The big picture

Goals

- Recall foundational concepts related to the contemporary big data landscape.
- Define the core challenges with building a big data architecture.
- Explain how the core components of a Lakehouse relate to the Inmon Architecture.
- Explain how Delta Lake can be used to build a Lakehouse.
- Describe the core components of Delta Lake.

The big data landscape

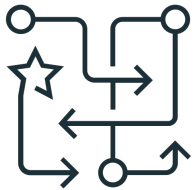
databricks

The big data problem

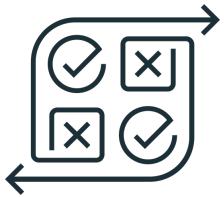
Volume

Velocity

Variety



Veracity



Value

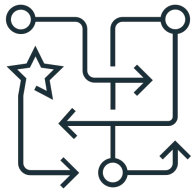
Brainstorm

- How do the 5 V's of big data tie back into your Moovio dataset?

Volume

Velocity

Variety



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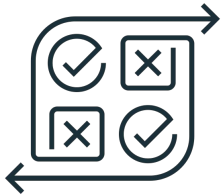


Value

Service level agreements (SLAs)

Data freshness

Query speed

Data reliability

Ease of use

At Moovio, your SLA includes:

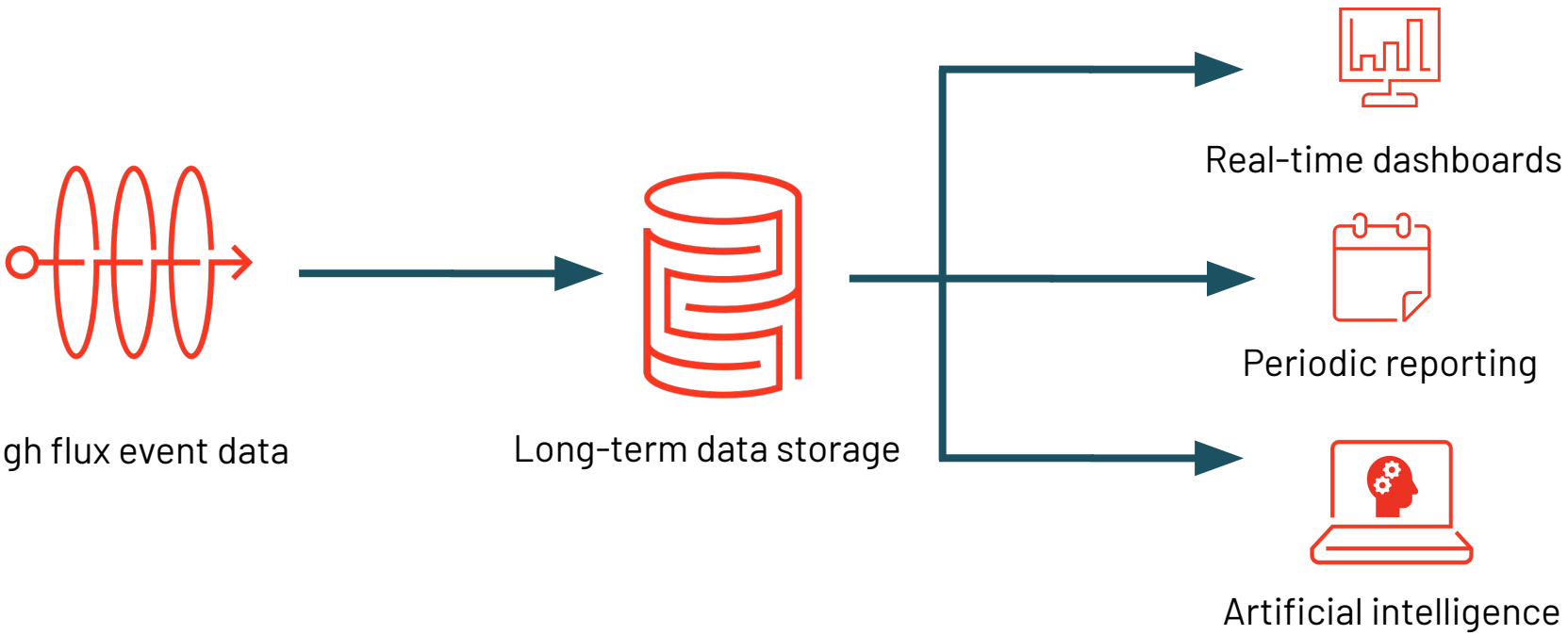
Data freshness

Query speed

Data reliability

Ease of use

Big data needs



A single source of truth

Enterprise Decision Support System (EDSS)

- Information system used by an organization to help decision-making
- Can be built:
  - On-premises or in the cloud
  - Using data lake, data warehouse or data lakehouse technology

