Auditability** | Log source\_file, ingestion\_timestamp, and validation status |
| **Lineage & Governance** | Register tables in Unity Catalog for RBAC + data lineage |

**Summary**

Auto Loader enables smart, scalable, fault-tolerant ingestion of files into your lakehouse. With schema inference, checkpointing, and built-in cloud integration, it simplifies Bronze layer development.

**How to Detect Auto-Loader Failure in Databricks**

## How to Detect Auto Loader Failures (Step-by-Step)

### Objective:

Monitor Auto Loader jobs and **detect errors** like:

* Missing or corrupted files
* Schema mismatches
* Write failures
* Source path access issues

### ****Step 1: Wrap Your Streaming Query in a Listener****

Use a custom **StreamingQueryListener** to detect and log any job failures or terminations:

python

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from pyspark.sql.streaming import StreamingQueryListener

class AutoLoaderErrorListener(StreamingQueryListener):

def onQueryProgress(self, event):

print("Batch processed successfully:", event.progress.batchId)

def onQueryTerminated(self, event):

if event.exception:

print("🚨 Auto Loader FAILED!")

print("Reason:", event.exception)

else:

print("Stream terminated normally.")

# Register the listener

spark.streams.addListener(AutoLoaderErrorListener())

### ****Step 2: Define the Auto Loader Stream with a Try/Except Block****

python

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from pyspark.sql.functions import input\_file\_name, current\_timestamp, upper, col

try:

df = (

spark.readStream

.format("cloudFiles")

.option("cloudFiles.format", "csv")

.option("cloudFiles.inferColumnTypes", "true")

.option("cloudFiles.schemaLocation", "/mnt/data/autoloader/schema/people/")

.load("/mnt/data/autoloader/incoming/")

)

df\_transformed = (

df.withColumn("FirstName", upper(col("FirstName”)))

.withColumn("ingestion\_timestamp", current\_timestamp())

.withColumn("source\_file", input\_file\_name())

)

query = (

df\_transformed.writeStream

.format("delta")

.option("checkpointLocation", "/mnt/data/autoloader/checkpoints/people/")

.outputMode("append")

.start("/mnt/data/bronze/people/")

)

except Exception as e:

print("Auto Loader failed to start:", str(e))

### ****Step 3: (Optional) Log Errors into a Delta Table****

You can write the error to an error log table for review:

python

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from datetime import datetime

def log\_autoloader\_error(error\_msg):

error\_df = spark.createDataFrame(

[(str(error\_msg), datetime.now())],

["error\_message", "logged\_at"]

)

error\_df.write.mode("append").saveAsTable("error\_logs.autoloader\_errors")

Use it in the exception block:

python

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except Exception as e:

log\_autoloader\_error(e)

### ****Step 4: Monitor via Databricks Workflows (Optional)****

If you're running Auto Loader as part of a **Databricks Job**, you can:

* Enable **Job failure alerts** via email or webhooks
* Automatically **retry failed tasks**
* Log job run details in the **Workflows UI**

## Summary

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| **Step** | **Action** |
| 1 | Add a StreamingQueryListener to monitor progress & termination |
| 2 | Wrap your Auto Loader logic in try/except to catch runtime errors |
| 3 | Log errors into a Delta table (error\_logs.autoloader\_errors) |
| 4 | (Optional) Use **Databricks Workflows** for alerting and retries |

**When to Reset Auto Loader in Databricks**

## ****When to Reset Auto Loader****

You might want to reset Auto Loader if:

1. A file was missed due to a crash or misconfiguration.
2. You updated logic (e.g., transformations or schema).
3. Files were partially written or failed mid-batch.
4. You want to **reprocess everything** from scratch.

## ****What Resetting Actually Means****

Resetting Auto Loader means:

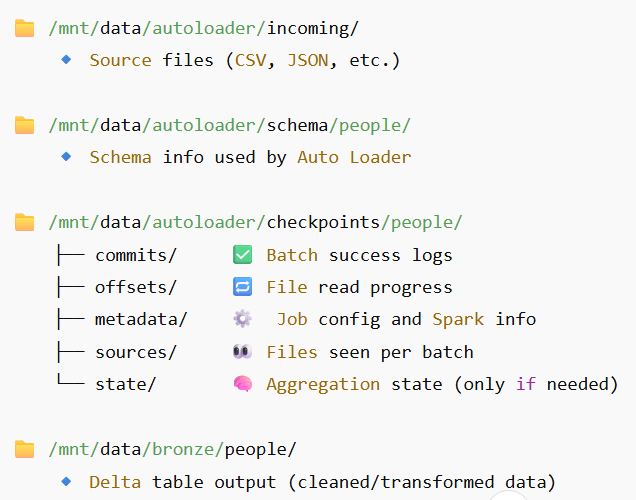
* **Deleting the checkpoint** folder — so Spark **forgets what it already processed**.
* (Optional) **Deleting the output Delta table or path** — if you want to **fully reload the data**.

