



Apache Spark Programming

With Databricks



Welcome

2



Course Agenda

Here's where we're headed

DataFrames	Introduction	Databricks Platform	Spark SQL	Reader & Writer	DataFrame & Column
Transformations	Aggregation	Datetimes	Complex Types	Additional Functions	User-Defined Functions
Performance	Spark Architecture	Query Optimization	Partitioning		
Structured Streaming and Delta	Streaming Query	Aggregating Streams	Delta Lake		

Lesson Objectives

By the end of this course, you should be able to:

- 1 Identify core features of Spark and Databricks
- 2 Describe how DataFrames are created and evaluated in Spark
- 3 Apply the DataFrame API to process and analyze data
- 4 Demonstrate how Spark is optimized and executed on a cluster
- 5 Apply Delta Lake and Structured Streaming to process data

Module 1

Introductions

5



Welcome!

Let's get to know you



- Name
- Role and team
- Programming experience
- Motivation for attending
- Personal interest



Module 2

Spark Core





Spark Core

Databricks Ecosystem

Spark Overview

Spark SQL

Reader & Writer

DataFrame & Column

Databricks Ecosystem

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Lakehouse

One simple platform to unify all of
your data, analytics, and AI workloads

Customers

5000+

across the globe



Original creators of:





Data
Lake

Lakehouse

One platform to unify all of
your data, analytics, and AI
workloads



Data
Warehouse



Data Lake



DELTA LAKE

An open approach to bringing
data management and
governance to data lakes

Better reliability with transactions

48x faster data processing with
indexing

Data governance at scale with
fine-grained access control lists



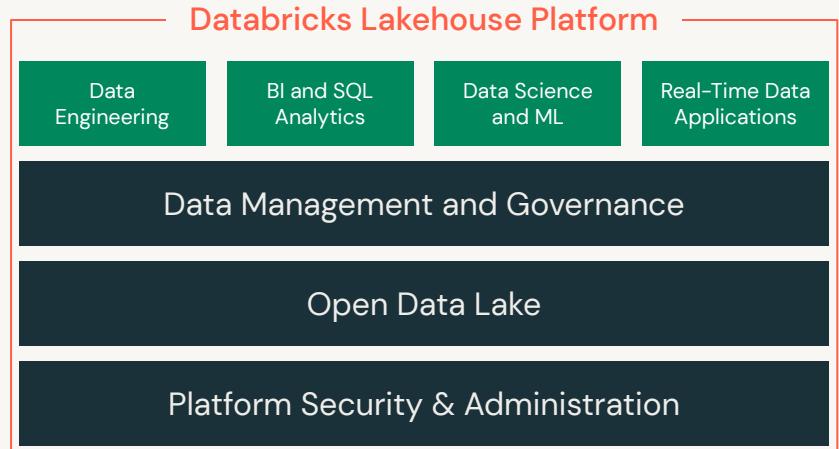
Data Warehouse

The Databricks Lakehouse Platform

 Simple

 Open

 Collaborative



Unstructured, semi-structured, structured, and streaming data



The Databricks Lakehouse Platform



Simple

Unify your data, analytics, and AI on one common platform for all data use cases

Databricks Lakehouse Platform

Data Engineering

BI and SQL Analytics

Data Science and ML

Real-Time Data Applications

Data Management and Governance

Open Data Lake

Platform Security & Administration



Unstructured, semi-structured, structured, and streaming data



Microsoft Azure



Google Cloud



The Databricks Lakehouse Platform



Open

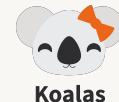
Unify your data ecosystem
with open source standards
and formats.

Built on the innovation of
some of the most
successful open source
data projects in the world

30 Million+
Monthly downloads



mlflow™



re'dash

The Databricks Lakehouse Platform



Unify your data ecosystem
with open source standards
and formats.

450+

Partners across the
data landscape

Visual ETL & Data Ingestion



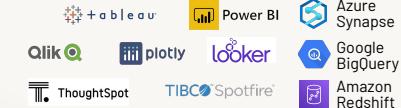
Data Providers



Top Consulting & SI Partners



Business Intelligence



Machine Learning



Centralized Governance



databricks
Lakehouse Platform

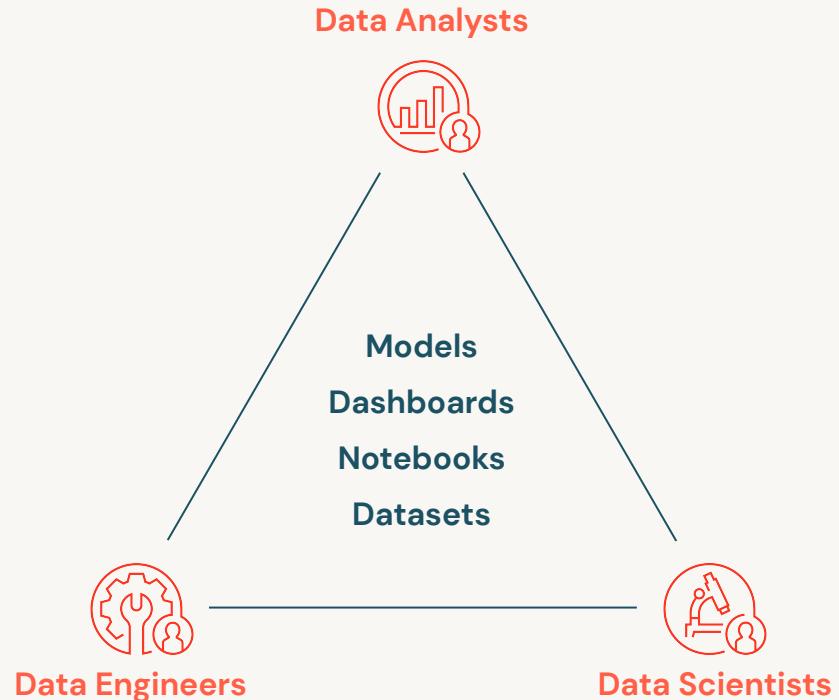
Microsoft Azure aws
Google Cloud

The Databricks Lakehouse Platform



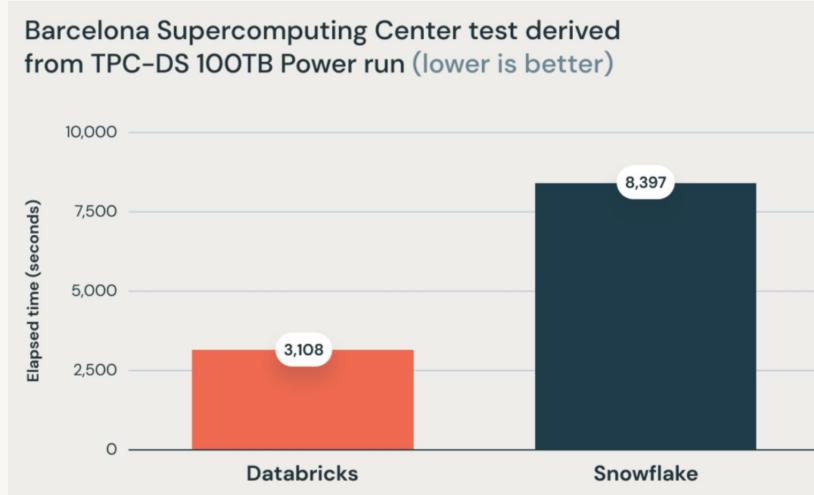
Collaborative

Unify your data teams to collaborate across the entire data and AI workflow



TPC-DS

Databricks SQL set **official data warehousing performance record** – outperformed the previous record by 2.2x.



Spark Overview



- De-facto standard unified analytics engine for big data processing
- Largest open-source project in data processing
- Technology created by the founders of Databricks

Spark Benefits



Fast



Easy to Use



Unified



Spark API

Spark SQL +
DataFrames

Streaming

MLlib

Spark Core API

R

SQL

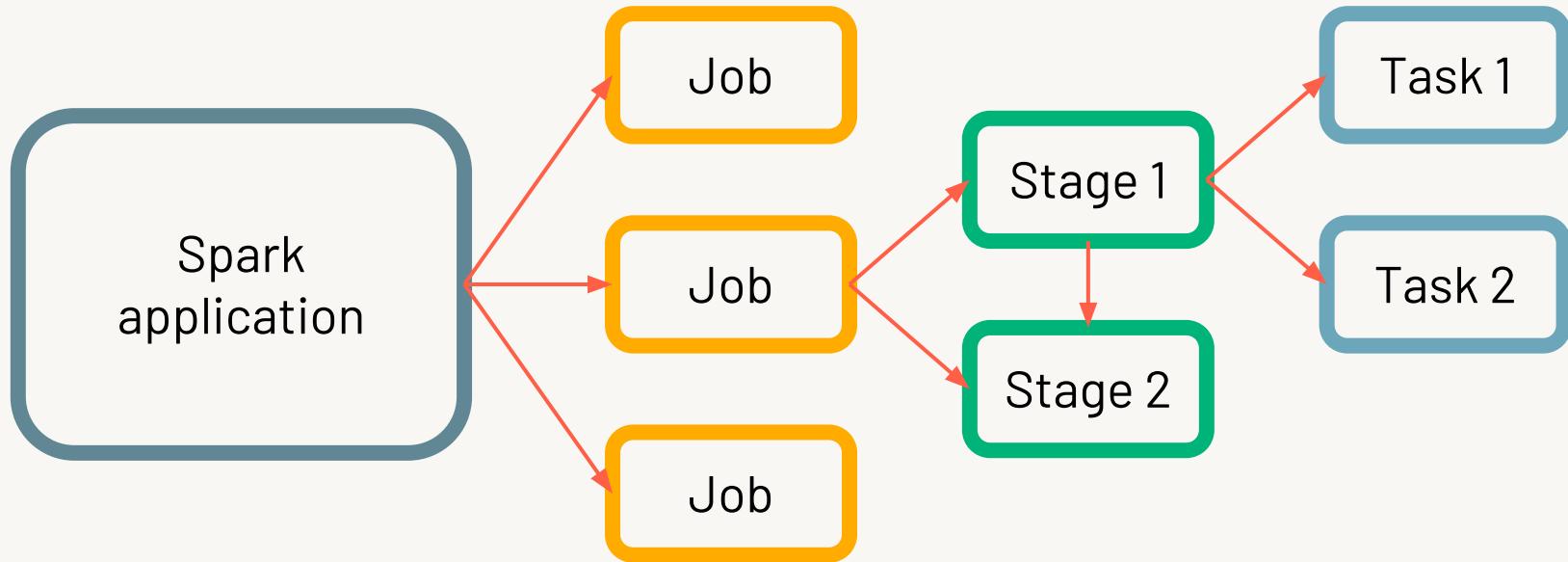
Python

Scala

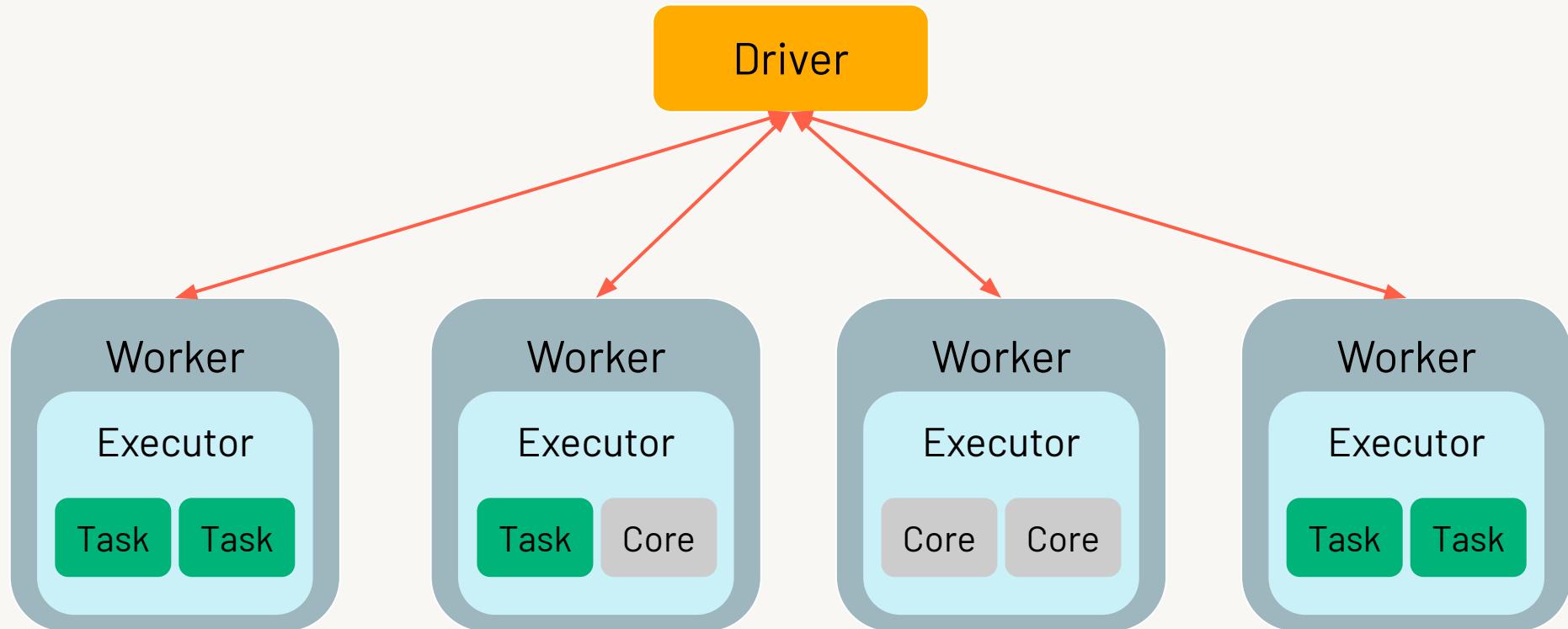
Java



Spark Execution



Spark Cluster



Bonus: Magic commands in Notebook cells

Magic commands allow you to override default languages as well as a few auxiliary commands that run utilities/commands. For example:

1. `%python, %r, %scala, %sql` Switch languages in a command cell
2. `%sh` Run shell code (runs only on Spark Driver, and not the Workers)
3. `%fs` Shortcut for **dbutils** filesystem commands
4. `%md` Markdown for styling the display
5. `%run` Execute a remote Notebook from a Notebook
6. `%pip` Install new Python libraries



CSV

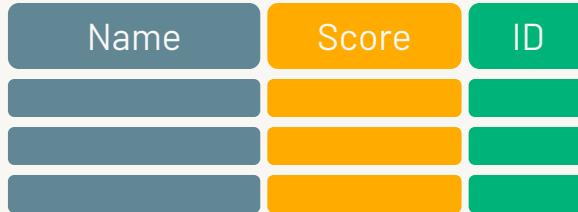
Comma Separated Values

```
item_id, name, price, qty
M_PREM_Q, Premium Queen Mattress, 1795, 35
M_STAN_F, Standard Full Mattress, 945, 24
M_PREM_F, Premium Full Mattress, 1695, 45
M_PREM_T, Premium Twin Mattress, 1095, 18
```



Parquet

A columnar storage format



Row-Oriented data on disk



Column-Oriented data on disk

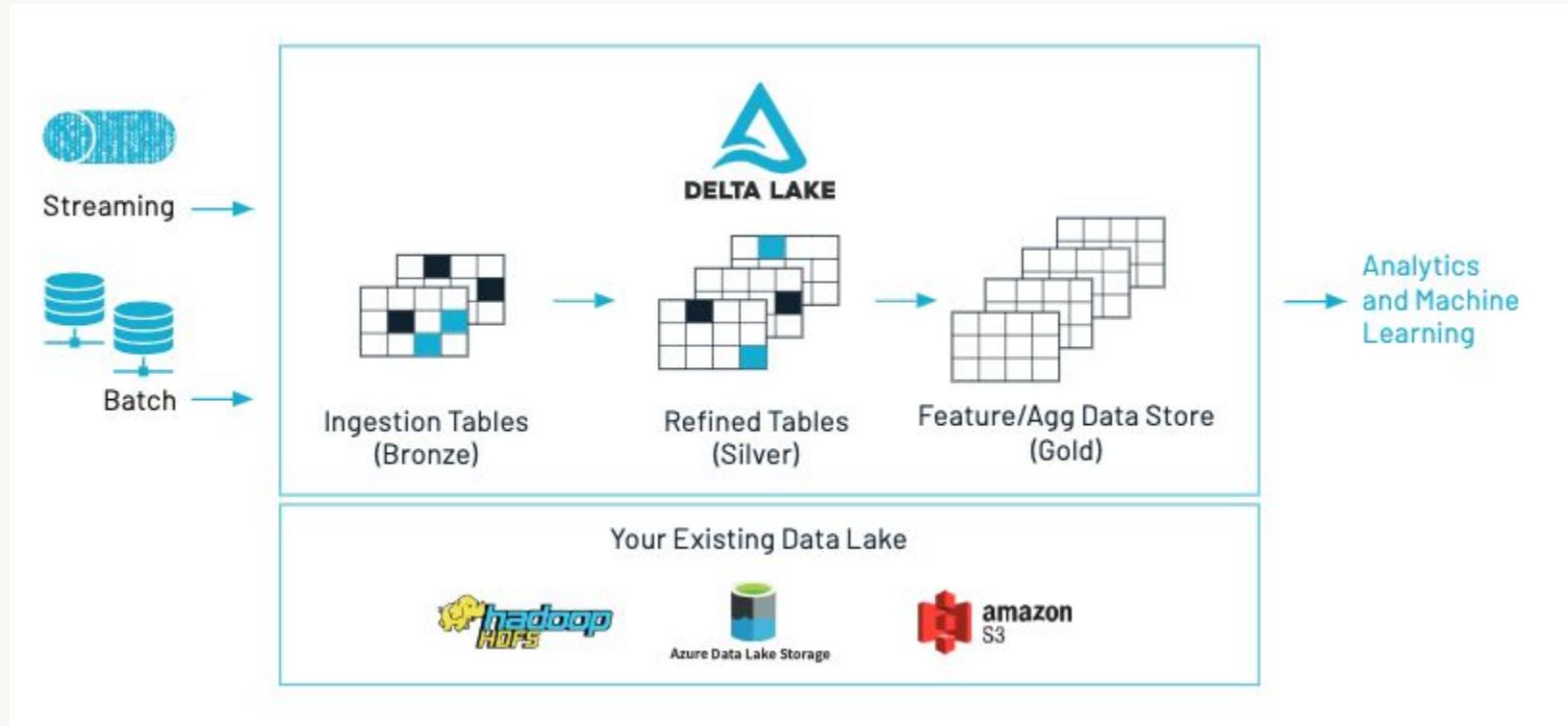


Delta Lake

Technology designed to be used with Apache Spark to build robust data lakes



Open-source Storage Layer



Delta Lake's Key Features

- ACID transactions
- Time travel (data versioning)
- Schema enforcement and evolution
- Audit history
- Parquet format
- Compatible with Apache Spark API



Module 3

Functions





Functions

Aggregation

Datetimes

Complex Types

Additional Functions

User-Defined Functions

Module 4

Performance





Performance

Spark Architecture

Query Optimization

Partitioning



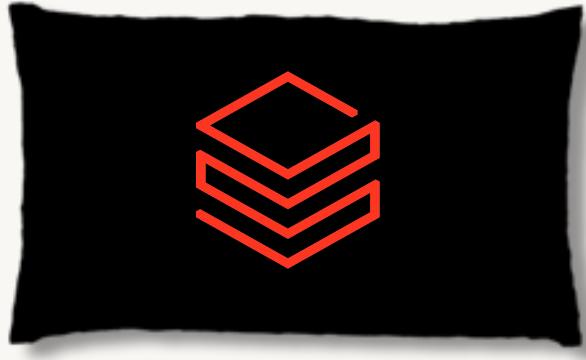
Spark Architecture

Spark Cluster

Spark Execution

35





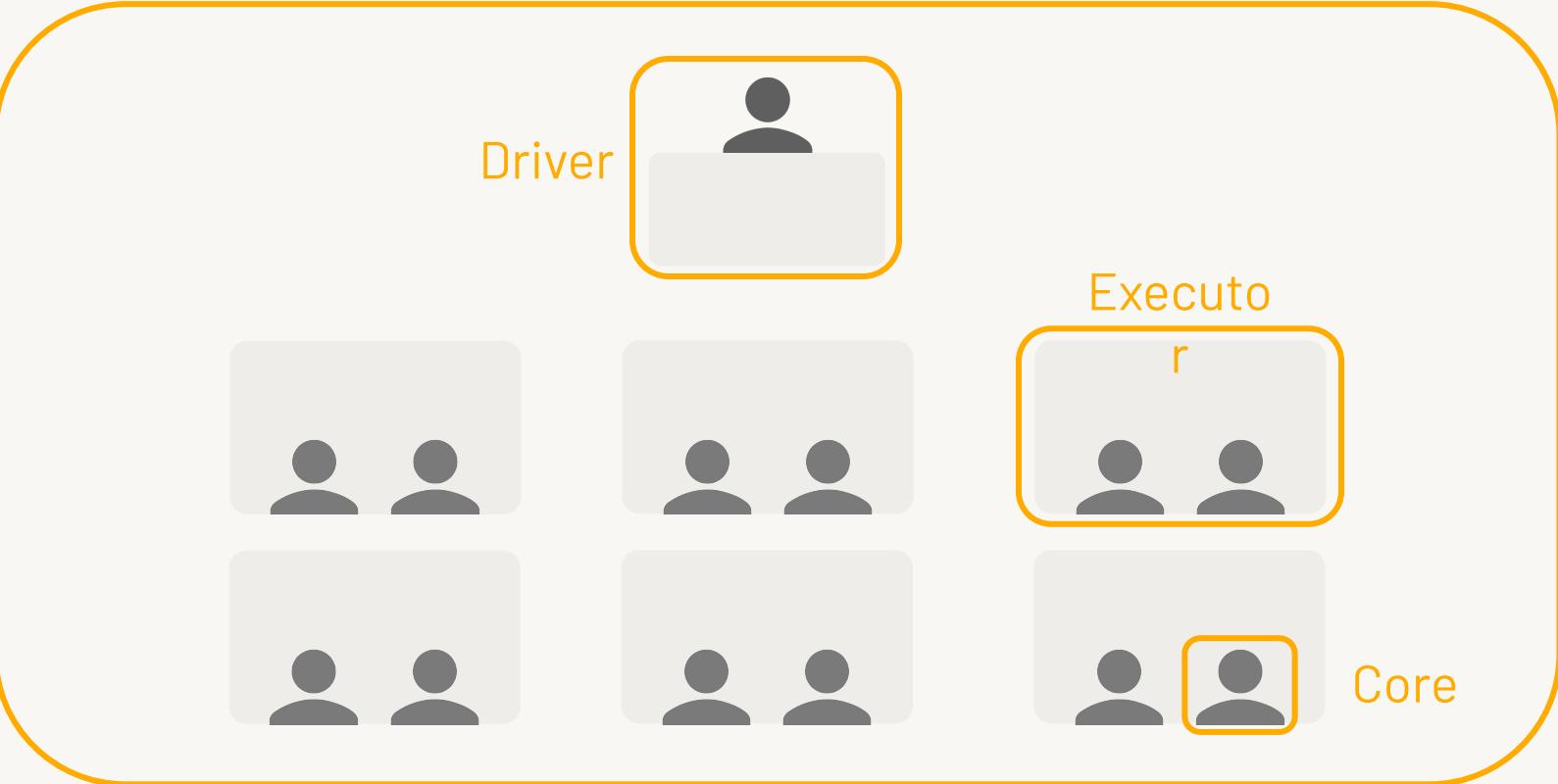
Scenario 1: Filter out brown pieces from candy bags

