DeepLearning.AI

The Data Engineering Lifecycle & Undercurrents

Week 2

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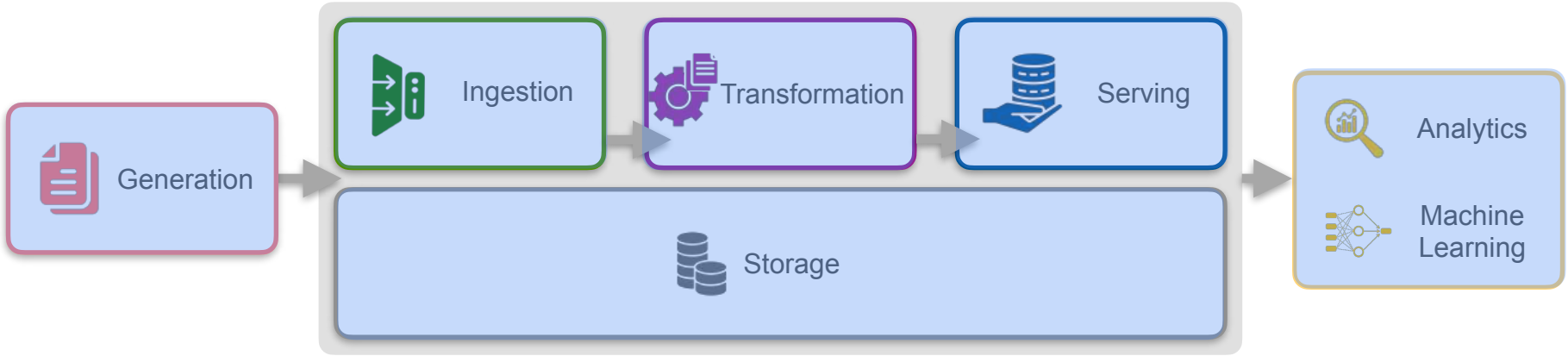
The Data Engineering Lifecycle & Undercurrents

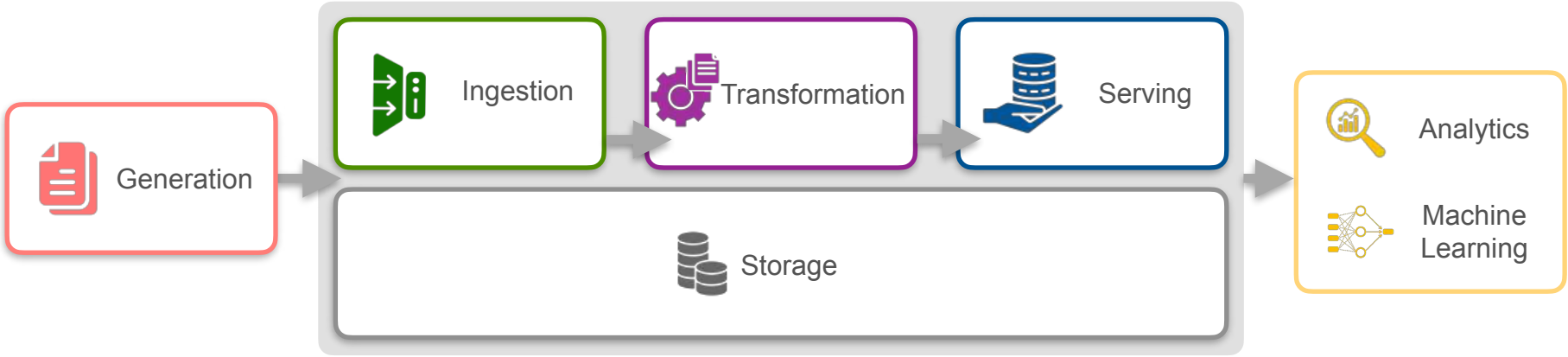
Week 2 Overview

The Data Engineering Lifecycle



Get raw data → Turn it into something useful → Make it available for downstream use cases