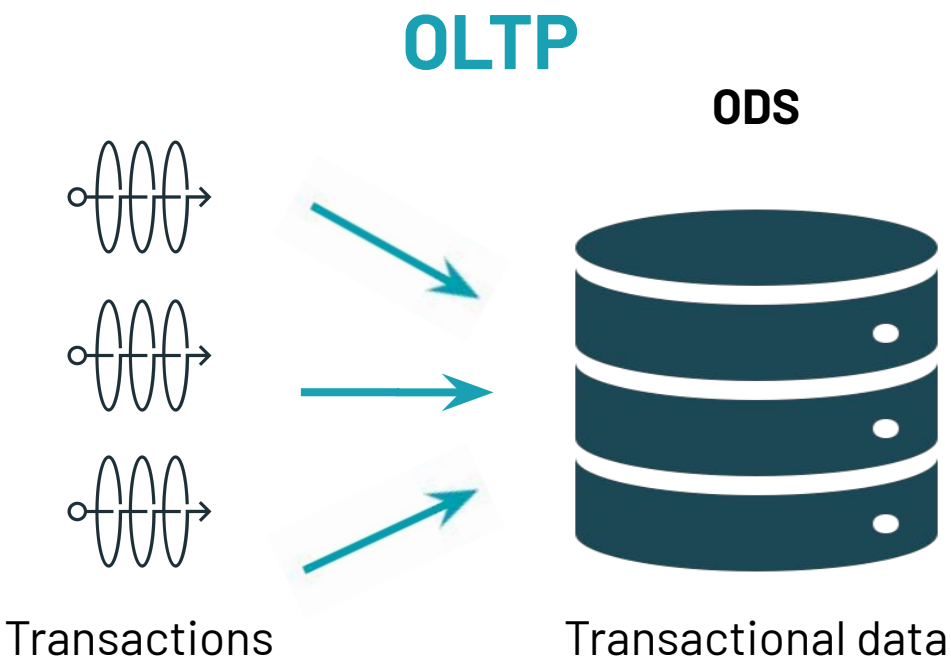
Analytical and operational layers

An **EDSS** performs **Online Analytical Processing (OLAP)**

An **ODS** performs **Online Transaction Processing (OLTP)**

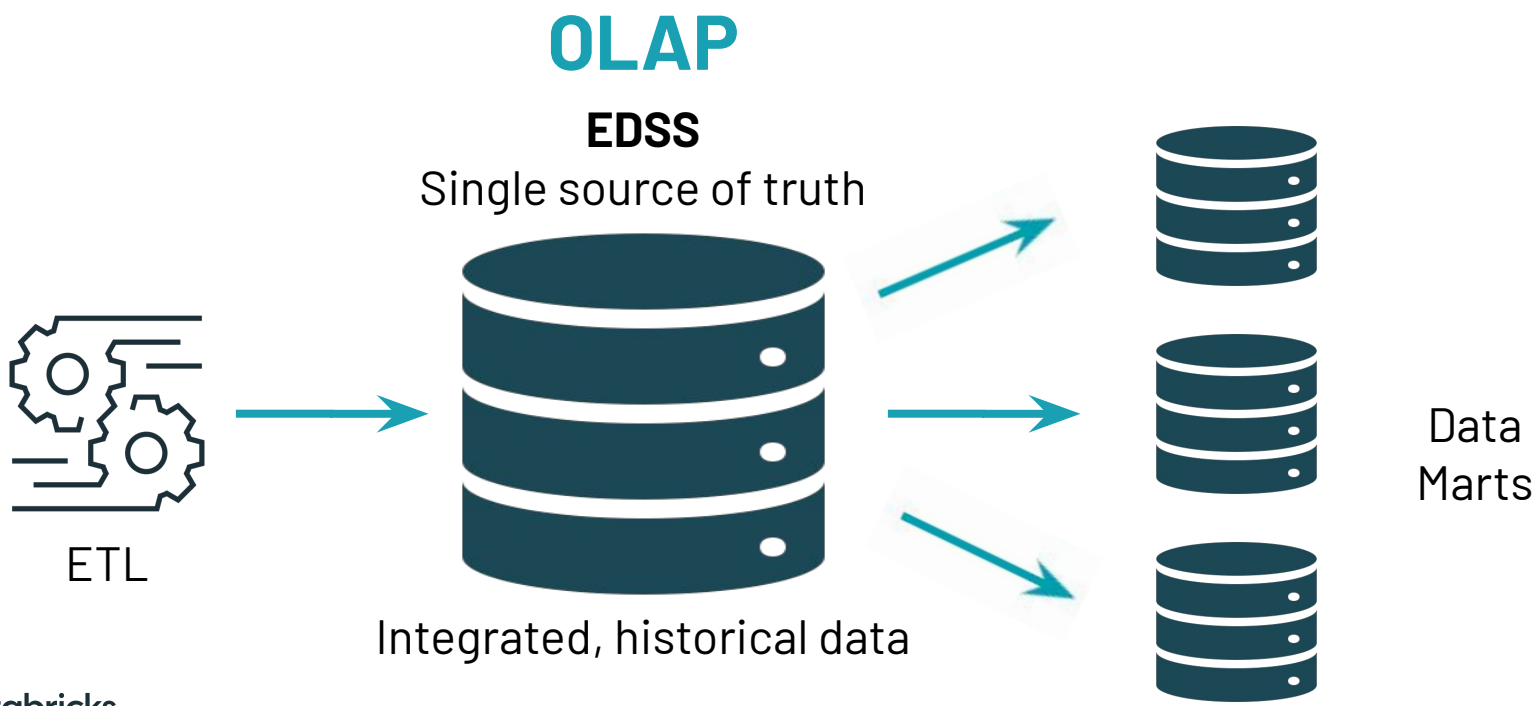
ODS and OLTP

Operational Data Store and Online Transaction Processing



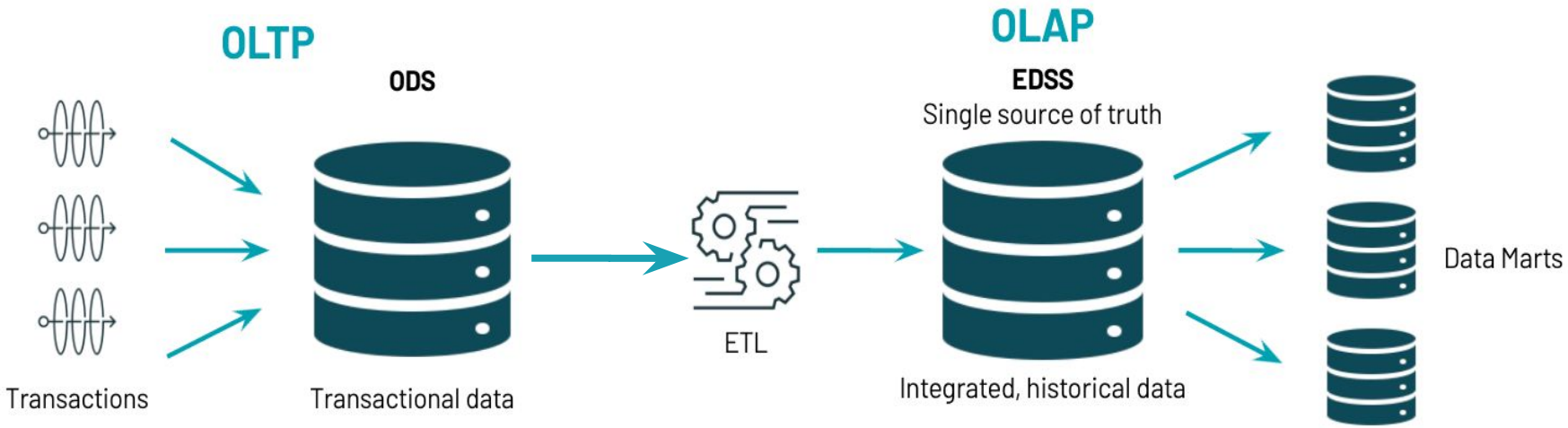
EDSS and OLAP

The Enterprise Decision Support System and Online Analytical Processing



Complete data system

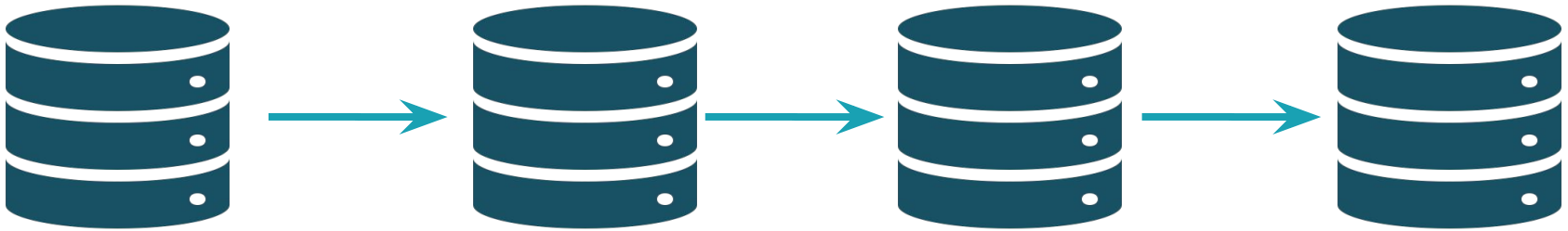
- An ETL process pulls data from the ODS to be loaded into the EDSS



Brainstorm

- Relate this process and its components (EDSS and ODS) to Moovio's data infrastructure.