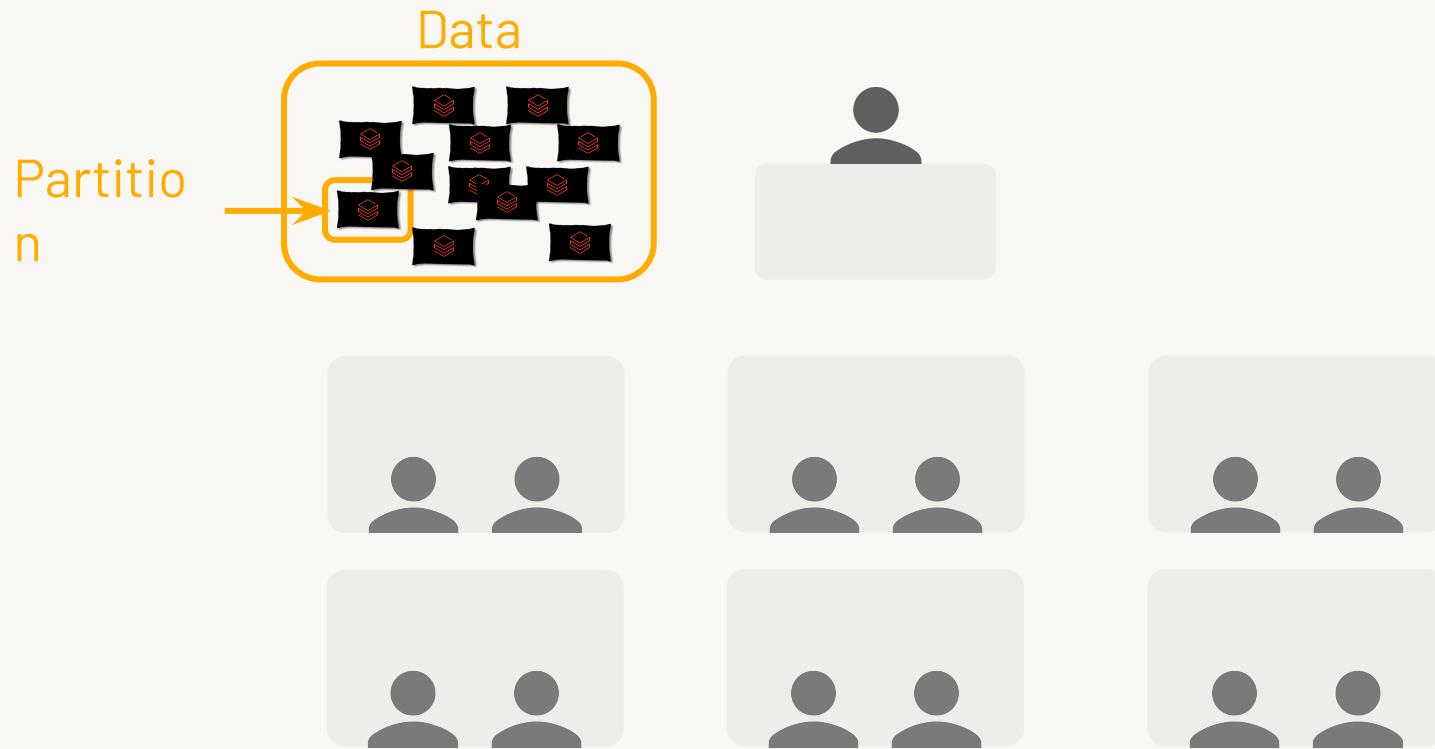
Cluster

Driver

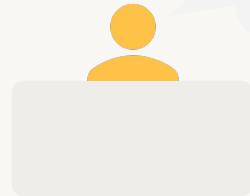
Executor

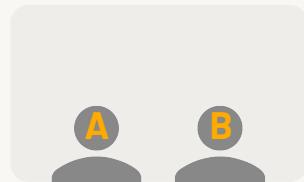
Core

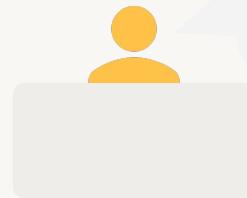




We need filter out brown pieces
from these candy bags







Student A get bag # 1
Student B get bag # 2
Student C get bag # 3

...



A
B



C
D



E
F



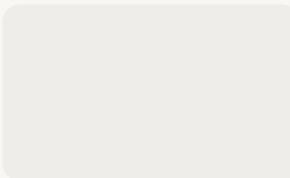
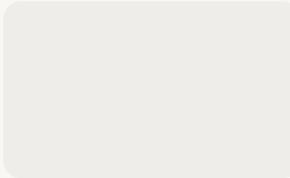
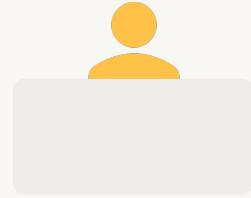
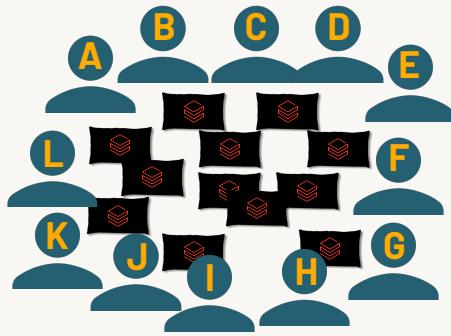
G
H

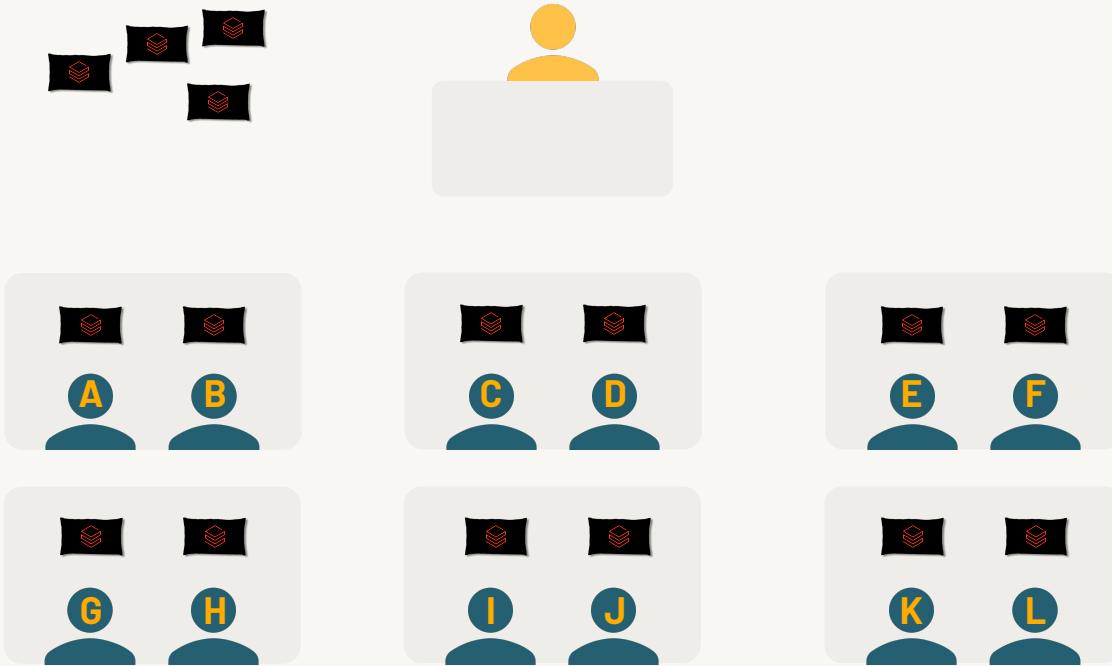


I
J

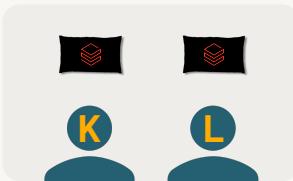
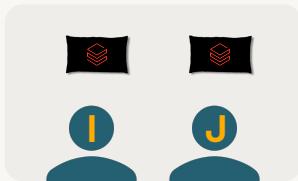
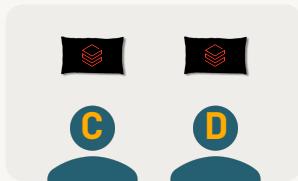
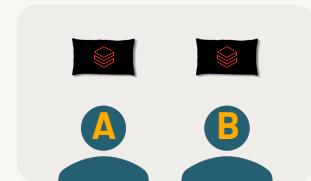
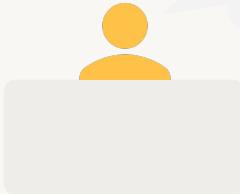


K
L

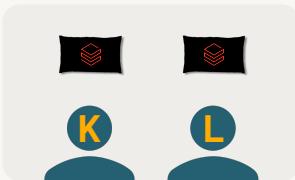
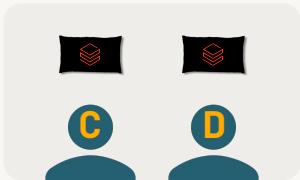
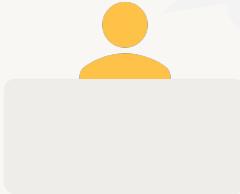


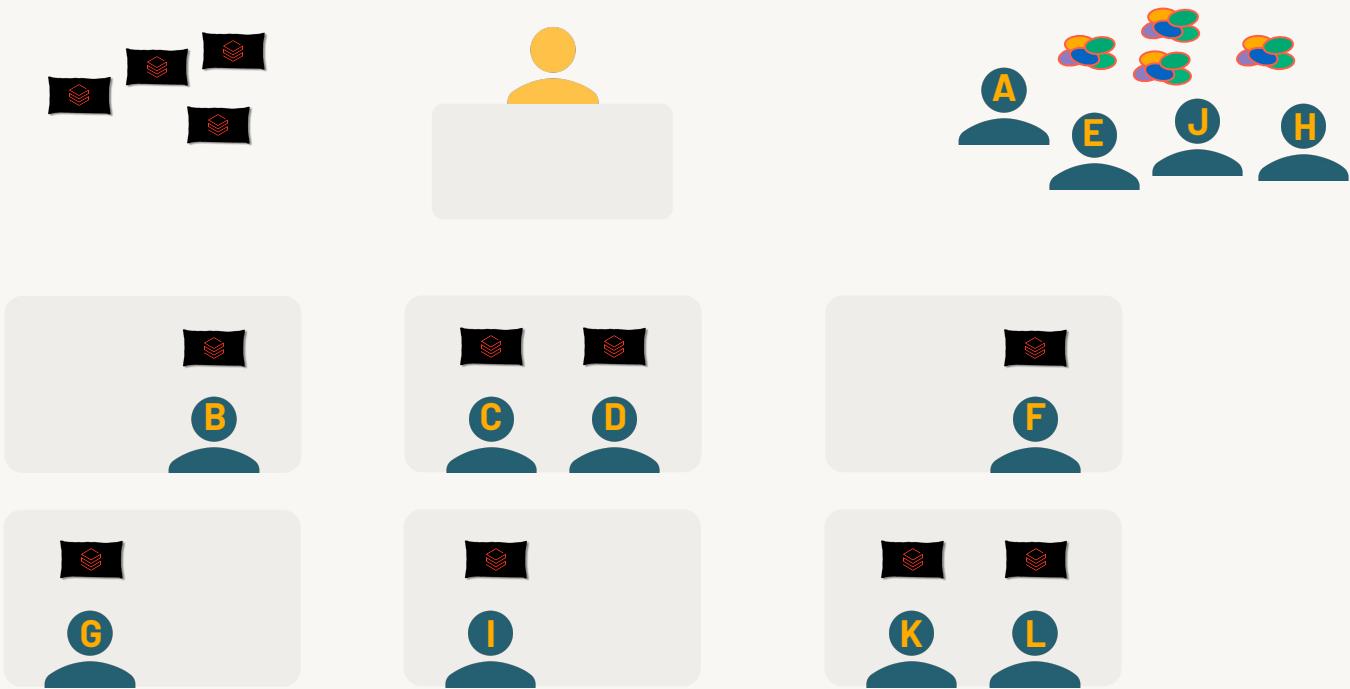


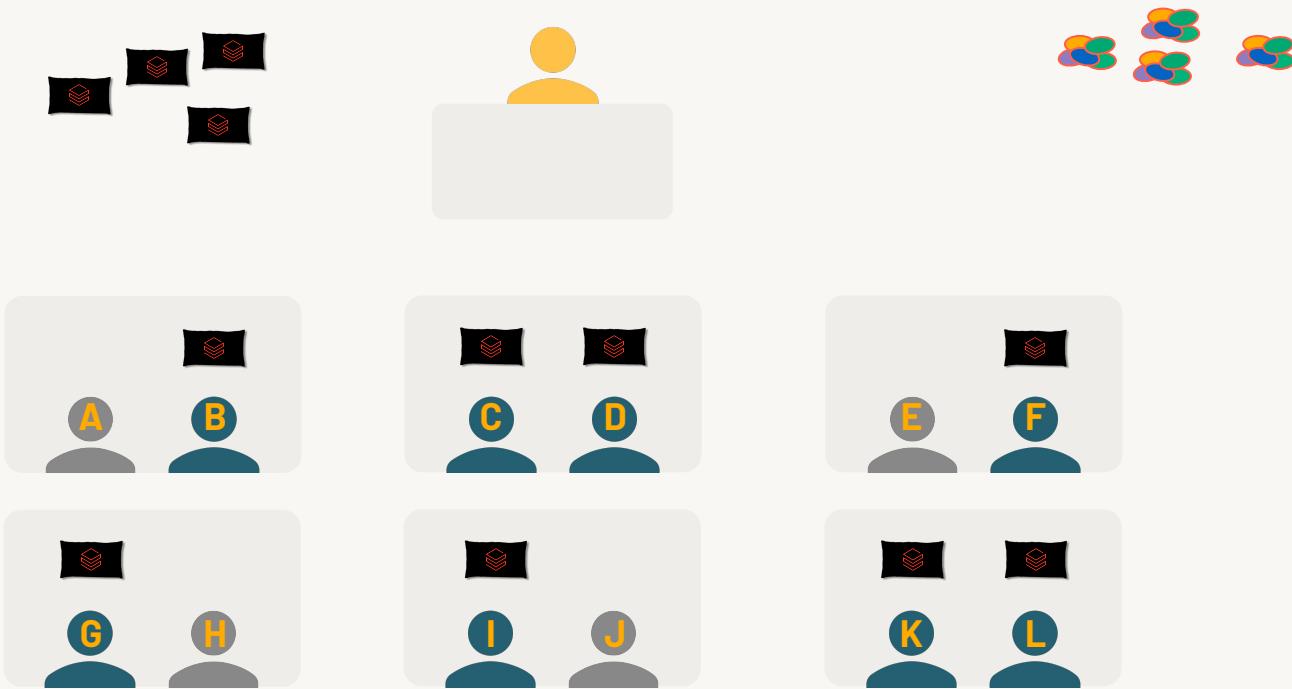
Eliminate the brown candy pieces
and pile the rest in the corner