The Undercurrents



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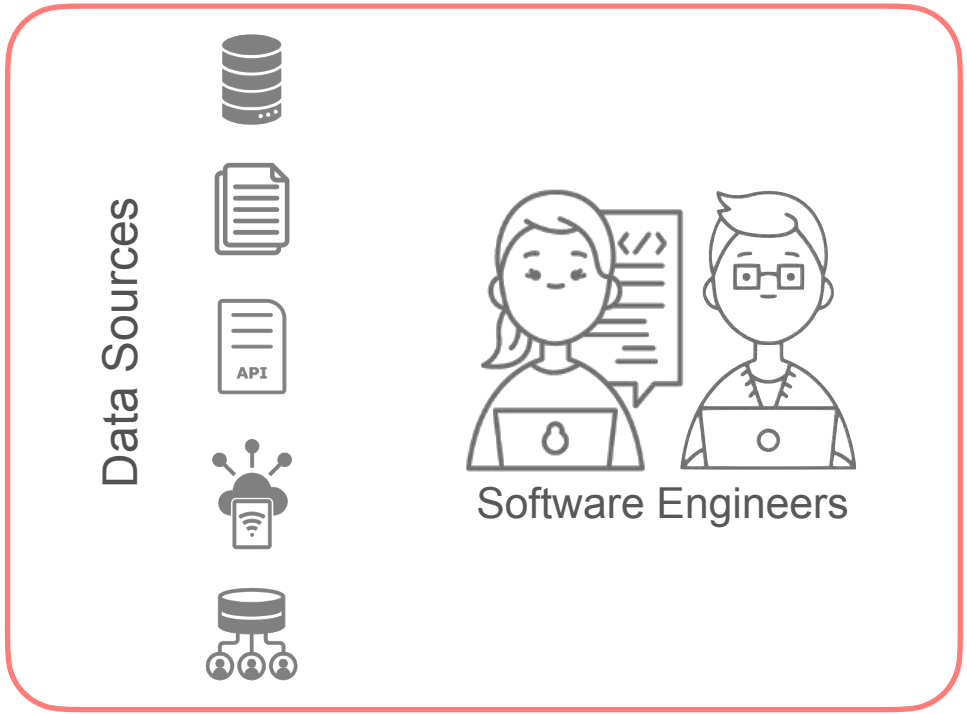
The Data Engineering Lifecycle