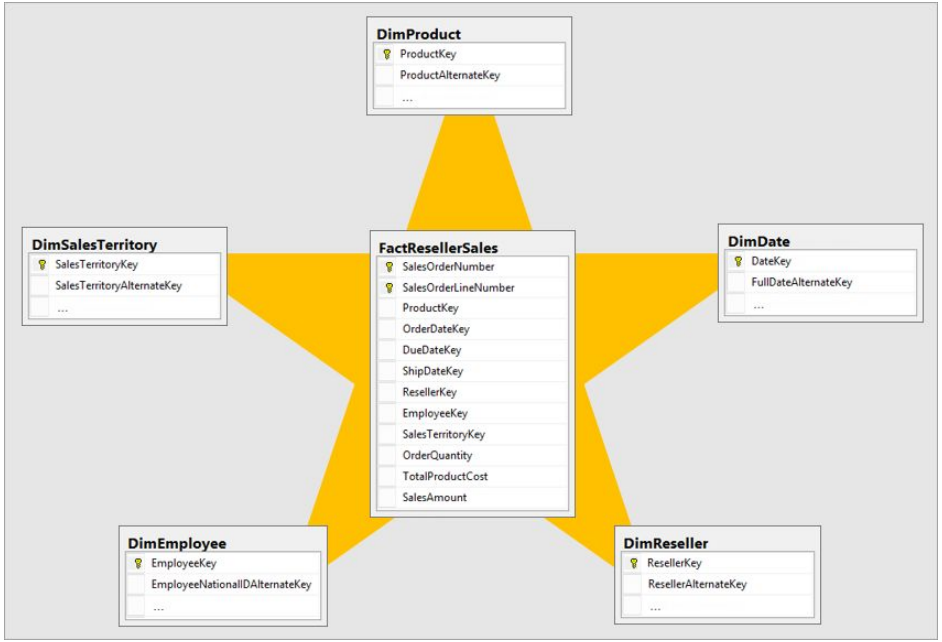
Levels of data



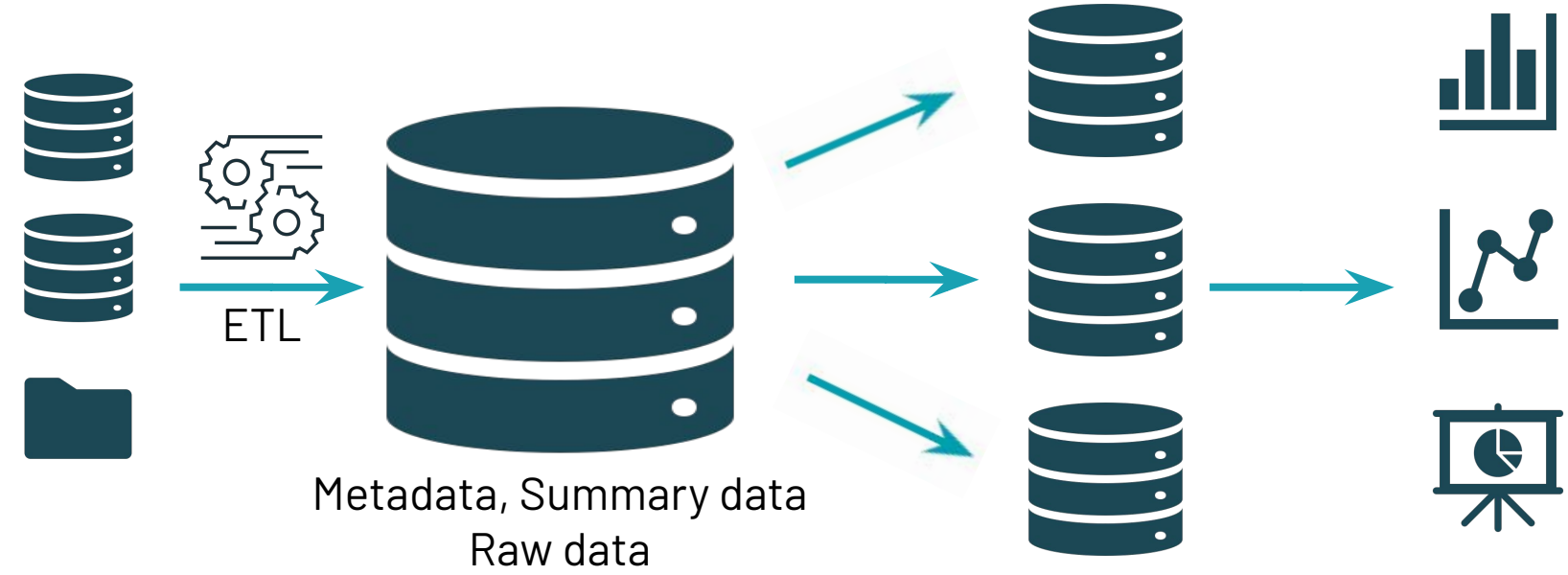
Fact and dimension tables

Dimensional modeling

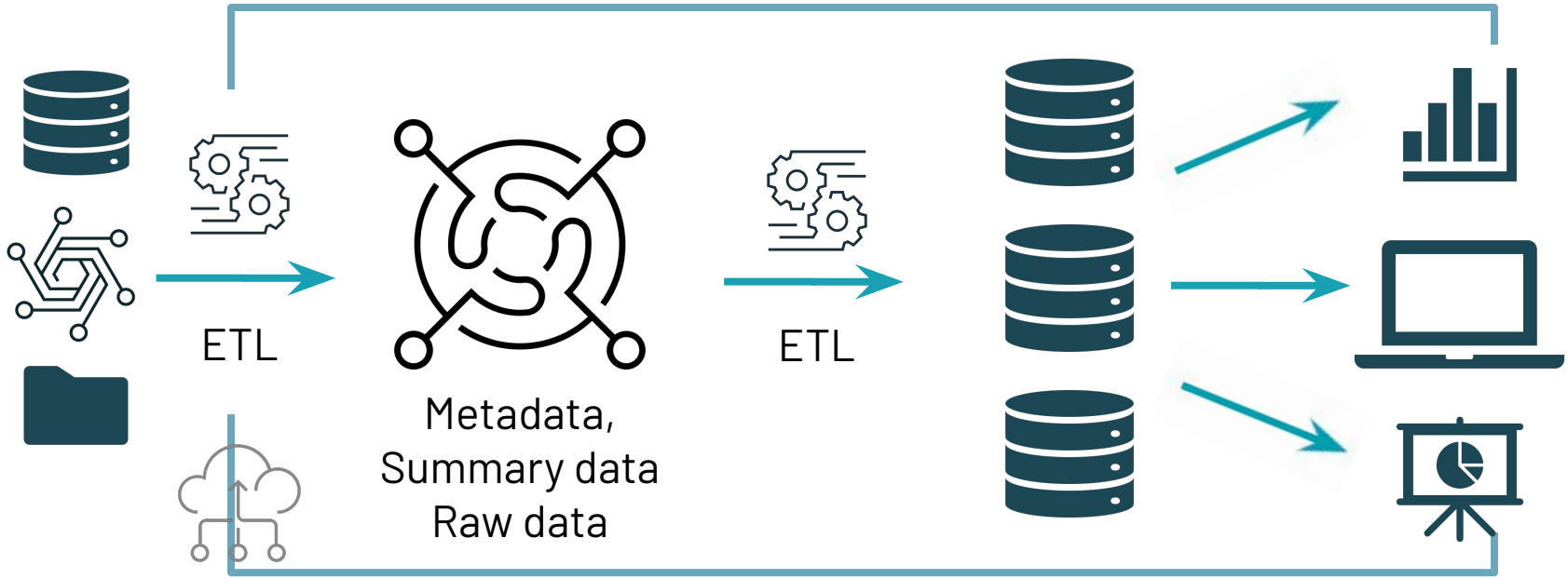
- Fact tables
- Dimension tables
- Aggregate fact tables