Eliminate the brown candy pieces
and pile the rest in the corner

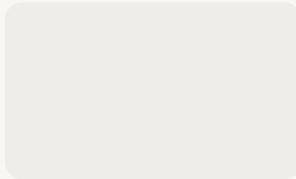
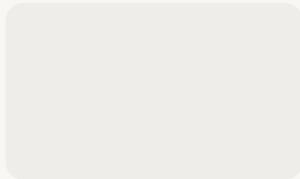
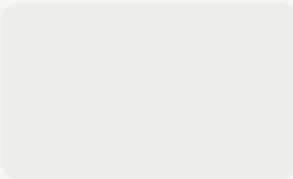
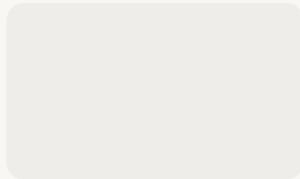
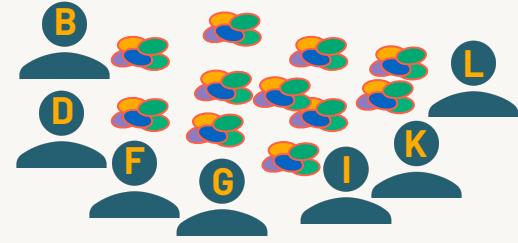
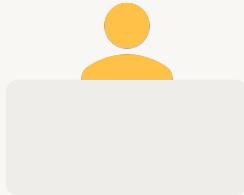
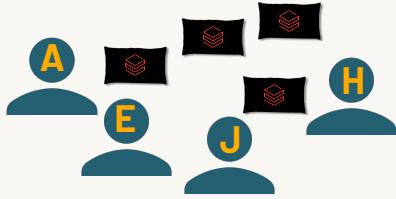


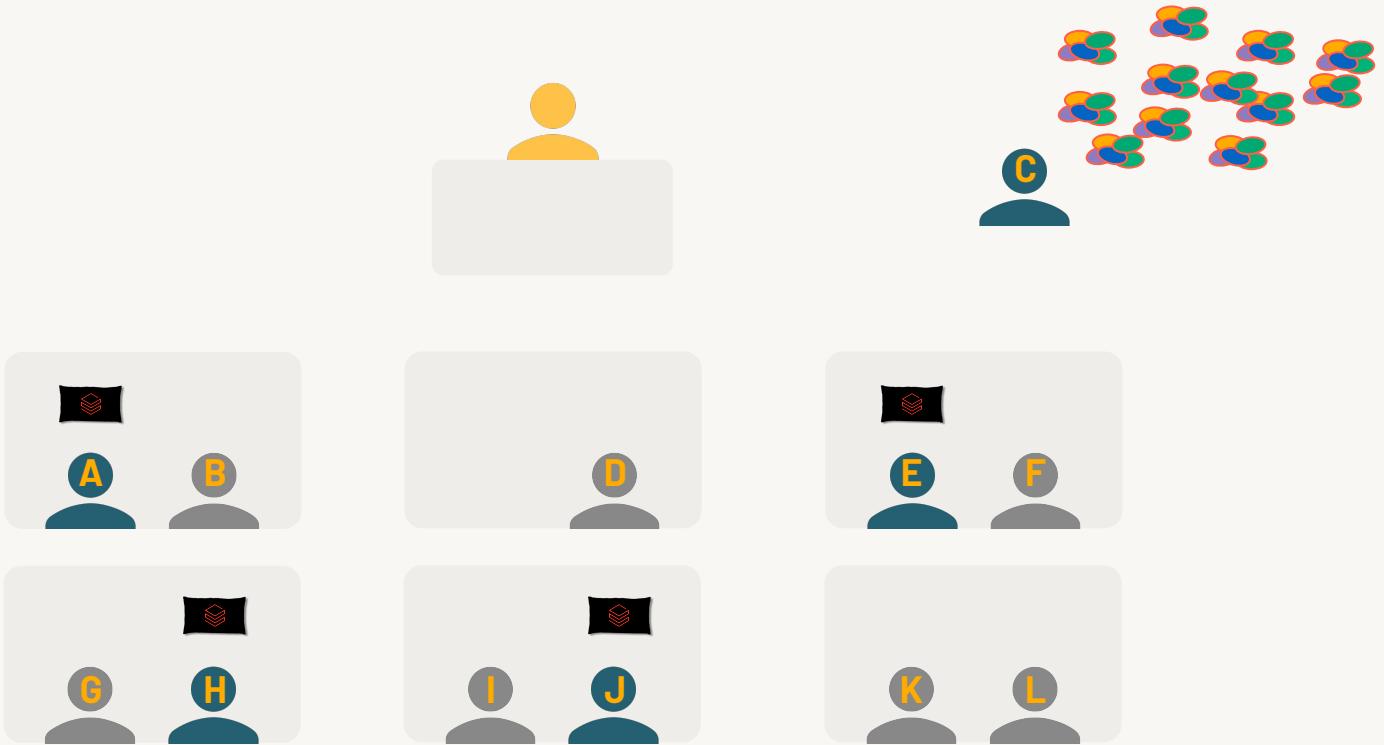


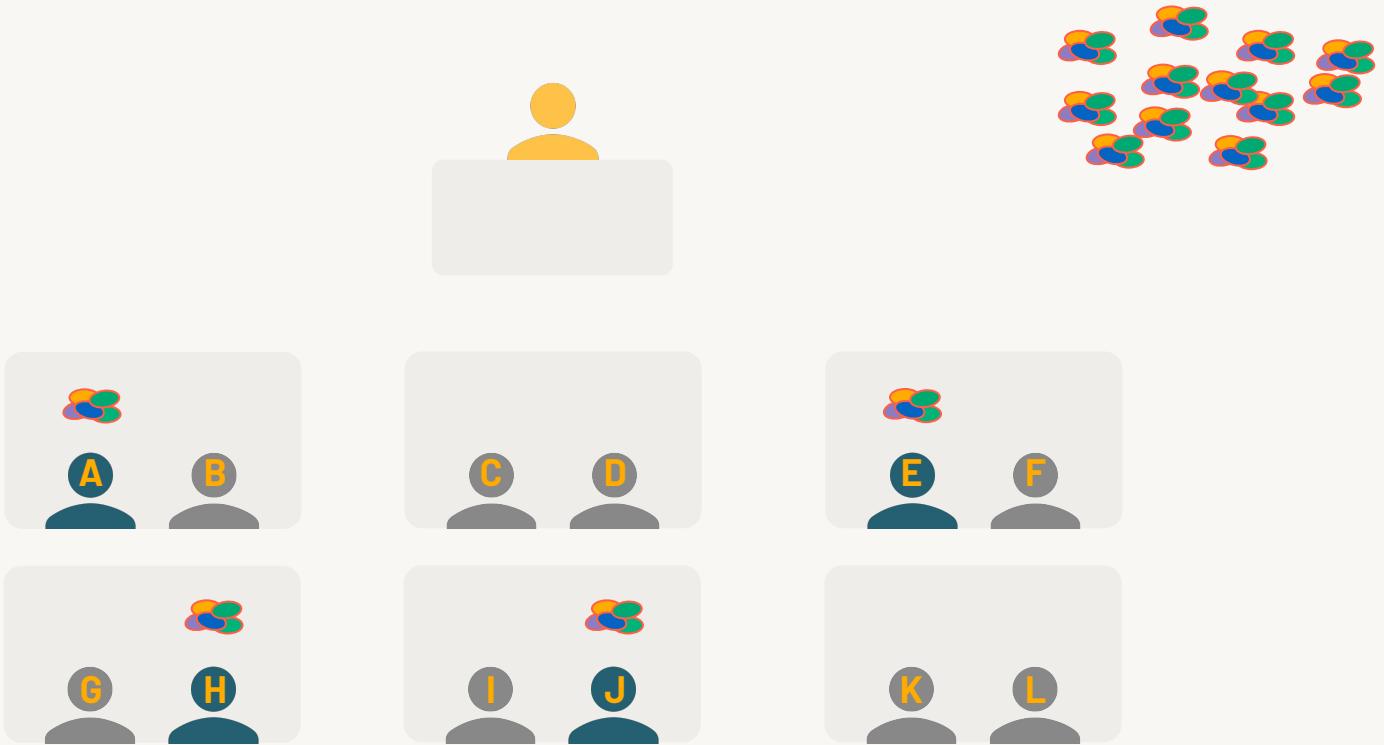


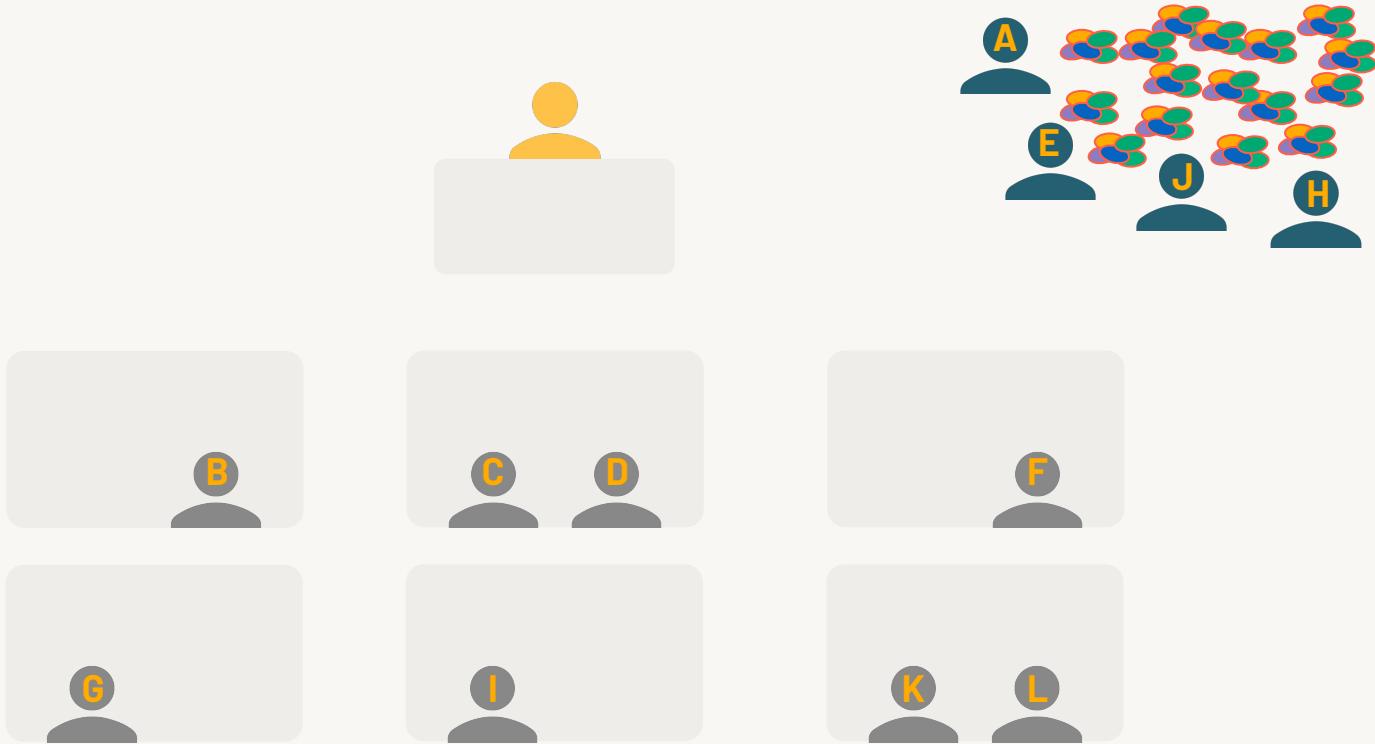
Students A, E, H, J,
get bags 13, 14, 15, 16