Data Generation in Source Systems

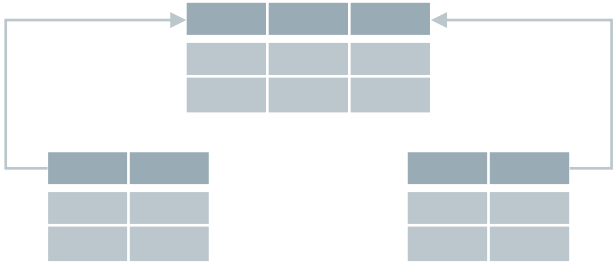
Source Systems



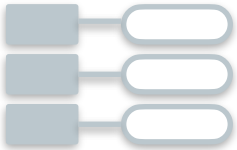
Source Systems - Databases

Databases

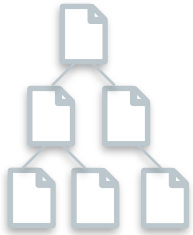
Relational Databases



NoSQL Databases



Key-Value



Document Stores

Source Systems - Files

Files

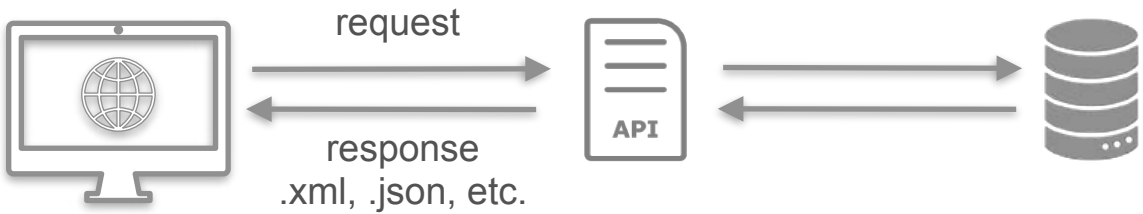
Text

Audio

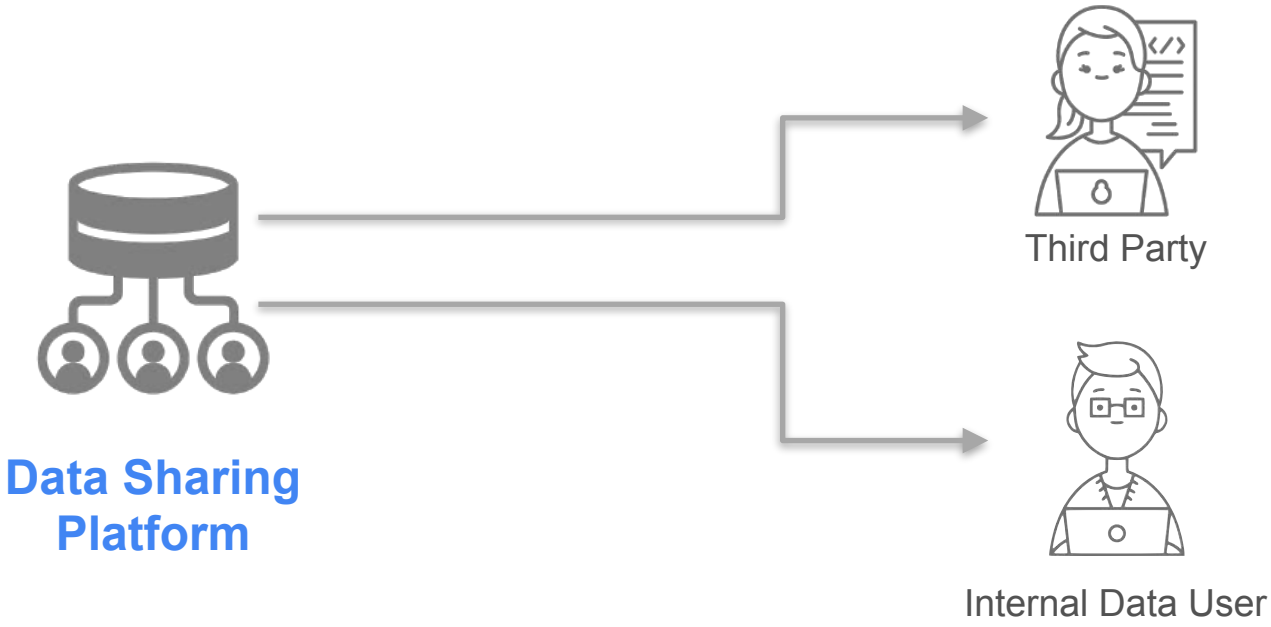
Video

Source Systems - API

Application Programming Interface (API)