Bill Inmon's Theoretical Data Warehouse Architecture



Lakehouse



Operational
ODS

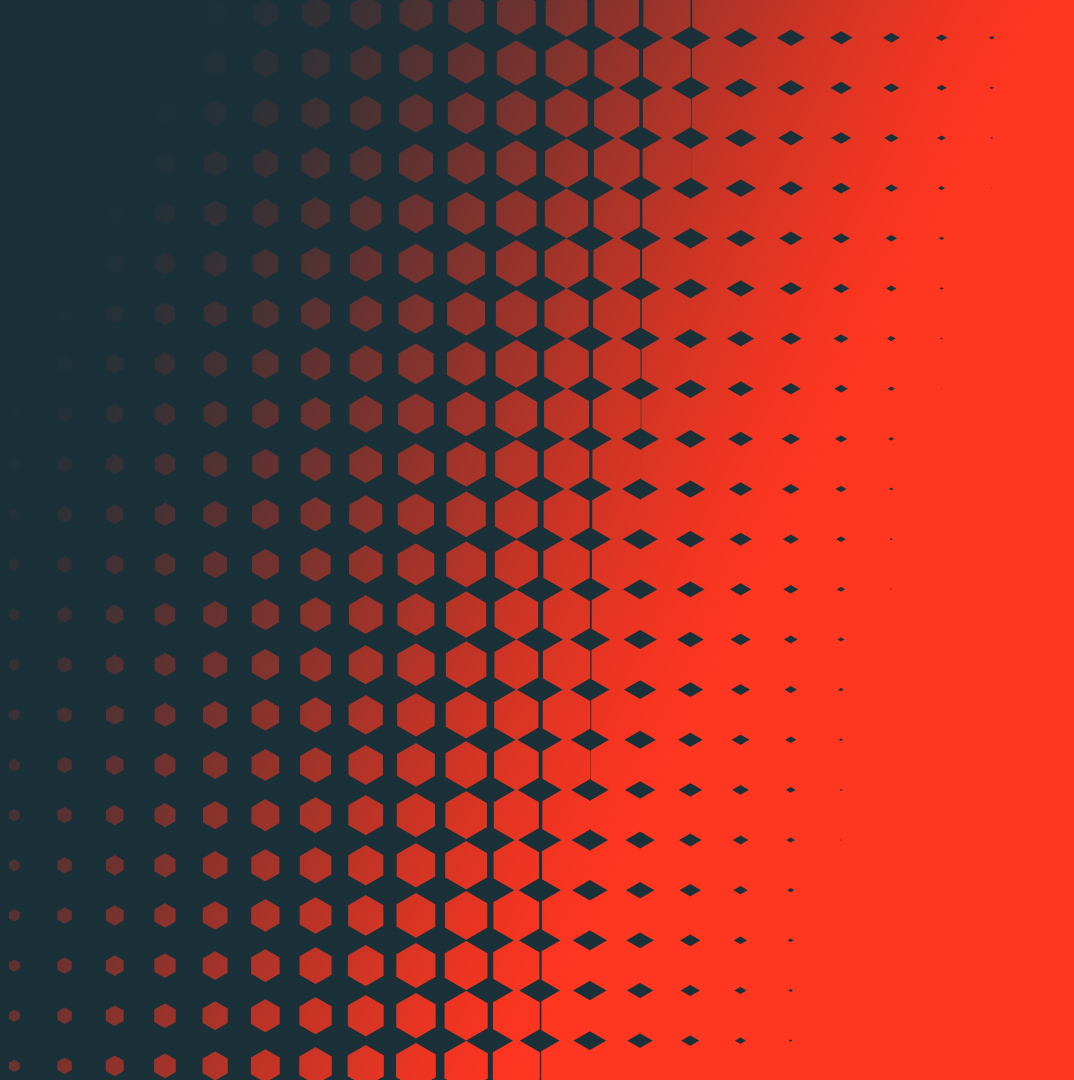
Atomic
EDSS
Data Lake

Departmental
Data Marts
Data warehouse

Individual
End users

databricks

The Lakehouse



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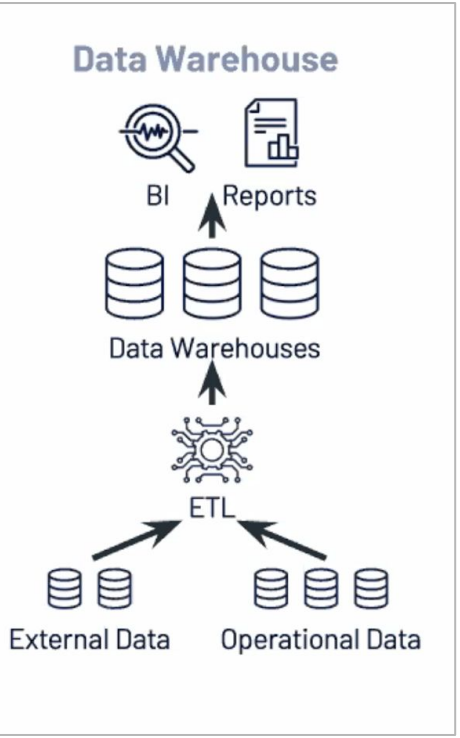
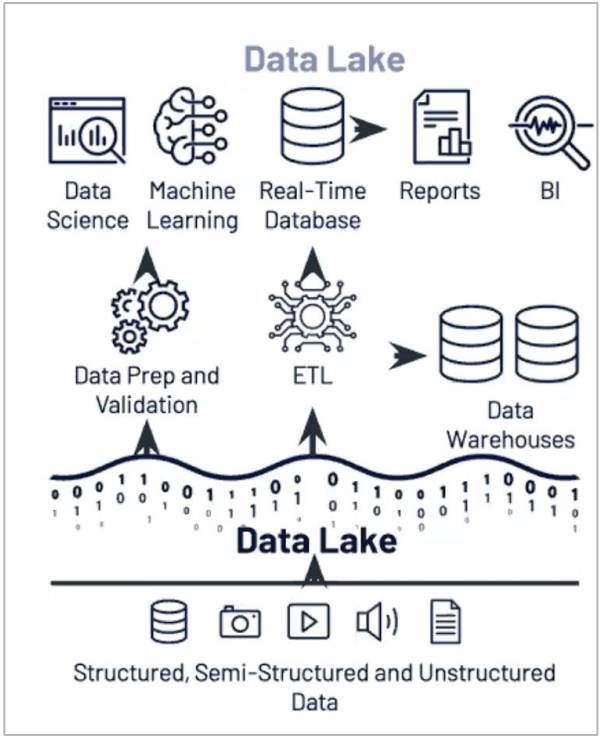
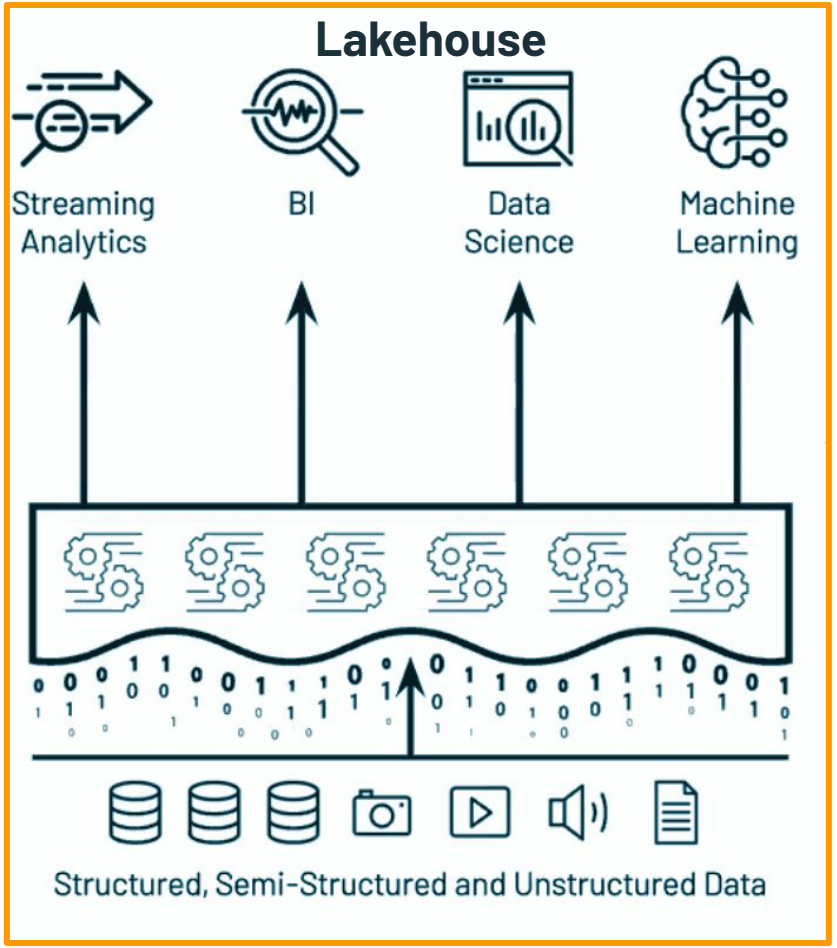
What is a Lakehouse?