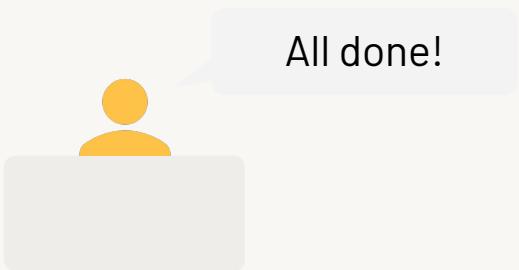




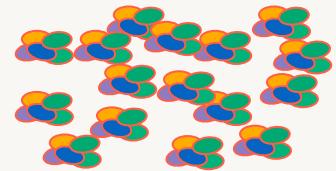


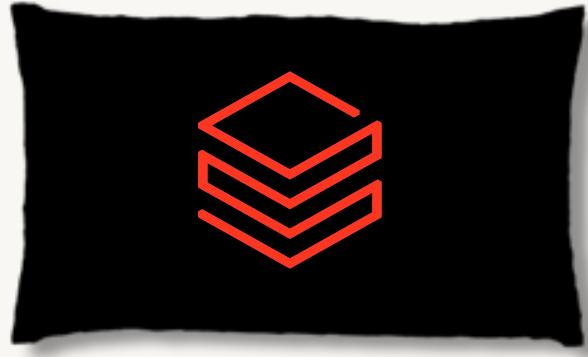






All done!





Scenario 2: Count total pieces in candy bags



Stage 1: Local Count



Stage 1: Local Count



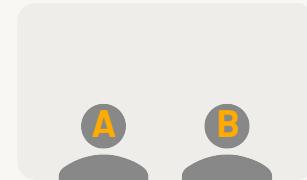
We need to count the total pieces
in these candy bags



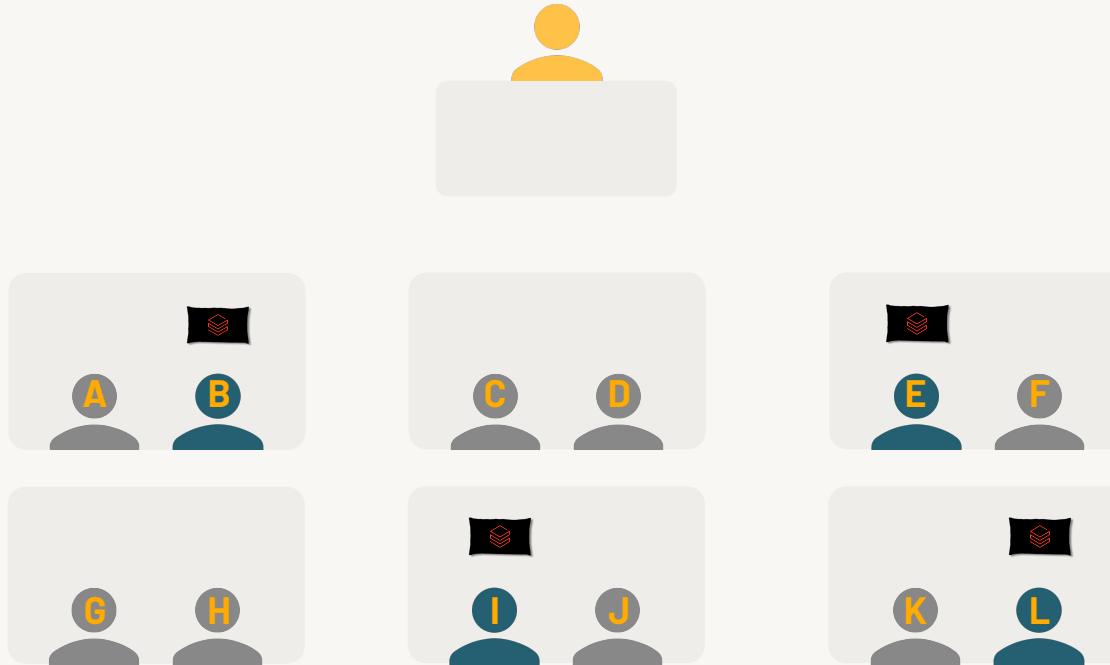
Stage 1: Local Count



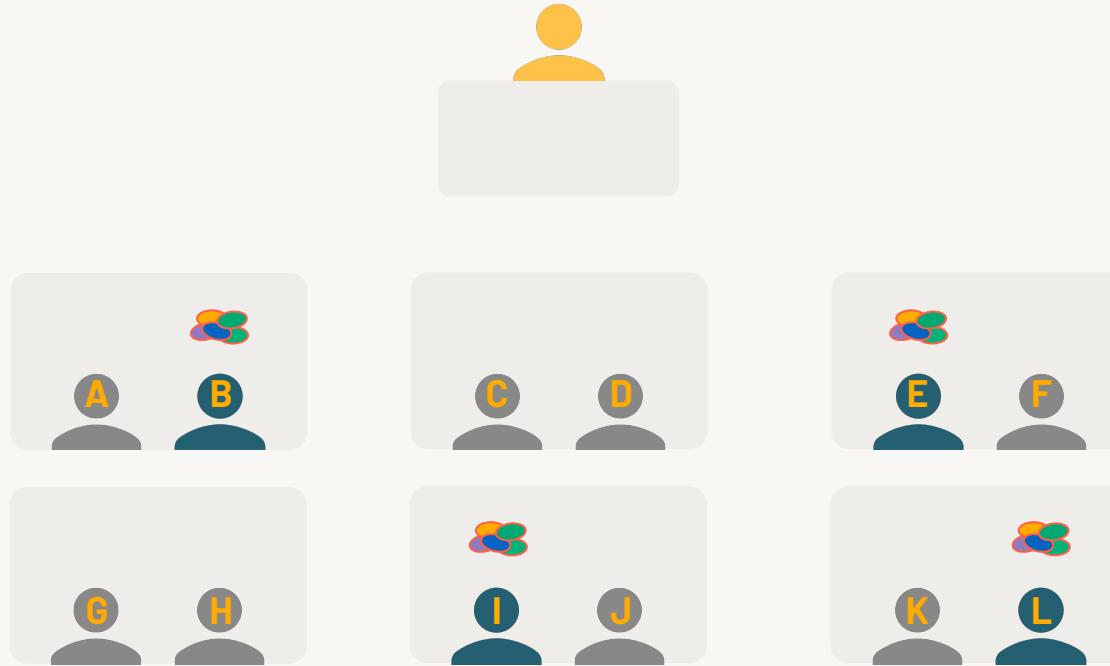
Students B, E, I, L,
get these four bags