Source Systems - Data Sharing



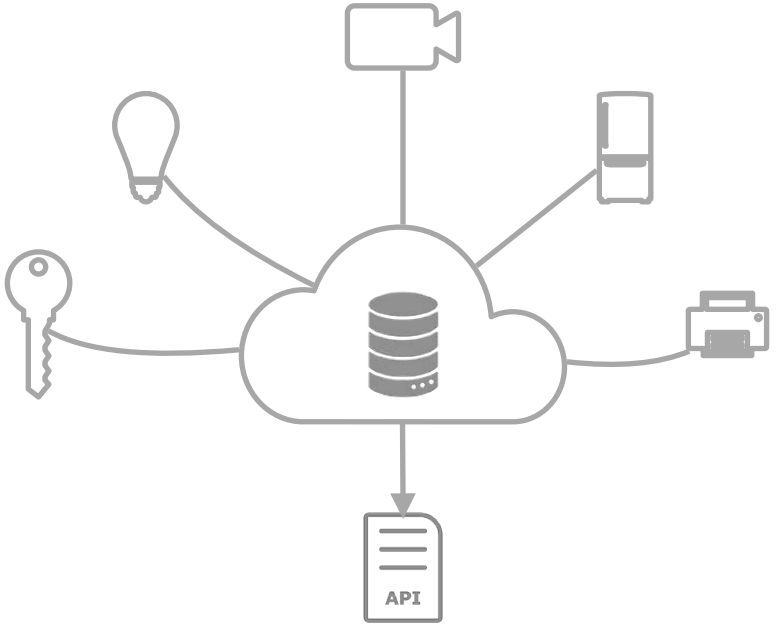
Source Systems - IoT

IoT devices
Internet of Things

“Swarm” of IoT devices

Source Systems - IoT

IoT devices
Internet of Things



Source Systems

Deliver data

Downstream Systems

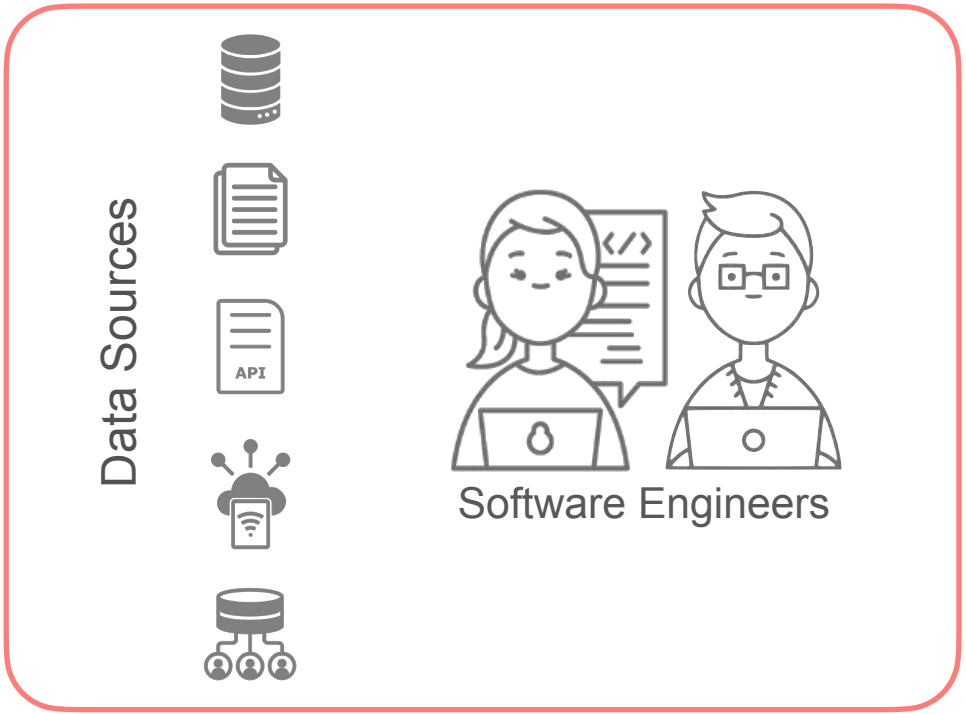
Unpredictable systems

- Systems go down
- Change in format/schema of data
- Change in data

Source Systems