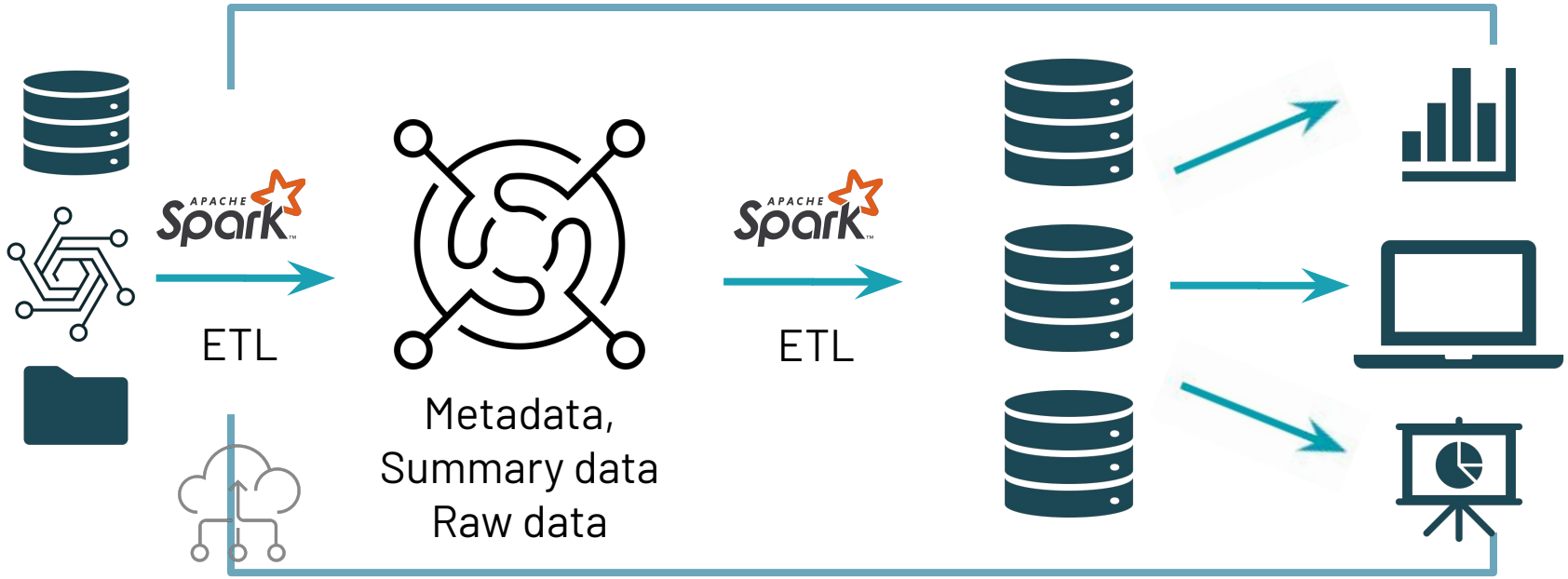






databricks

Levels of data in a Lakehouse



Operational
ODS

Atomic
EDSS
Data Lake

Departmental
Data Marts
Data warehouse

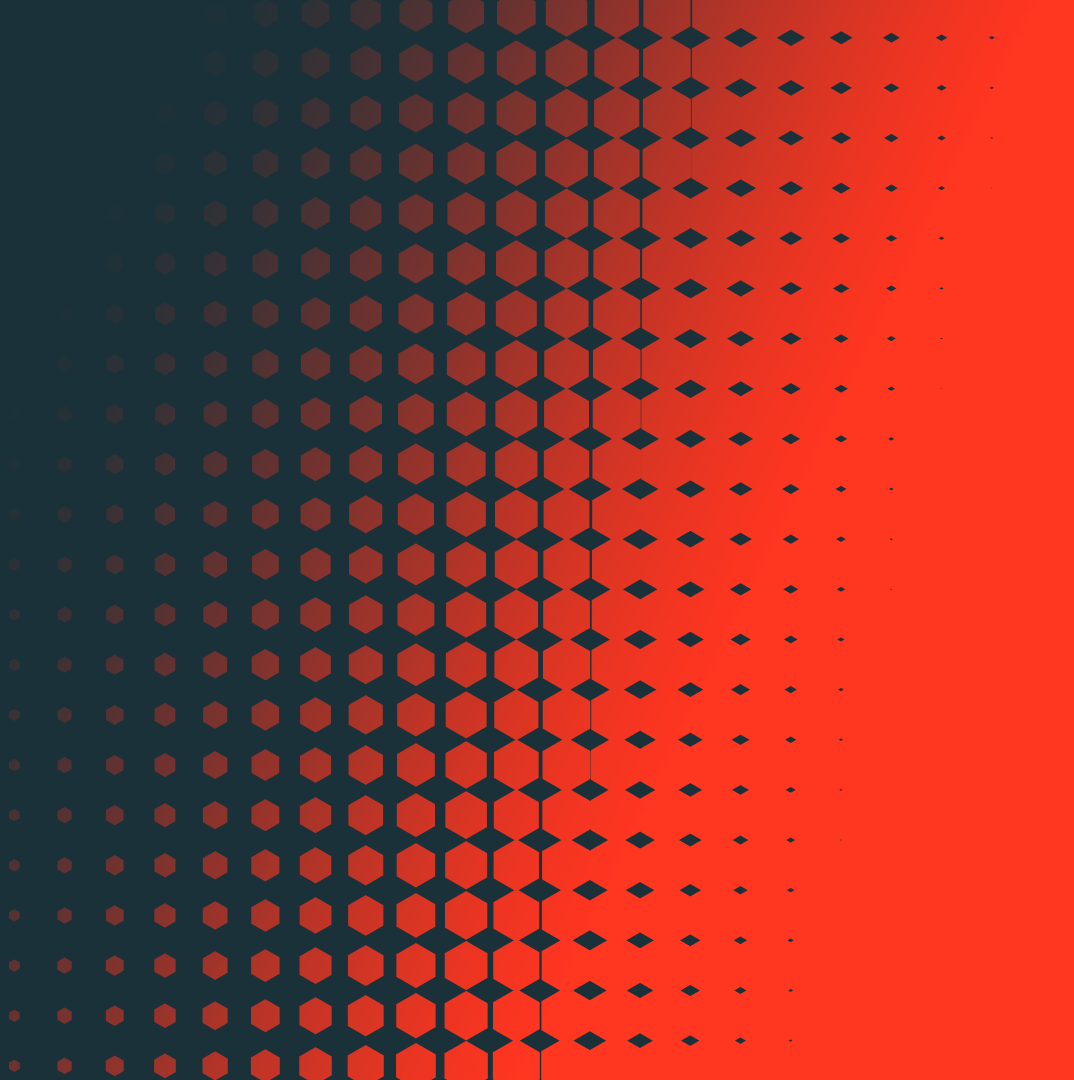
Individual
End users

databricks

Benefits of a Lakehouse

- Separation of compute and storage
- Infinite storage capacity
- Leverage best aspects of a data warehouse
- Low data gravity
- High data throughput
- No limits on data structure
- Mix batch and streaming workloads

The Delta architecture



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What is **Delta Lake**?