## ****Important Warning****

❗ Resetting the checkpoint will cause **all files in the input directory** to be **reprocessed**, even those already written to the target table — unless deduplication logic is used.

## ****Step-by-Step: Reset Auto Loader****

Folder Structure:



| **Config Path** | **Internally Controls or Maps To** |
| --- | --- |
| source\_path | sources/, offsets/ (files discovered + read) |
| schema\_path | Maintains schema inference snapshots |
| checkpoint\_path | Creates commits/, offsets/, sources/, etc. |
| target\_path | Stores the final Delta data output |

### Assume your setup:

python

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source\_path = "/mnt/data/autoloader/incoming/"

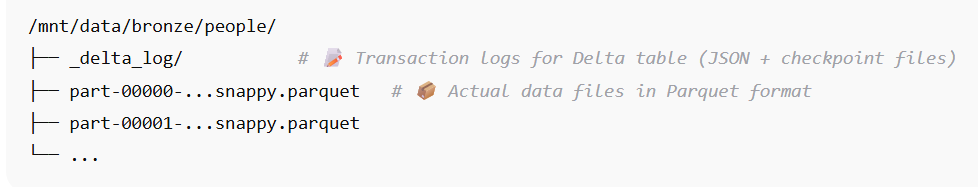
schema\_path = "/mnt/data/autoloader/schema/people/"

checkpoint\_path = "/mnt/data/autoloader/checkpoints/people/"

target\_path = "/mnt/data/bronze/people/"

Once Auto Loader starts writing, this folder will contain:

Target\_path is the **location on DBFS or cloud storage** where **processed data is written**.



| **Folder / File** | **Description** |
| --- | --- |
| \_delta\_log/ | Stores metadata about the table (transaction history, schema changes, commit logs) |
| \*.parquet | Your actual **ingested and transformed data** |
| (No checkpoint/ here) | Checkpoint is stored separately under checkpoint\_path, not here |

Register it as Delta Table , below is the run query:

CREATE TABLE bronze\_people

USING DELTA

LOCATION '/mnt/data/bronze/people/'

SELECT \* FROM bronze\_people;

## Summary

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| **Term** | **Path** | **Stores What?** |
| target\_path | /mnt/data/bronze/people/ | Delta table (data + metadata) |
| Contents | \_delta\_log/ + \*.parquet | All processed data from Auto Loader pipeline |

Note:

If the table is not registered, you can still read it using the **Delta table path**, but you **can’t query it by name** in SQL or Unity Catalog.

**You can't see data lineage in Unity Catalog** if the table is **not registered** — lineage tracking only works for **registered tables** in a **Unity Catalog-enabled metastore**.

### 1. ****Stop the Streaming Job****

You can do this from the notebook UI, Jobs tab, or by calling .stop() if you’ve assigned it to a variable:

python

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query = df\_transformed.writeStream...start()

query.stop()

### 2. ****Delete the Checkpoint Directory****

python

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dbutils.fs.rm(checkpoint\_path, recurse=True)

This erases:

* commits/
* offsets/
* sources/
* state/

→ Spark no longer knows which files were already processed.

### (Optional) 3. ****Delete the Output Delta Table****

If you want to **rebuild from scratch**:

python

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dbutils.fs.rm(target\_path, recurse=True)

Or if registered as a table:

sql

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DROP TABLE IF EXISTS bronze.people;

### 4. ****Re-run Your Auto Loader Job****

Use the same logic from the document:

python

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from pyspark.sql.functions import current\_timestamp, input\_file\_name, upper, col

df = (

spark.readStream

.format("cloudFiles")

.option("cloudFiles.format", "csv")

.option("cloudFiles.inferColumnTypes", "true")

.option("cloudFiles.schemaLocation", schema\_path)

.load(source\_path)

)

df\_transformed = (

df.withColumn("FristName", upper(col("FirstName")))

.withColumn("ingestion\_timestamp", current\_timestamp())

.withColumn("source\_file", input\_file\_name())

)

df\_transformed.writeStream \

.format("delta") \

.option("checkpointLocation", checkpoint\_path) \

.outputMode("append") \

.start(target\_path)

## Optional: Add Deduplication to Avoid Double Processing

If you can't delete the output but still want to reprocess without duplicating:

python

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from pyspark.sql.functions import expr

df\_deduped = df\_transformed.dropDuplicates(["id", "source\_file"])