- How are the systems set up?
- What kind of changes are to expect?

Source Systems



Data Engineer

Understand how source systems work

- How they generate data
- How the data may change over time
- How the changes will impact downstream systems

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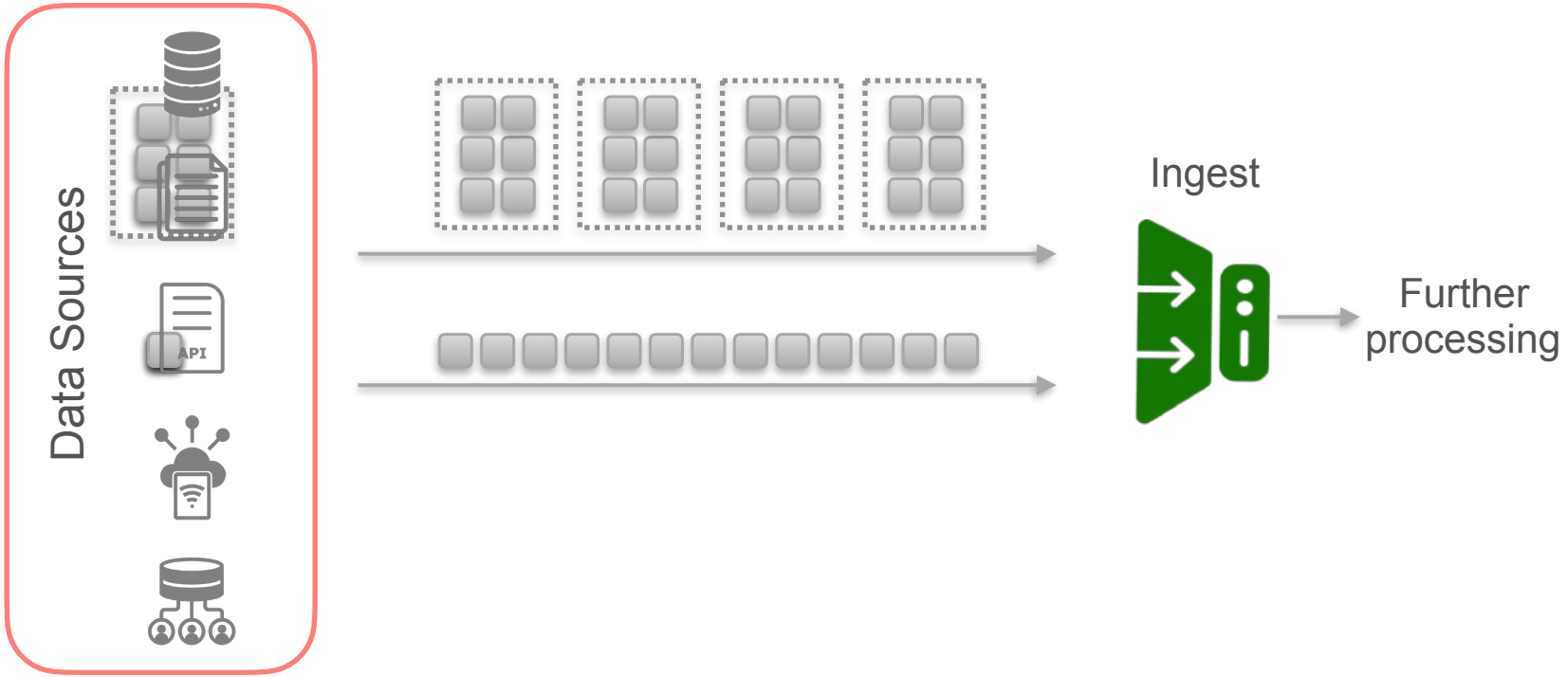
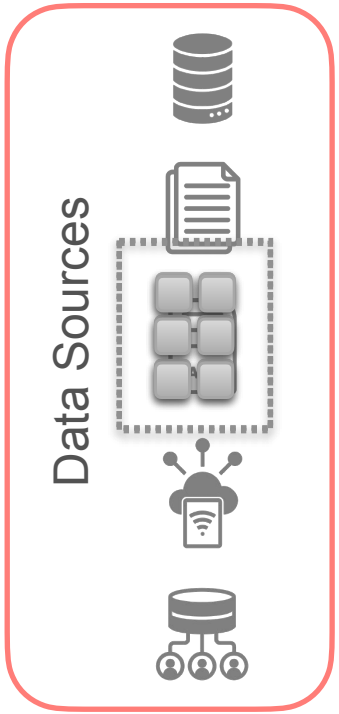
The Data Engineering Lifecycle