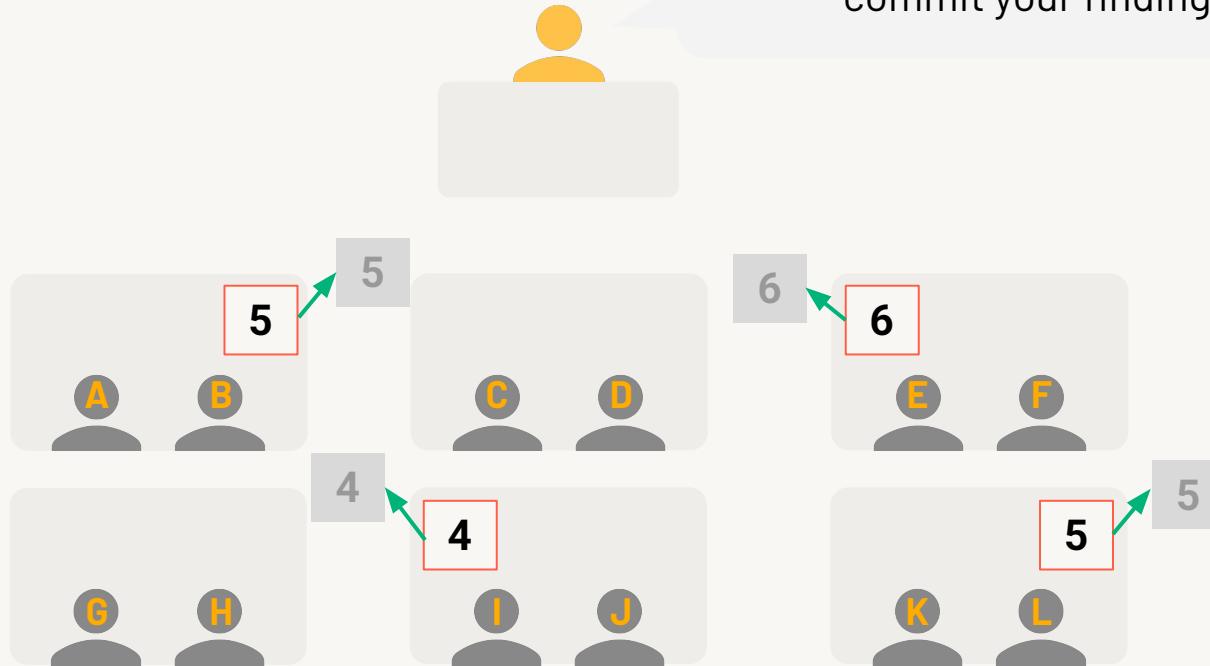
Stage 1: Local Count



Stage 1: Local Count

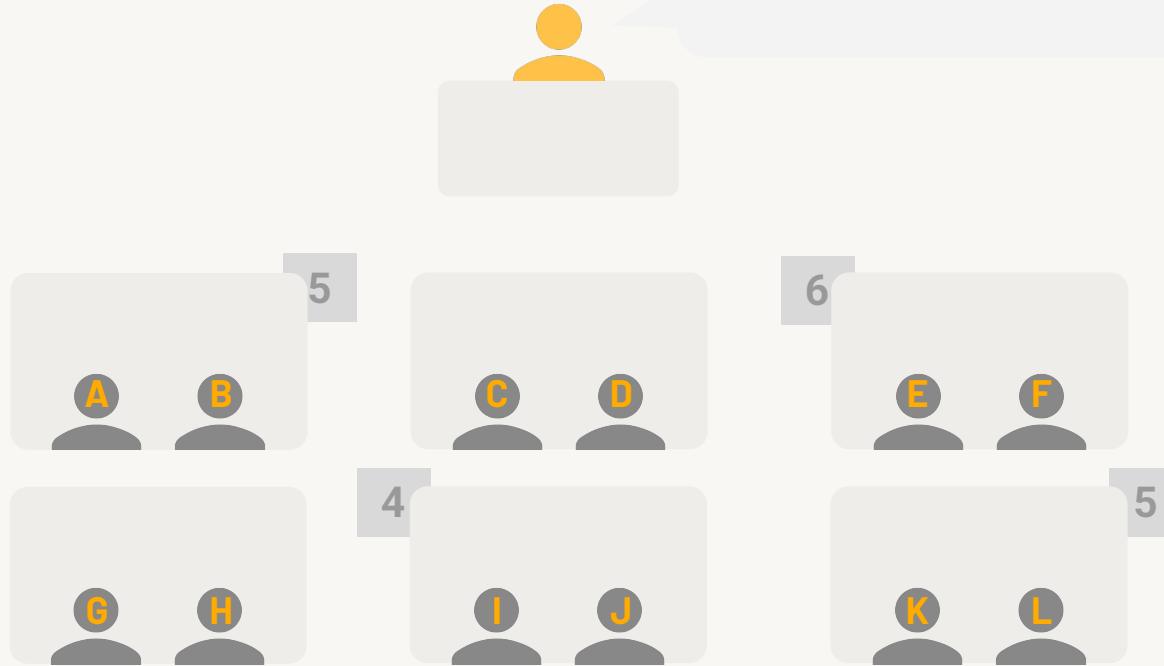


Stage 1: Local Count



Stage 1: Local Count

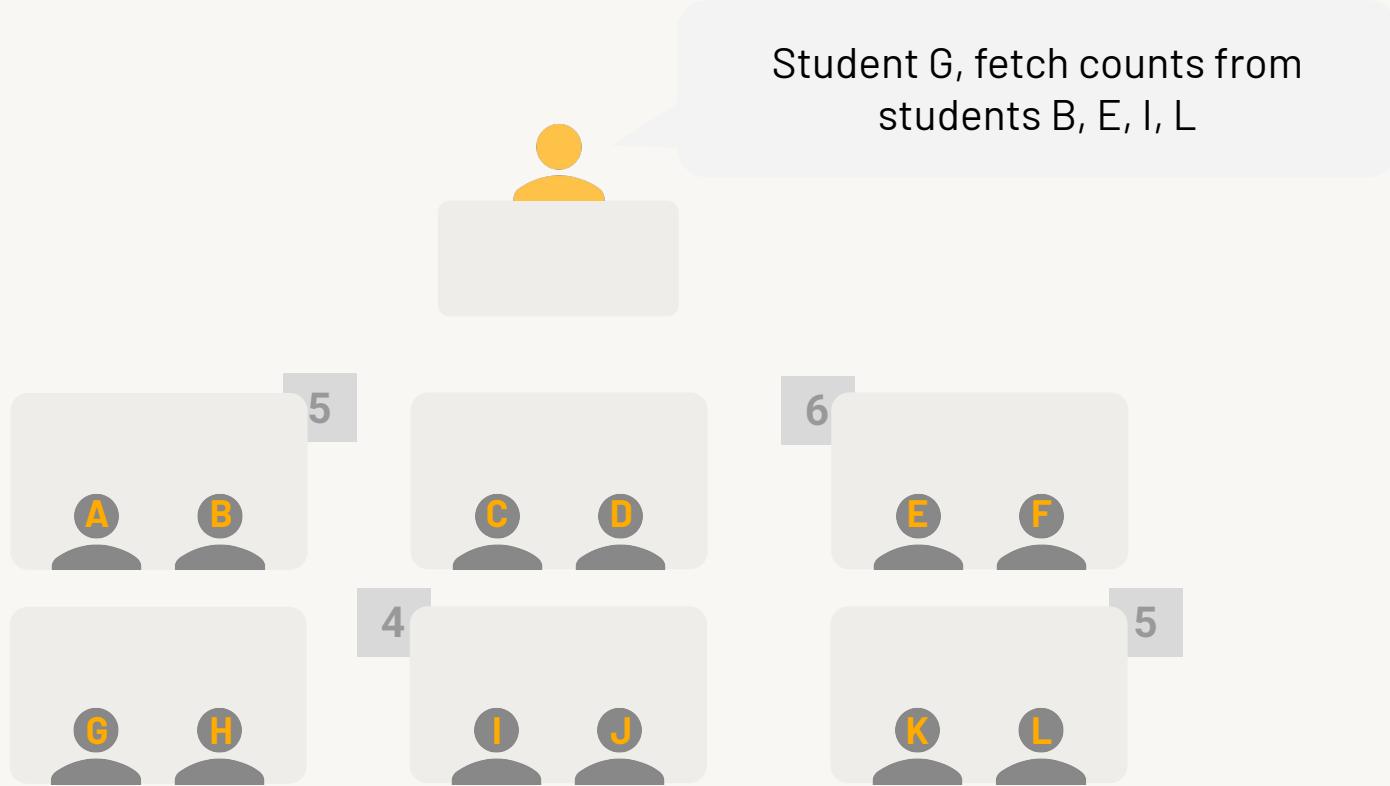
Stage 1 is complete!