# Or add a hash-based deduplication

## Summary: Reset Guide

| **Step** | **Action** |
| --- | --- |
| Stop the stream | .stop() or notebook control |
| Delete checkpoint | dbutils.fs.rm(checkpoint\_path, recurse=True) |
| Delete output (optional) | dbutils.fs.rm(target\_path, recurse=True) |
| Restart the job | Run your Auto Loader pipeline again |

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| ****Pros of Unregistered (Path-Based) Tables**** | **Cons of Not Registering** |
| |  |  | | --- | --- | | **Advantage** | **Description** | | **Simple setup** | No need to create a table in metastore | | **Flexible for ad-hoc use** | Useful for temporary or dev pipelines | | **Easier testing** | You can write and delete freely without affecting production tables | | **Still fully readable** | Use .read.format("delta").load("/path/") in PySpark | | **Portable** | Can be copied or moved without breaking SQL references | | |  |  | | --- | --- | | **Limitation** | **Description** | | **No SQL name** | Can’t use SELECT \* FROM table\_name — must use path | | **No Unity Catalog support** | No lineage, governance, or RBAC features | | **Harder collaboration** | Other users must know the exact path to access | | **No lineage tracking** | Data lineage graph in Unity Catalog won't include it | | **No data discovery** | Won’t show up in catalogs, schemas, or SHOW TABLES | | **Prone to accidental overwrite** | No metastore protection for concurrent writes | |

**Trainee Q&A: How Auto Loader Handles Files Across Batches**

* **Mentor (IT Architect)**
* **Trainee (Junior Data Engineer)**

**Auto Loader** is a high-performance, scalable file ingestion tool provided by Databricks for ingesting new data files from cloud storage (like AWS S3, Azure Data Lake, or Google Cloud Storage) **automatically and incrementally** using **Databricks Structured Streaming**.

**Purpose:**

* Watches a directory for **new files only** — no need to reprocess old data.
* Supports **schema inference** and **evolution**.
* Handles **millions of files** efficiently using file notification services.
* Works with formats like **CSV, JSON, Parquet, Avro**, and more.
* Ideal for implementing **Bronze layer ingestion** in Delta Lake.

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| Trainee | Mentor |
| Hey, I’ve been exploring Auto Loader in Databricks, and I’ve got a question. Let’s say we have 5 files to ingest — how exactly are they represented in the checkpoint directory?  Specifically in commits/ and sources/ — does sources track all 5 files or only the ones from the current micro-batch? | That’s a great question! Auto Loader organizes metadata in a very structured way — and understanding it will help you debug and optimize streaming jobs efficiently.  Let me break it down for you. There are **two possible ways** those 5 files could be processed, depending on when they arrive and your stream's trigger setting. |

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| Mentor  **Option A: All 5 files arrive together (one micro-batch)**  If all 5 files are discovered **before the next trigger fires**, Auto Loader groups them into a **single batch**.  You’ll see:   * commits/0 → indicating **batch 0 was committed** * sources/0 → listing all files seen in this batch:   json  CopyEdit  "seenFiles": [  "people\_1.csv",  "people\_2.csv",  "people\_3.csv",  "people\_4.csv",  "people\_5.csv"  ]  So in this case, sources/0 alone shows all 5 files — and they were all committed in batch 0. |

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| **Trainee:** Got it — so if all files arrive close together, one batch can handle all of them. What if the files arrive at different times? |

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| **Mentor**  **Option B: Files arrive at different times (multiple batches)**  Let’s say:   * 3 files arrive first, * and 2 more come in **10 seconds later**.   With a typical trigger interval (like every 10 seconds), Spark will process them in **two separate batches**:   * commits/0 → batch 0   + sources/0 → "seenFiles": ["people\_1.csv", "people\_2.csv", "people\_3.csv"] * commits/1 → batch 1   + sources/1 → "seenFiles": ["people\_4.csv", "people\_5.csv"]   So the files are **split across multiple sources/N files**, but all 5 are still tracked. |

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| **Trainee:** Oh, I see. So even though they’re split across batches, the total seen files still add up to 5. Makes sense! |

**Final Takeaway**

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| **Folder** | **What it Reflects** |
| commits/ | Number of **micro-batches** (e.g., 0, 1, 2...) |
| sources/ | Tracks the **files seen in each batch** |
| Total seenFiles | Equals all files that were **actually processed** |

So, even if you process 5 files over 1, 2, or 10 batches, the total number of seenFiles across sources/ will still be 5.