Ingestion

Frequency of Ingestion

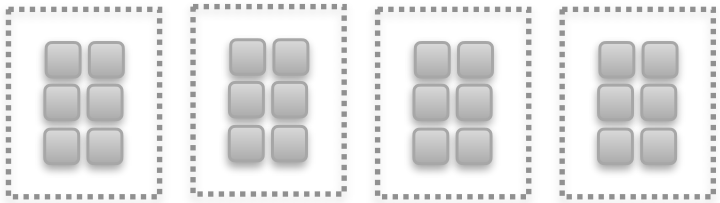


Batch Ingestion



Single batch

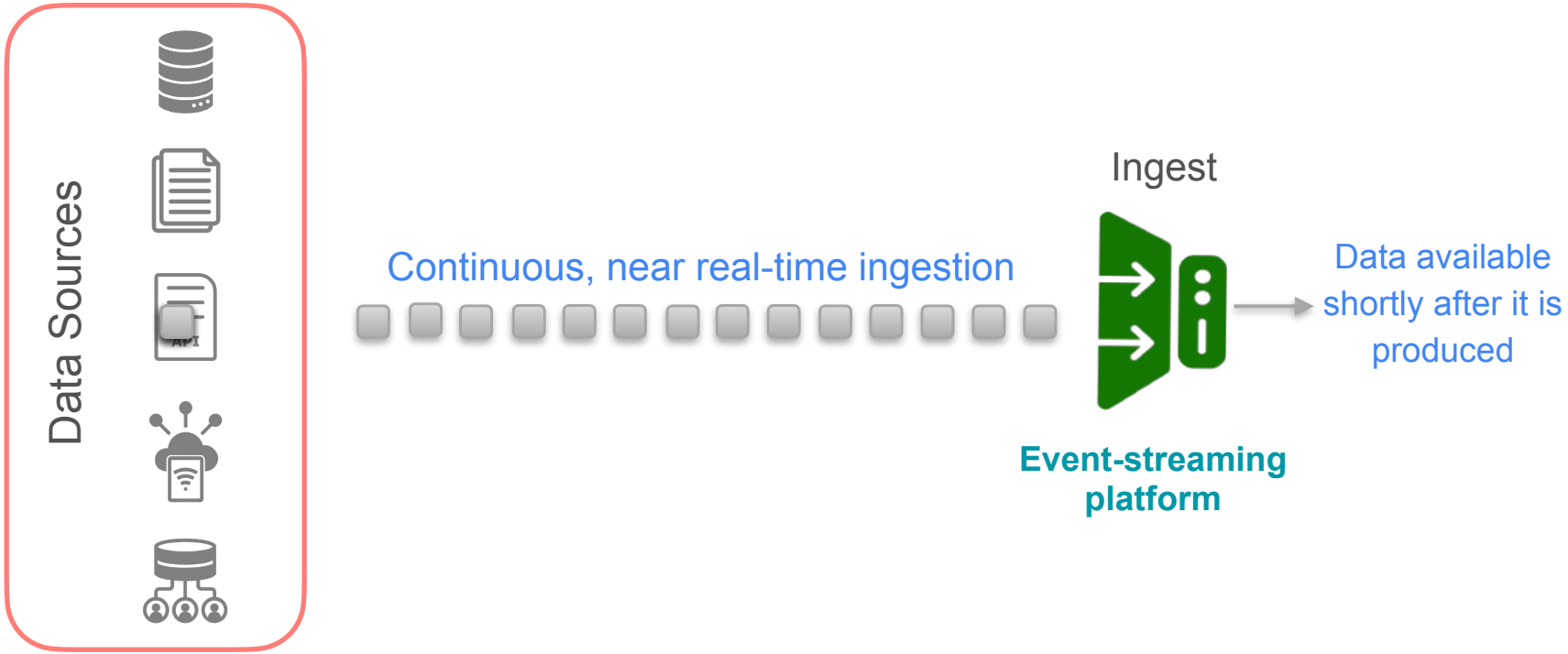
Entire day's worth of data



Ingest

- Based on predetermined time interval
- Based on preset size threshold

Streaming Ingestion

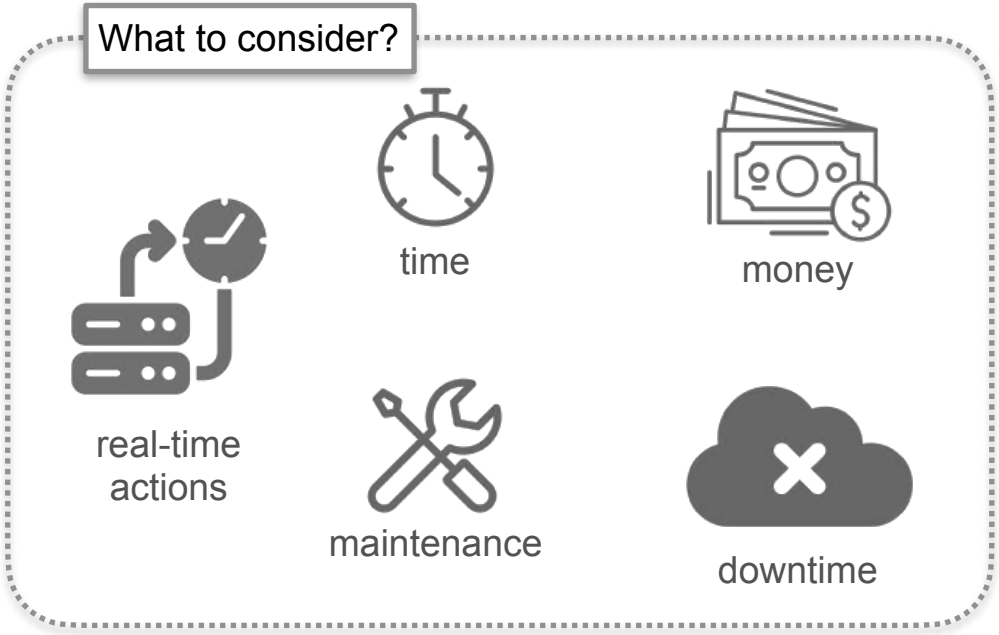


Ingestion

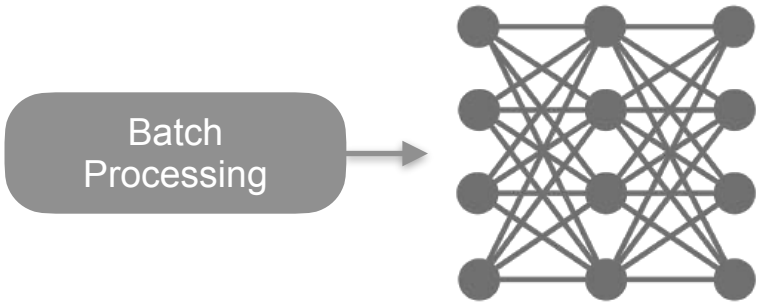
Batch Ingestion

vs.