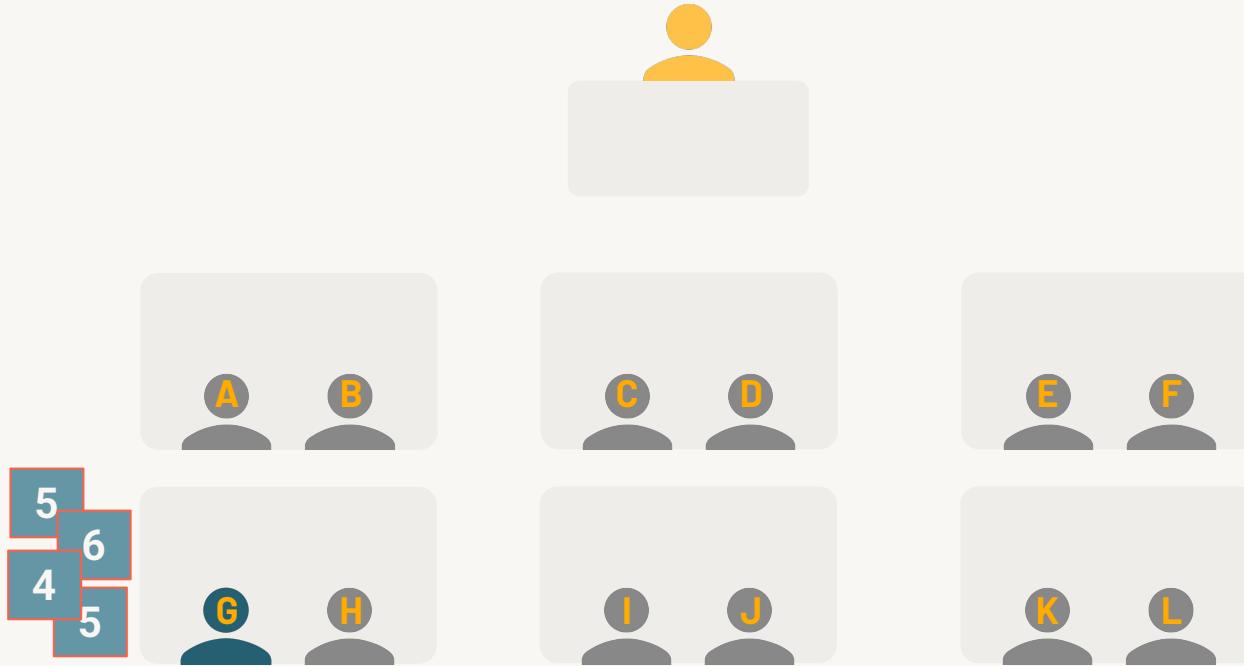
Stage 2: Global Count



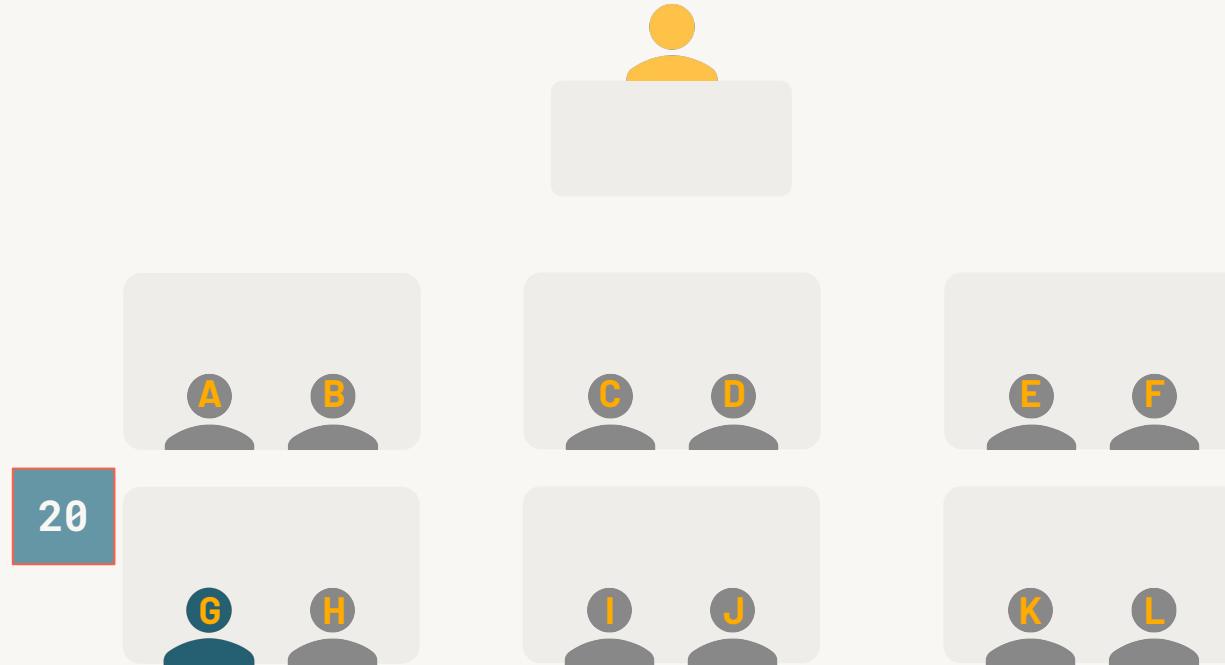
Stage 2: Global Count



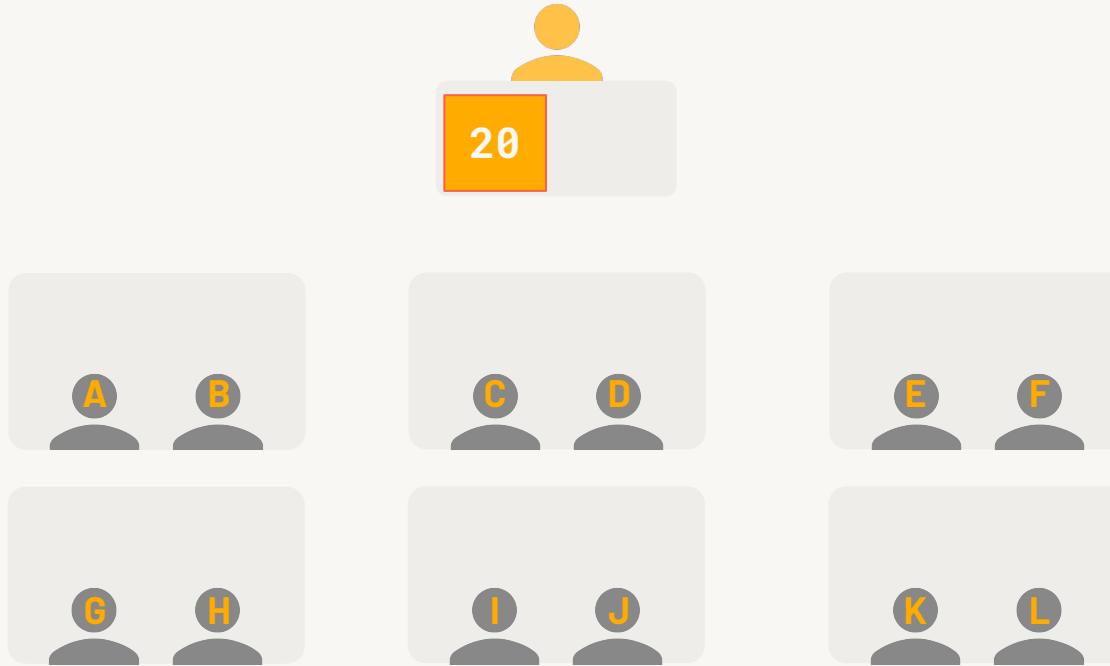
Stage 2: Global Count



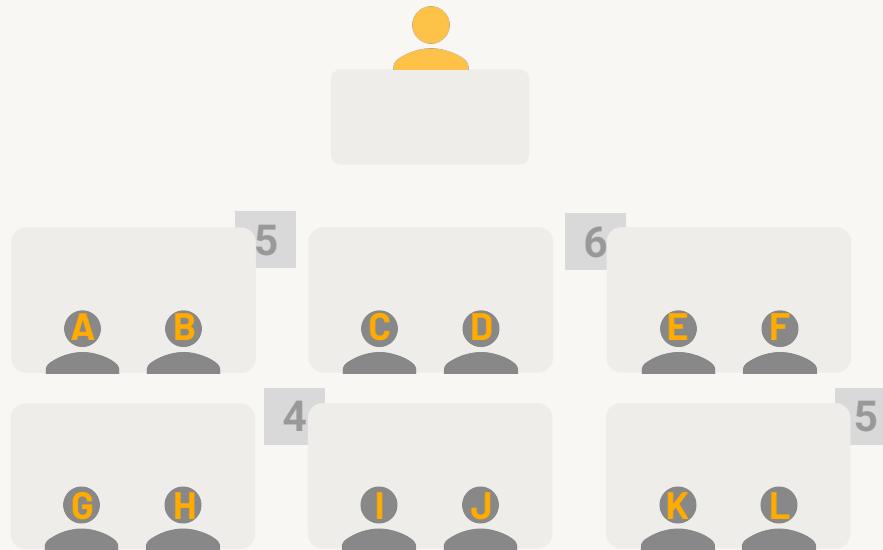
Stage 2: Global Count



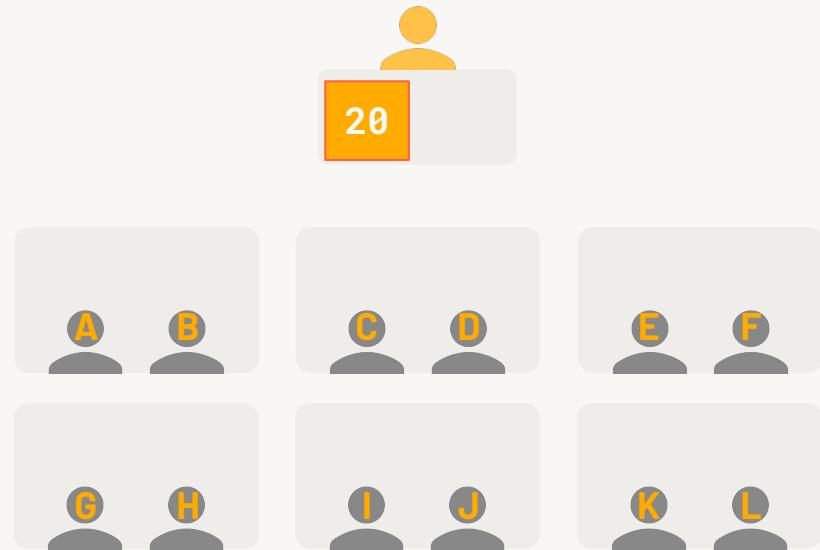
Stage 2: Global Count



Stage 1: Local Count



Stage 2: Global Count



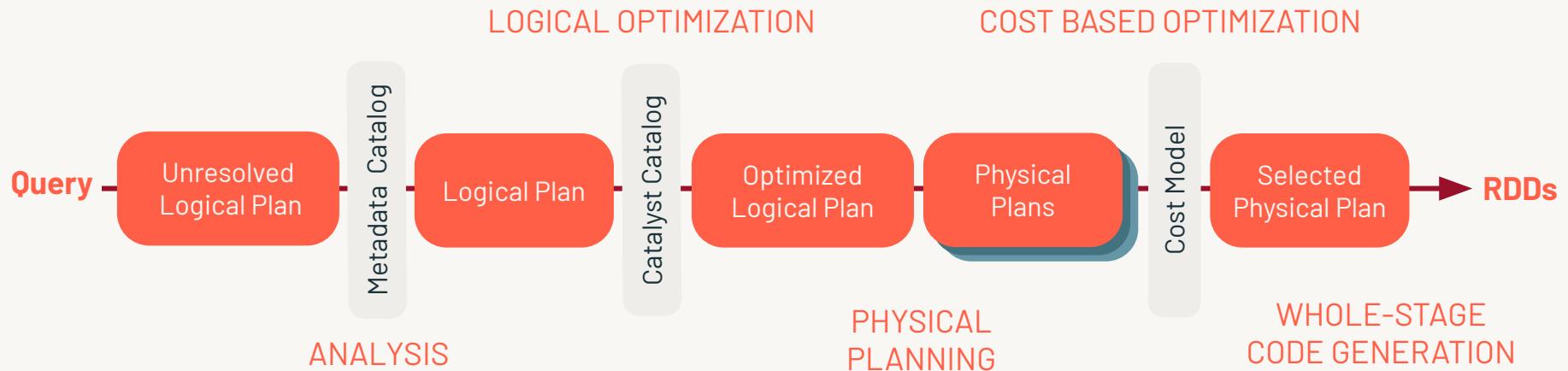
Query Optimization

Catalyst Optimizer
Adaptive Query Execution

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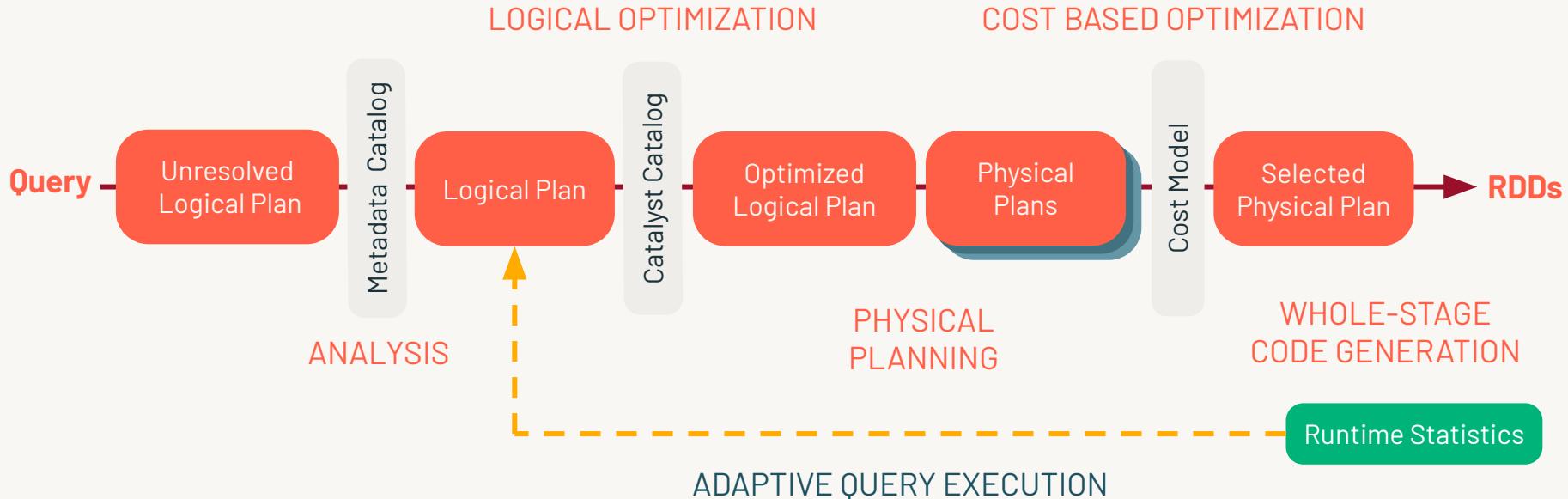


Query Optimization



Query Optimization with AQE

New in Spark 3.0, **enabled** by default as of Spark 3.2



Module 5

Structured Streaming





Structured Streaming

Streaming Query
Stream Aggregations

Streaming Query

Advantages

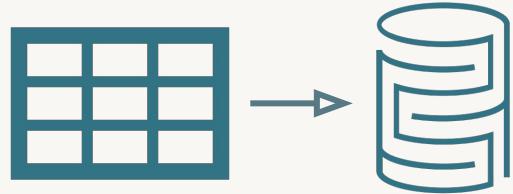
Use Cases

Sources

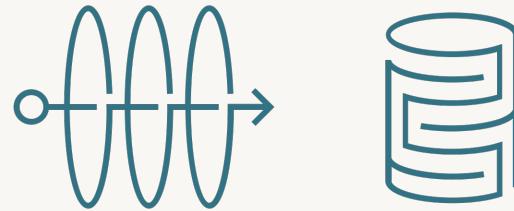
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Batch Processing



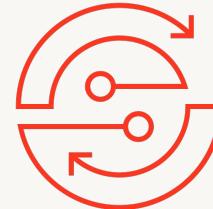
Stream Processing



Advantages of Stream Processing



Lower latency



Efficient Updates

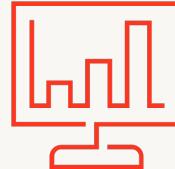


Automatic bookkeeping on new data

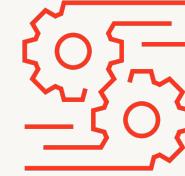
Stream Processing Use Cases



Notifications



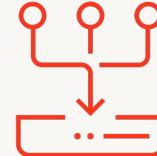
Real-time
reporting



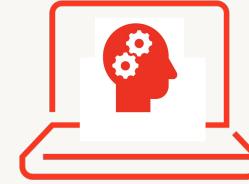
Incremental ETL



Update data to
serve in
real-time

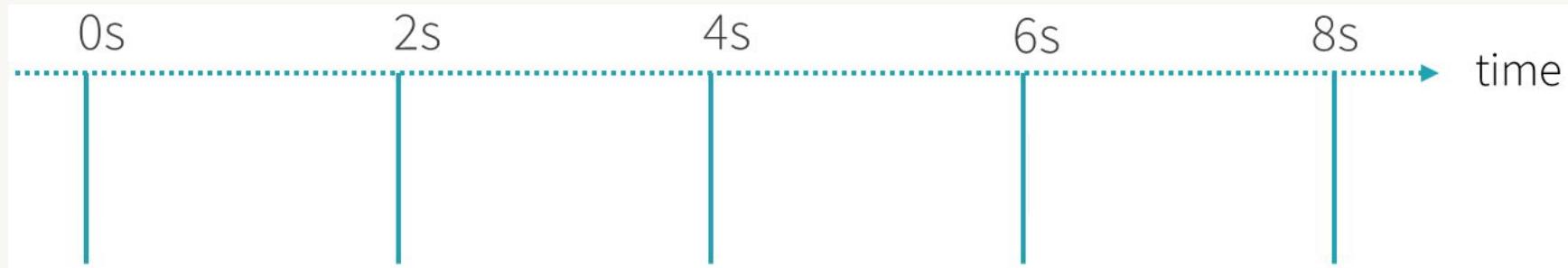


Real-time
decision making

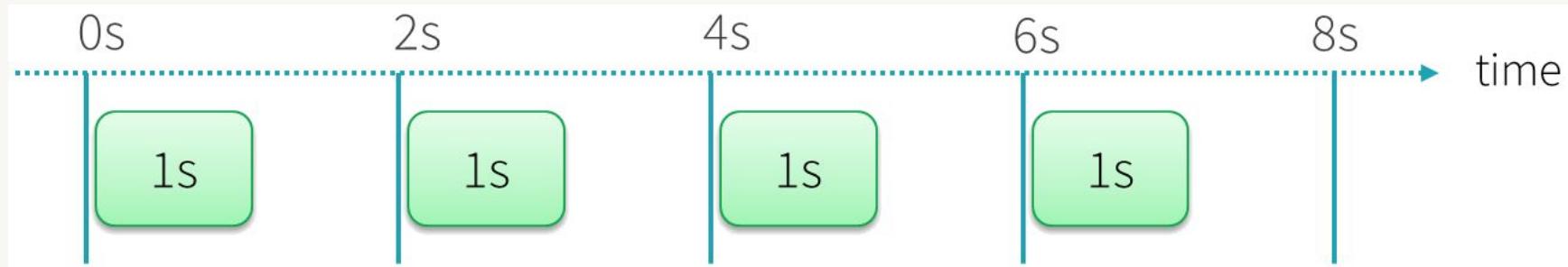


Online ML

Micro-Batch Processing



Micro-Batch Processing



Structured Streaming

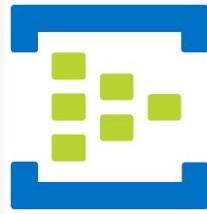


Input Sources

Kafka



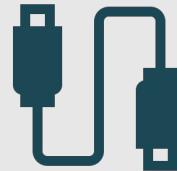
Event Hubs



Files



Sockets



Generator



FOR TESTING

Sinks

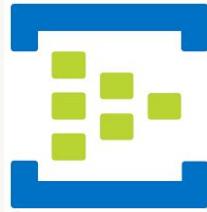
Kafka



Files



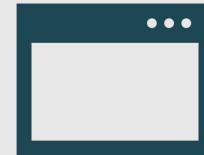
Event Hubs



Foreach



Console



Memory



FOR DEBUGGING

Output Modes

APPEND

Add new records
only

UPDATE

Update changed
records in place

COMPLETE

Rewrite full output



Trigger Types

Default	Process each micro-batch as soon as the previous one has been processed
Fixed interval	Micro-batch processing kicked off at the user-specified interval
One-time	Process all of the available data as a single micro-batch and then automatically stop the query
Continuous Processing	Long-running tasks that continuously read, process, and write data as soon events are available <i>*Experimental</i> See Structured Streaming Programming Guide



End-to-end fault tolerance

Guaranteed in Structured Streaming by

Checkpointing and write-ahead logs

Idempotent sinks

Replayable data sources



Stream Aggregations

Aggregations
Windows
Watermarking

85



Real-time Aggregations



Errors in IoT data by device type



Anomalous behavior in server log files by country



Behavior analysis on messages by hashtags

Time-Based Windows

Tumbling Windows

No window overlap

Any given event gets aggregated into **only one** window group

e.g. 1:00–2:00 am, 2:00–3:00 am, 3:00–4:00 am, ...