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| **Trainee:** That clears it up perfectly! So it’s the **batches** that control the file grouping, not the number of files per se. |

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| **Mentor:** Exactly! It's **time-based batching**, not file-count-based. And once you understand how commits/ and sources/ align, it’s much easier to track and debug your Auto Loader pipelines. |

Appendix:

## ****Sample Auto Loader Code****

python

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from pyspark.sql.functions import current\_timestamp, input\_file\_name, upper, col

# Read data using Auto Loader

df = (

spark.readStream

.format("cloudFiles")

.option("cloudFiles.format", "csv") # File format

.option("cloudFiles.inferColumnTypes", "true") # Infer schema

.option("cloudFiles.schemaLocation", "/mnt/data/autoloader/schema/employee/") # Where schema is stored

.load("/mnt/data/autoloader/incoming/") # Input folder

)

# Apply transformations

df\_transformed = (

df.withColumn("department", upper(col("department")))

.withColumn("ingestion\_timestamp", current\_timestamp())

.withColumn("source\_file", input\_file\_name())

)

# Write to Delta Lake with checkpointing

(

df\_transformed.writeStream

.format("delta")

.option("checkpointLocation", "/mnt/data/autoloader/checkpoints/employee/") # Required

.outputMode("append")

.start("/mnt/data/bronze/employee") # Bronze table path

)

**AutoLoader**

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| --- | --- |
| Config : Without Trigger | Config : With Trigger |
| df.writeStream \  .format("delta") \  .option("checkpointLocation", "/mnt/checkpoints/people") \  .start("/mnt/data/delta/bronze\_people") | df.writeStream \  .format("delta") \  .option("checkpointLocation", "/mnt/checkpoints/people") \  .trigger(processingTime="5 seconds") \  .start("/mnt/data/delta/bronze\_people") |
| **Behavior:**   |  |  | | --- | --- | | **Time** | **Action** | | 00:00 | Spark sees people\_1.csv and processes it in **batch 0** immediately | | 00:03 | Spark detects people\_2.csv and runs **batch 1** | | 00:06 | Spark sees people\_3.csv and starts **batch 2** | | ... | Spark polls continuously with **no delay** | | Behavior:  |  |  | | --- | --- | | **Time** | **Action** | | 00:00 | Spark sees people\_1.csv and starts **batch 0** | | 00:05 | No new files → batch runs, nothing processed | | 00:10 | Sees people\_2.csv and people\_3.csv (if they arrived) → **batch 1** processes them together | |
| ➡**3 batches for 3 files** ➡Latency = **as fast as Spark can respond** | ➡**Only 2 batches for 3 files** ➡Latency = **bounded by 5-second interval** |
| Comparison Table  |  |  |  | | --- | --- | --- | | **Feature** | **Without Trigger** | **With .trigger(processingTime="5s")** | | Trigger | Default (as fast as possible) | Fixed 5-second interval | | Batch Count | 3 batches (1 per file) | 2 batches (grouped by time) | | Latency | Lower (real-time) | Medium (5s delay max) | | Resource Efficiency | High CPU usage per file | More efficient grouping | | Control over behavior | No | Yes | | Use in Production | Can be noisy / expensive | More predictable | | |
| Summary  * **Without .trigger()** = lower latency, high responsiveness, but may create too many small batches. * **With .trigger()** = more control, better performance, lower cost at scale. * Choose based on:   + **Latency sensitivity** (alerts? dashboards?)   + **Cost and throughput**   + **File arrival pattern** | |

Final Note:

**Auto Loader** = smart, incremental ingestion from cloud storage with schema management and fault tolerance built-in. It's the recommended way to build the **Bronze layer** in modern data lakehouses using Delta Lake.

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| Data Processed | Yet to Be Processed |
| Files that Auto Loader has **discovered, read, and successfully written** to the target table (e.g., Delta Lake). These are tracked in the **checkpoint** under commits/, offsets/, and sources/. | Files that are **newly arrived** in the input directory but **haven’t been picked up** by Auto Loader in any completed micro-batch yet. |
| * Already part of a **committed batch** * Logged in checkpoint metadata * Will **not** be reprocessed unless: * Checkpoint is deleted/reset * Source is modified manuall | * Discovered only if they appear in seenFiles in a future batch * Not yet included in commits/ or offsets/ * Will be automatically picked up in the **next streaming batch** |
| Example: *people\_1.csv* appears in *sources/0* and *commits/0* → processed. | Example: people\_4.csv was added to the folder after batch 0 completed → will be picked up in batch 1. |

**Final Analogy**

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| **Term** | **Think of it as...** |
| Data Processed | Checked in at airport & on the plane |
| Yet to Be Processed | Still waiting in line at security |

Ref: [checkpoint-in-databricks](https://www.linkedin.com/posts/sivakumarramar_checkpoint-in-databricks-activity-7347973646759432192-nNLP?utm_source=share&utm_medium=member_desktop&rcm=ACoAAAVIjd8BCcYFQhhpp-Q6JutqoA0lojJ3tqk)