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

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 components

Delta Lake storage layer

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

Delta Lake components

Delta Lake components

- Data in Parquet/Delta files
- Transaction log
- Registered in metastore (optional)

Data - Parquet files

- File format for tabular data stored as columns
- Fast and powerful
- Delta files = Parquet + versioning + metadata

Apache Parquet

- Initial effort by Twitter & Cloudera
- Open source storage format
  - Hybrid storage model (PAX)
- Widely used in Spark/Hadoop ecosystem (default format with Catalyst optimizer)
- One of the primary formats used by Databricks customers

Primitive Data Types

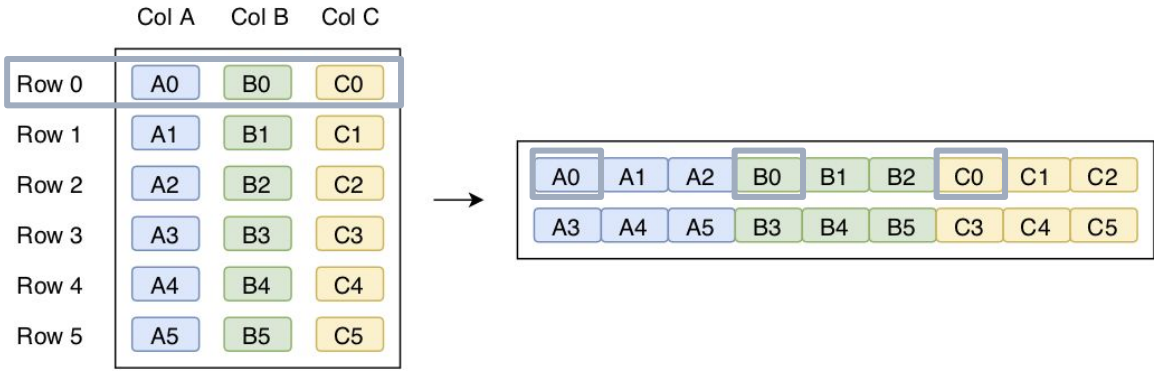
All data are encoded using a minimal set of types:

- BOOLEAN: 1 bit boolean
- INT32: 32 bit signed ints
- INT64: 64 bit signed ints
- INT96: 96 bit signed ints
- FLOAT: IEEE 32-bit floating point values
- DOUBLE: IEEE 64-bit floating point values
- BYTE_ARRAY: arbitrarily long byte arrays

Complex Types

- Parquet is self-describing for schema
- Logical types extend how primitive types should be interpreted
  - 16 bit integers are stored as INT32
  - Strings are stored as BYTE_ARRAY with UTF-8 encoding
- Arbitrarily nested data can be efficiently encoded
- Null values are not encoded in the data

Hybrid storage model



- Columnar storage
- Horizontal & vertical partitioning
- Used by Parquet & ORC
- Best of both worlds

Parquet “Files”

- On disk usually not a single file
- Logical file is defined by a root directory
  - Root dir contains one or multiple files

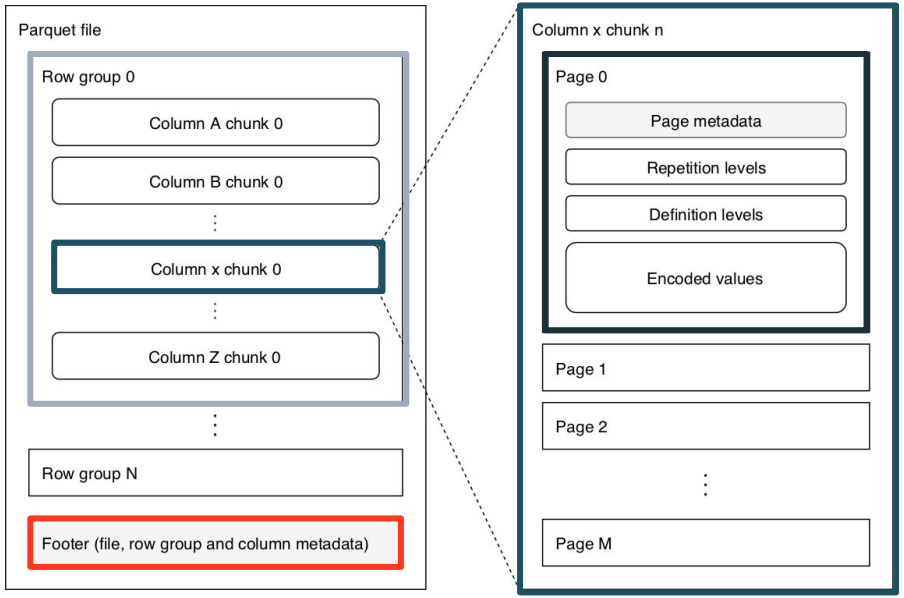
```
./example_parquet_file/
./example_parquet_file/part-00000-87439b68-7536-44a2-9eaa-1b40a236163d-c000.snappy.parquet
./example_parquet_file/part-00001-ae3c183b-d89d-4005-a3c0-c7df9a8e1f94-c000.snappy.parquet
```

  - **or** contains sub-directory structure with files in leaf directories

```
./example_parquet_file/
./example_parquet_file/country=Netherlands/
./example_parquet_file/country=Netherlands/part-00000-...-475b15e2874d.c000.snappy.parquet
./example_parquet_file/country=Netherlands/part-00001-...-c7df9a8e1f94.c000.snappy.parquet
```

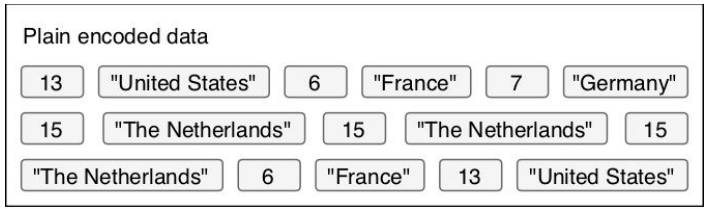
Data Organization

- Row-groups (*default 128MB*)
- Column chunks
- Pages (*default 1MB*)
  - Metadata
    - Min
    - Max
    - Count
  - Rep/def levels
  - Encoded values