Stream Ingestion

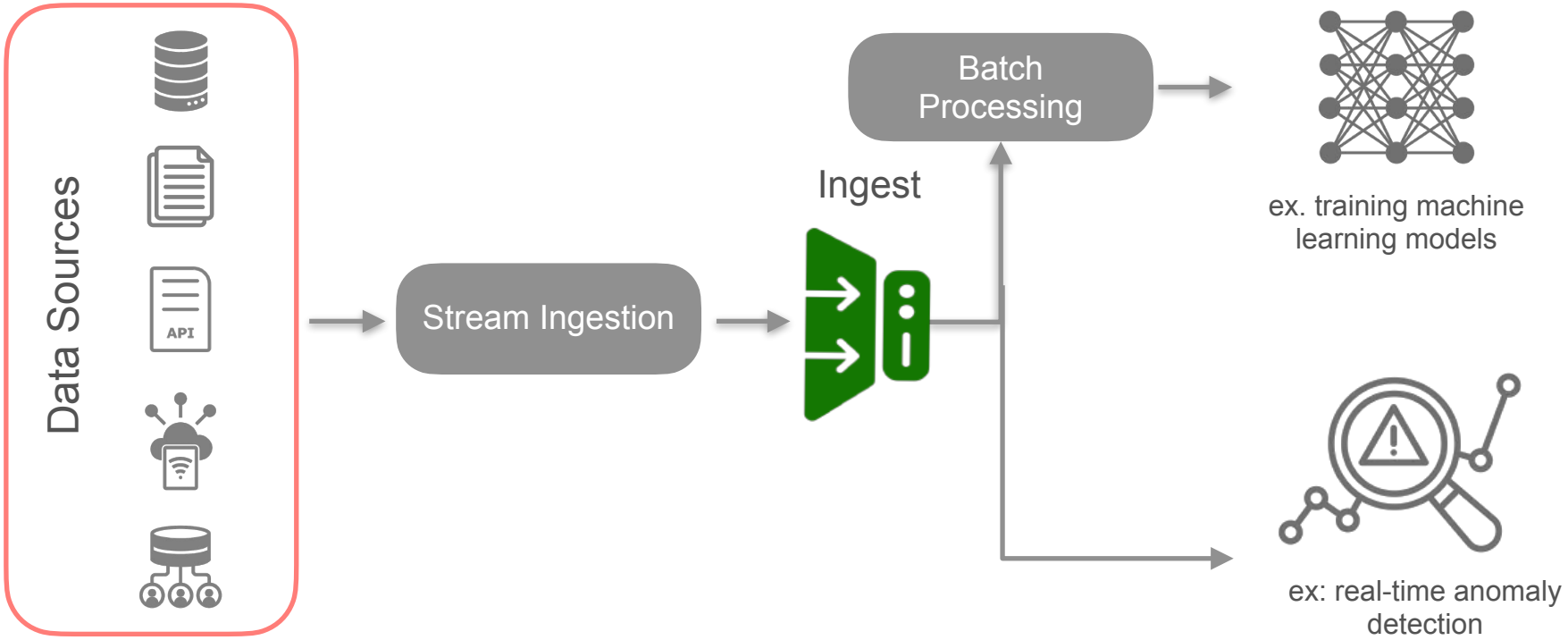


Streaming and Batch Components



ex. training machine learning models

Streaming and Batch Components



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The Data Engineering Lifecycle

Storage

Raw Hardware Ingredients

Solid-state storage

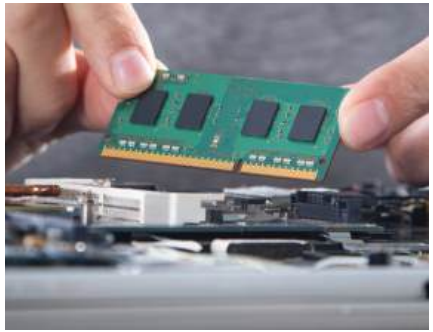
Magnetic disk

Magnetic disk

- Backbone of modern data storage system
- 2-3 times cheaper than solid-state storage