Sliding Windows

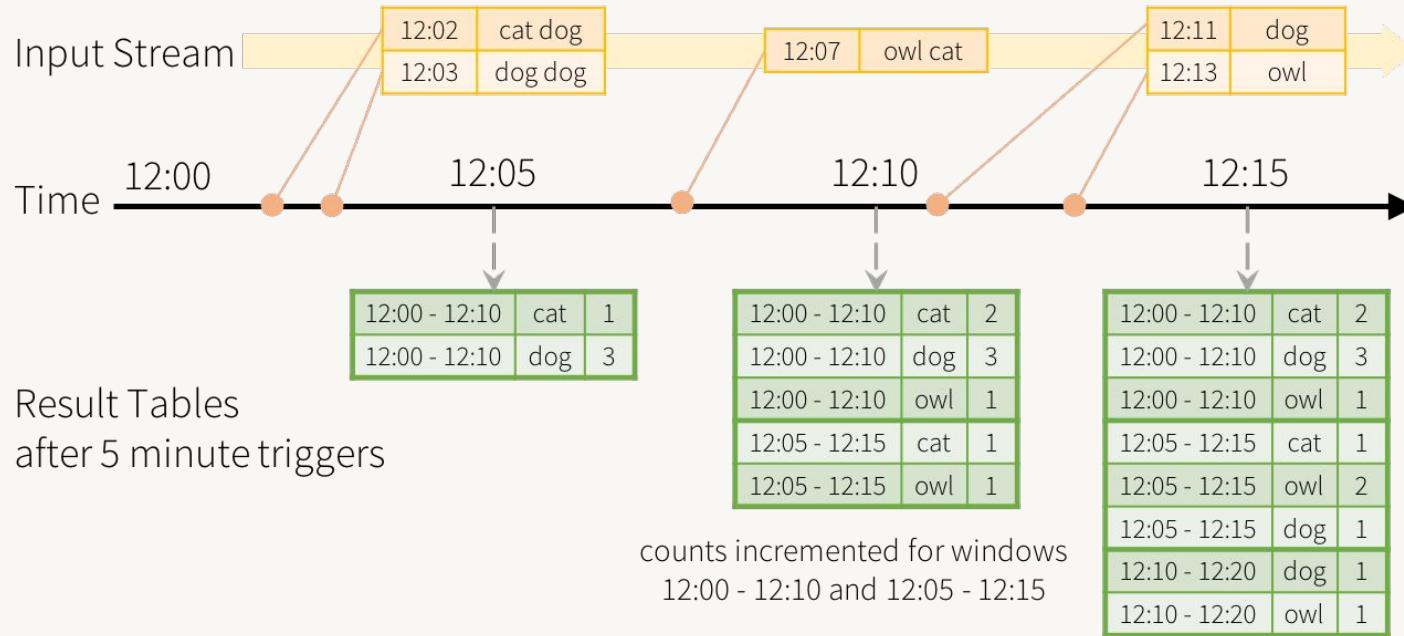
Windows overlap

Any given event gets aggregated into **multiple** window groups

e.g. 1:00–2:00 am, 1:30–2:30 am, 2:00–3:00 am, ...



Sliding Windows Example



Windowing

```
(streamingDF
    .groupBy(col("device"),
              window(col("time"), "1 hour"))
    .count())
```

[Cancel](#)

▼ (1) Spark Jobs

▼ Job 4 [View](#) (3 stages)

Stage 12:	<div style="width: 100%;">1/1 (0 running)</div>	i
Stage 13:	<div style="width: 39.5%; background-color: #00AEEF;">79/200 (4 running)</div>	i
Stage 14:	<div style="width: 0%;">0/1 (0 running)</div>	i

Why are we seeing 200 tasks for this stage?



Control the Shuffle Repartitioning

```
spark.conf.set("spark.sql.shuffle.partitions", spark.sparkContext.defaultParallelism)
```

The screenshot shows the Databricks UI interface. At the top left, there is a 'Cancel' button and a 'More' menu icon. Below that, a tree view shows '(1) Spark Jobs' expanded, revealing 'Job 42'. Under 'Job 42', there are three stages listed: Stage 126, Stage 127, and Stage 128. Each stage has a progress bar and some text next to it. Stage 126: '1/1 (0 running)' with an info icon. Stage 127: '4/4 (0 running)' with an info icon. Stage 128: '1/1 (0 running)' with an info icon.

Stage	Status	Info
Stage 126	1/1 (0 running)	i
Stage 127	4/4 (0 running)	i
Stage 128	1/1 (0 running)	i



Event-Time Processing

EVENT-TIME DATA

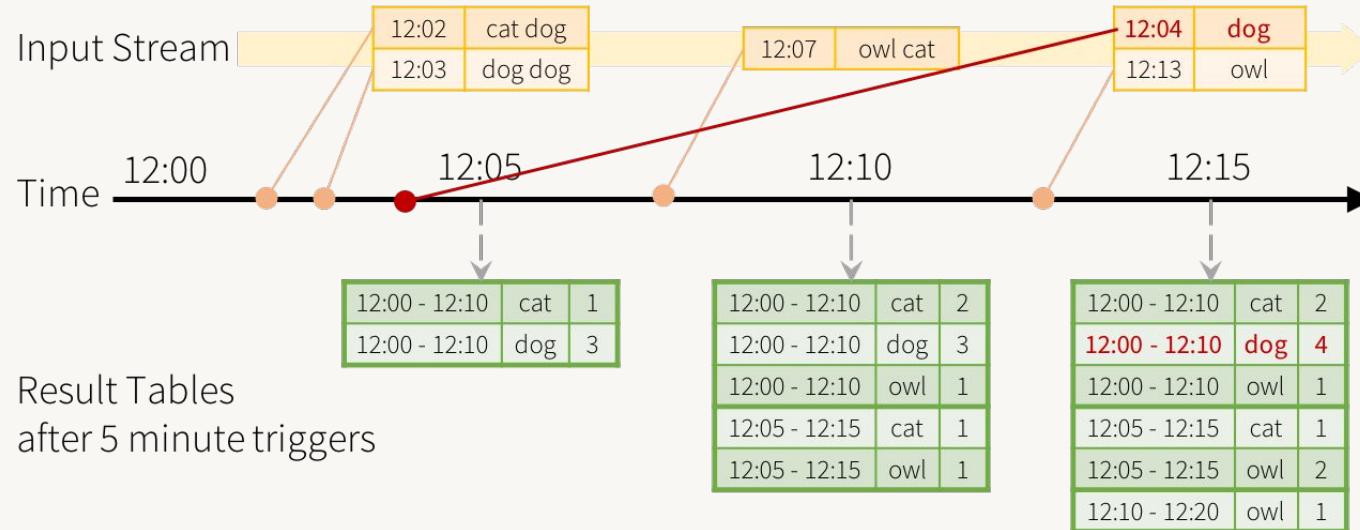
Process based on event-time
(time fields embedded in data)
rather than receipt time

WATERMARKS

Handle late data and limit how
long to remember old data



Handling Late Data and Watermarking



Watermarking

```
(streamingDF
    .withWatermark("time", "2 hours")
    .groupBy(col("device"),
              window(col("time"), "1 hour"))
    .count()
)
```





Module 6

Delta Lake





Delta Lake

Using Spark with Delta Lake



Delta Lake

Delta Lake Concepts

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What is Delta Lake?

- Technology designed to be used with Apache Spark to build robust data lakes
- Open source project at delta.io
- Databricks [Delta Lake documentation](#)



DELTA LAKE



Delta Lake features

- ACID transactions on Spark
- Scalable metadata handling
- Streaming and batch unification
- Schema enforcement
- Time travel
- Upserts and deletes
- Fully configurable/optimizable
- Structured streaming support



Delta Lake components

Delta Lake
storage
layer

Delta tables

Delta Engine



Delta Lake Storage Layer

- Highly performant and persistent
- Low-cost, easily scalable object storage
- Ensures consistency
- Allows for flexibility



Delta tables

- Contain data in Parquet files that are kept in object storage
- Keep transaction logs in object storage
- Can be registered in a metastore (optional)



Delta Engine

Databricks edge feature; not available in OS Apache Spark

- File management optimizations
- Auto-optimized writes
- Performance optimization via Delta caching



What is the Delta transaction log?

- Ordered record of the transactions performed on a Delta table
- Single source of truth for that table
- Mechanism that the Delta Engine uses to guarantee atomicity



How does the transaction log work?

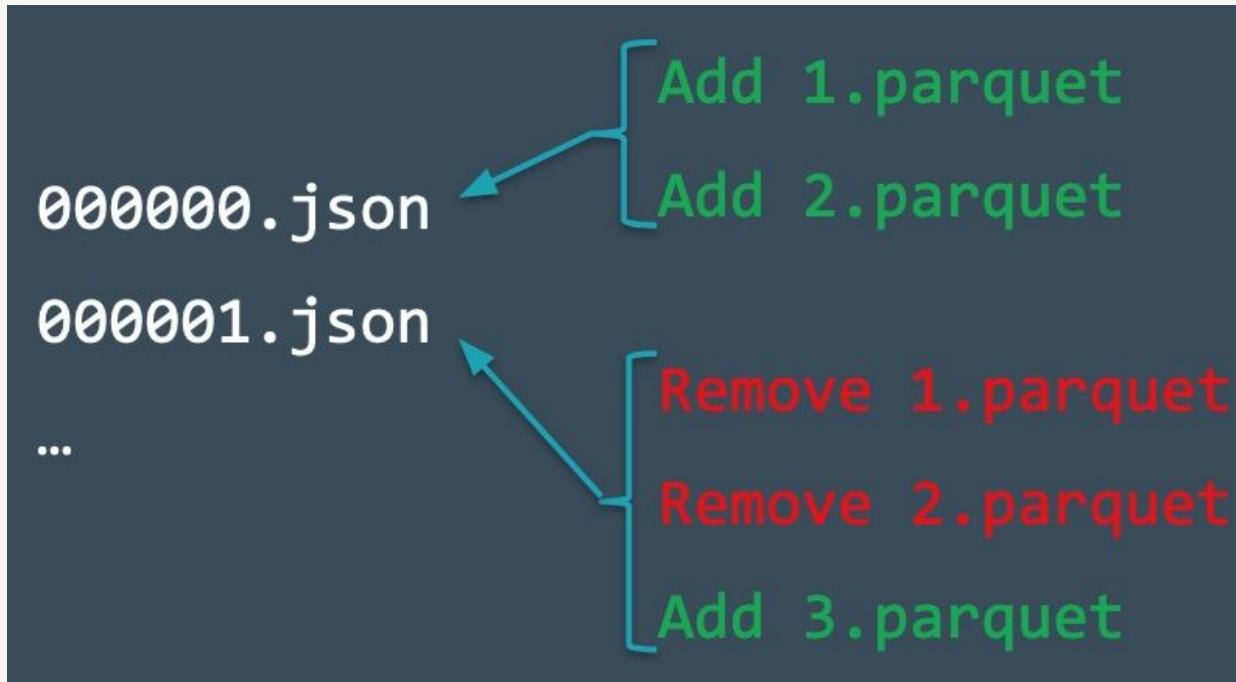
- Delta Lake breaks operations down into one or more of these steps:
 - Add file
 - Remove file
 - Update metadata
 - Set transaction
 - Change protocol
 - Commit info



Delta transaction log at the file level



Adding commits to the transaction log



DESCRIBE Command

- Returns the metadata of an existing table
 - Ex. Column names, data types, comments

DESCRIBE HISTORY Command

- Returns a more complete set of metadata for a Delta table
 - Operation, user, operation metrics



Delta Lake Time Travel

- Query an older snapshot of a Delta table
 - Re-creating analysis, reports or outputs
 - Writing complex temporal queries
 - Fixing mistakes in data
 - Providing snapshot isolation



Time Travel SQL syntax

```
SELECT * FROM events TIMESTAMP AS OF timestamp_expression  
SELECT * FROM events VERSION AS OF version
```



Time Travel SQL syntax

```
SELECT * FROM events TIMESTAMP AS OF timestamp_expression
```

- `timestamp_expression` can be:
 - String that can be cast to a timestamp
 - String that can be cast to a date
 - Explicit timestamp type (the result of casting)
 - Simple time or date expressions (see the [Databricks documentation](#))



Time Travel SQL syntax

```
SELECT * FROM events VERSION AS OF version
```

- Version can be obtained from the output of DESCRIBE HISTORY events.



Thank you! Congrats!