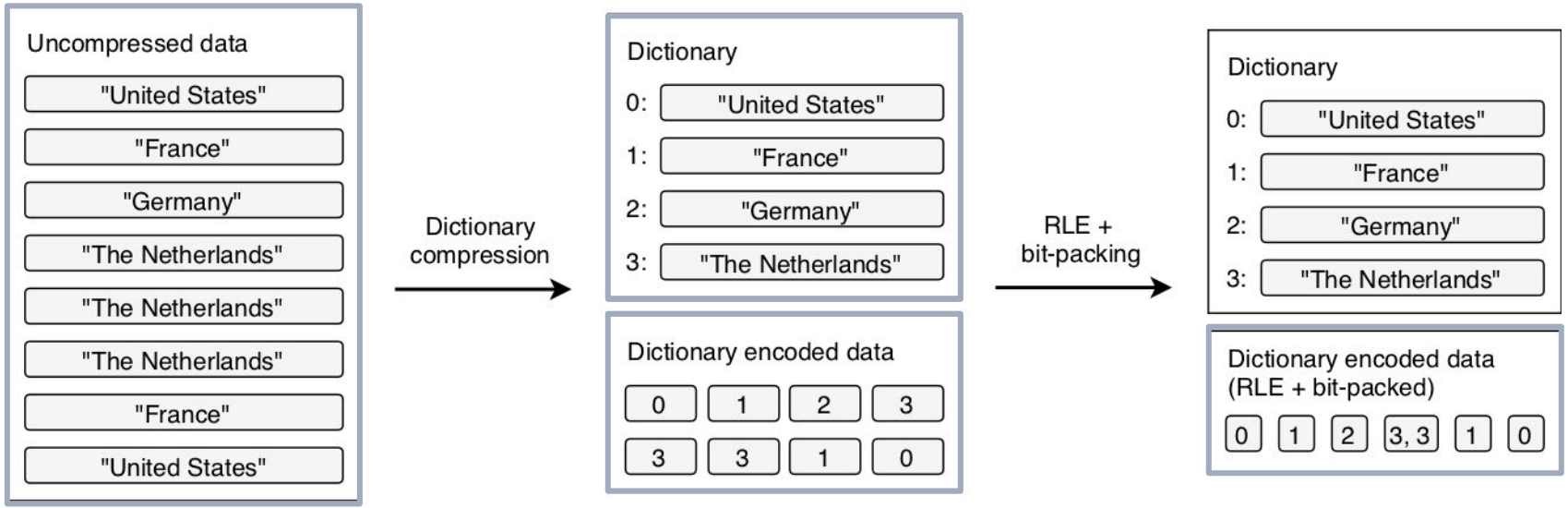
Encoding Schemes

- **PLAIN**
  - Fixed-width: back-to-back
  - Non fixed-width: length prefixed



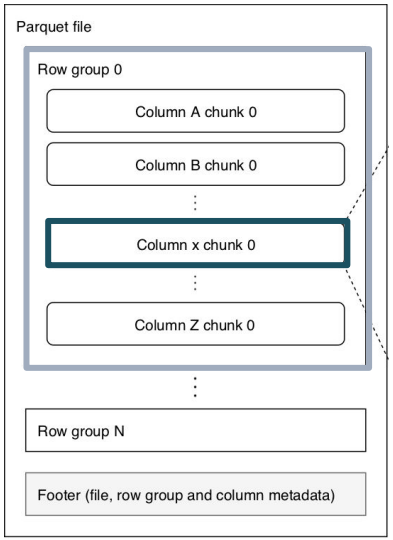
- **RLE_DICTIONARY**
  - Run-length encoding + bit-packing + dictionary compression
  - Assumes duplicate and repeated values

RLE_DICTIONARY



Dictionary Encoding

- Smaller files means less I/O
- Note: single dictionary per column chunk, size limit

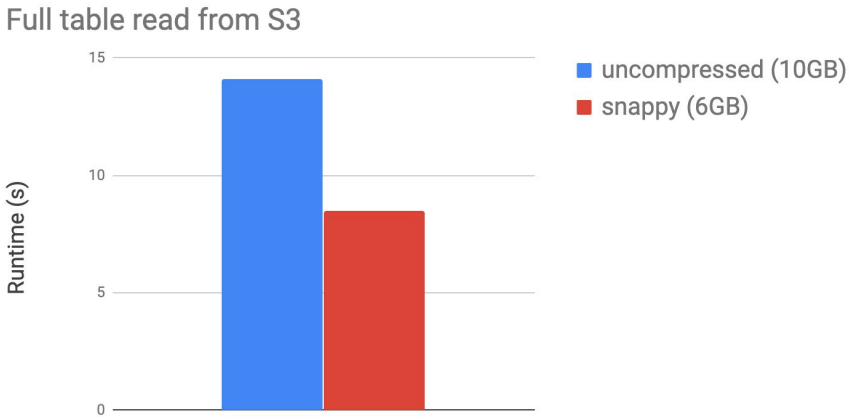


Dictionary too big?

Automatic fallback to `PLAIN`...

Page Compression

- Compression schemes (snappy, gzip, lzo...)
- Default: snappy
- Balances decompression speed vs I/O savings trade-off



Predicate Pushdown

```
SELECT * FROM table WHERE x > 5

Row-group 0: x: [min: 0, max: 9]
Row-group 1: x: [min: 3, max: 7]
Row-group 2: x: [min: 1, max: 4]
```

- Leverages min/max statistics
- Can also use dictionary filtering for fine-grained predicates
- Requires typed predicates

Partition Skipping

- Embed common predicates in directory structure
- Spark will skip directories

```
df.write.partitionBy("date").parquet(...)
```

```
./example_parquet_file/date=2019-10-15/...
./example_parquet_file/date=2019-10-16/...
./example_parquet_file/date=2019-10-17/part-00000-...-475b15e2874d.c000.snappy.parquet
```

…

Transaction log

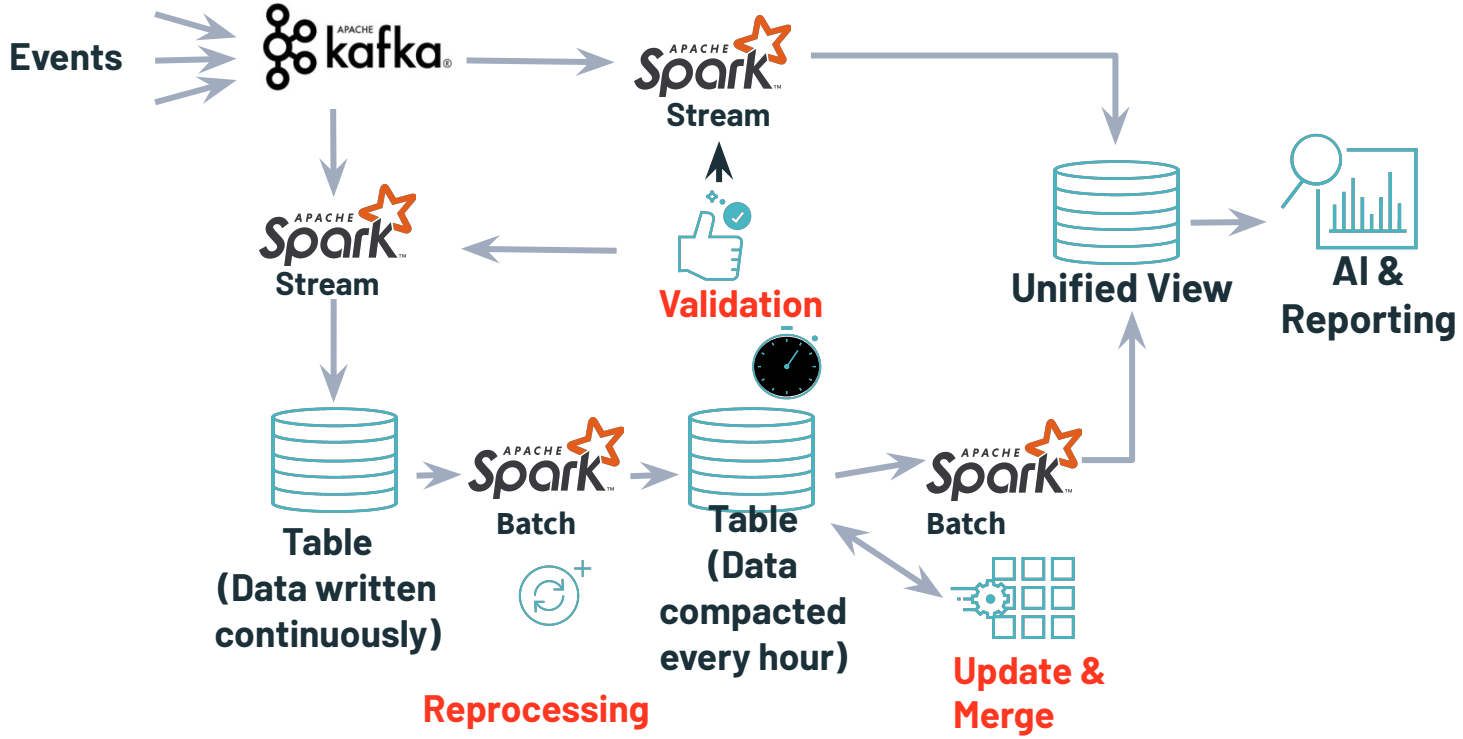
- Record of all transactions on a Delta table
- Prevents read conflicts
- Commits - ordered, atomic, json files
- Created automatically in the *_delta_log* subdirectory

Delta Lake components

Delta Engine

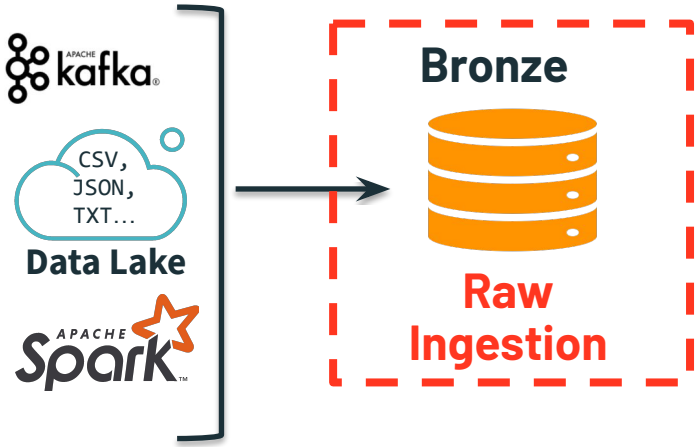
- File management optimizations
- Auto-optimized writes
- Performance optimization via Delta caching

The goal of a data engineer

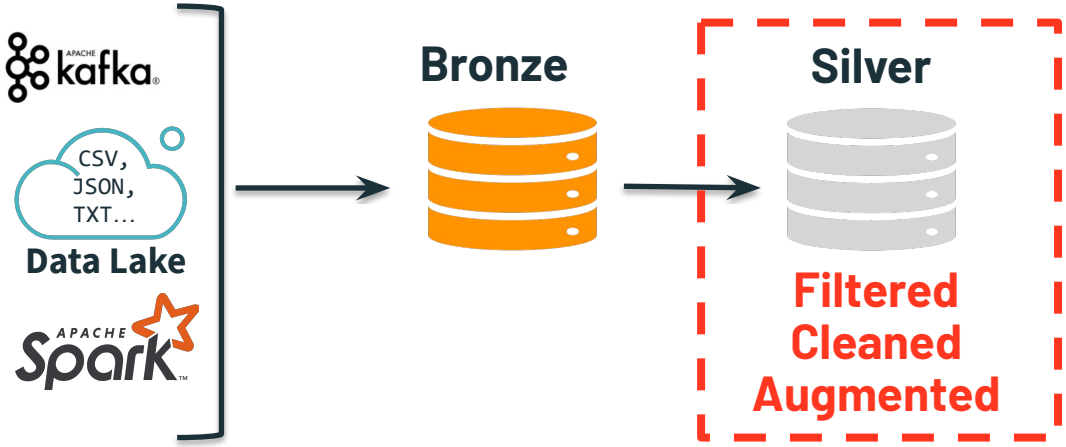


The Delta architecture design pattern

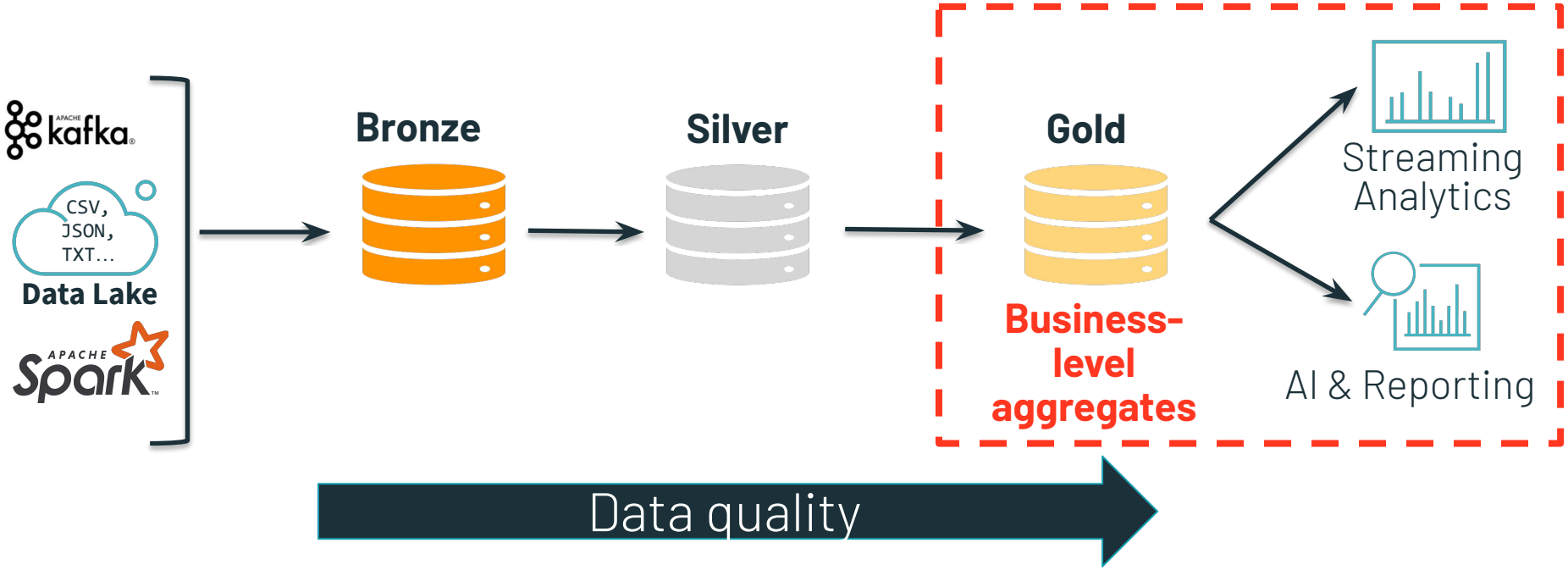
Delta architecture - Bronze



Delta architecture - Silver



Delta architecture - Gold

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