Raw Hardware Ingredients

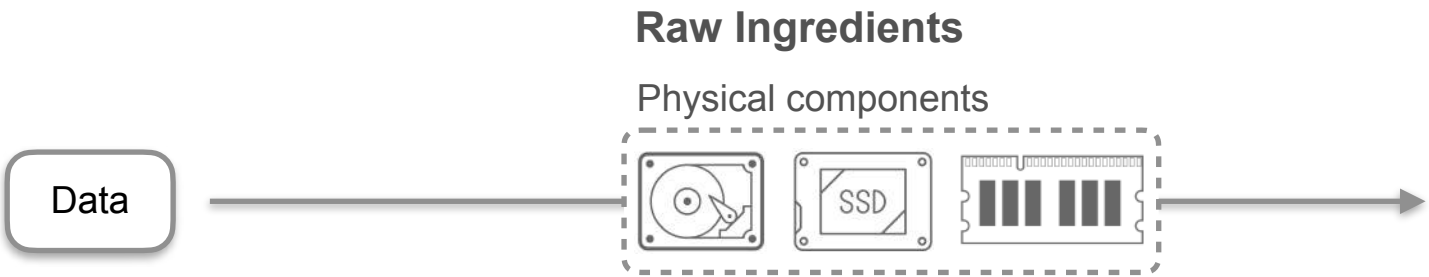
RAM (Random Access Memory)



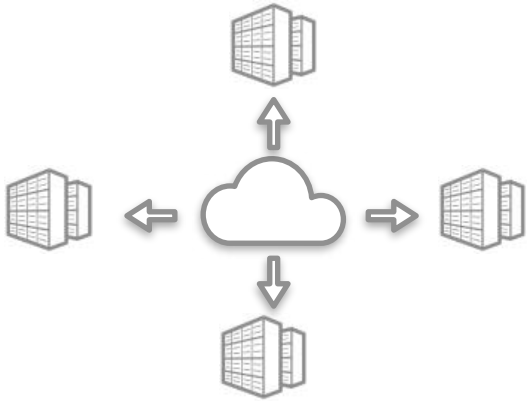
RAM

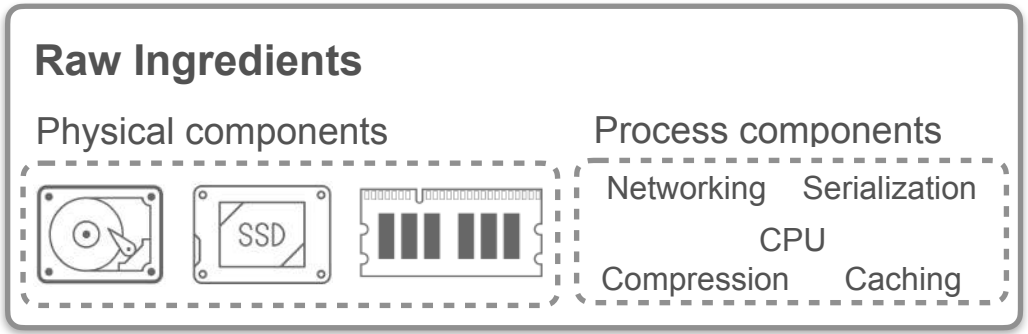
- Faster read and write speeds
- 30 - 50 times more expensive than solid-state storage
- Volatile

Storage

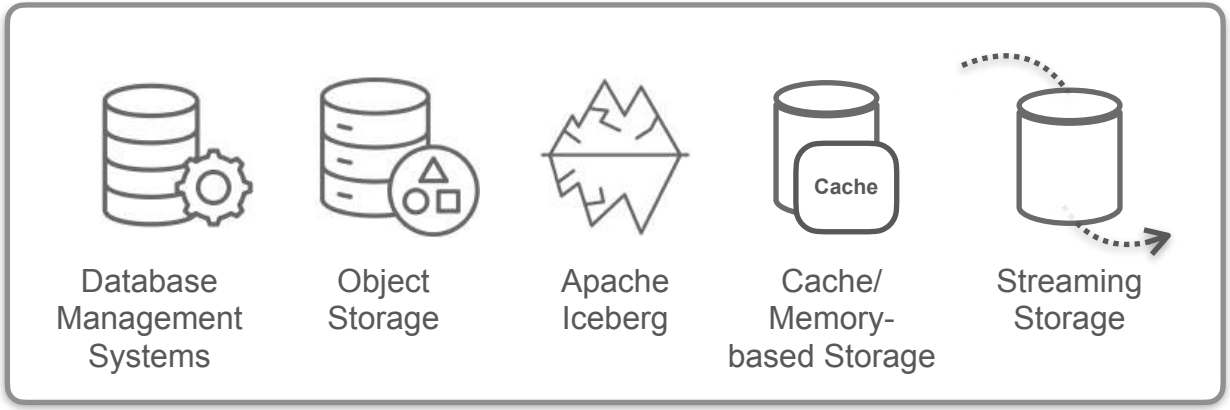


Storage

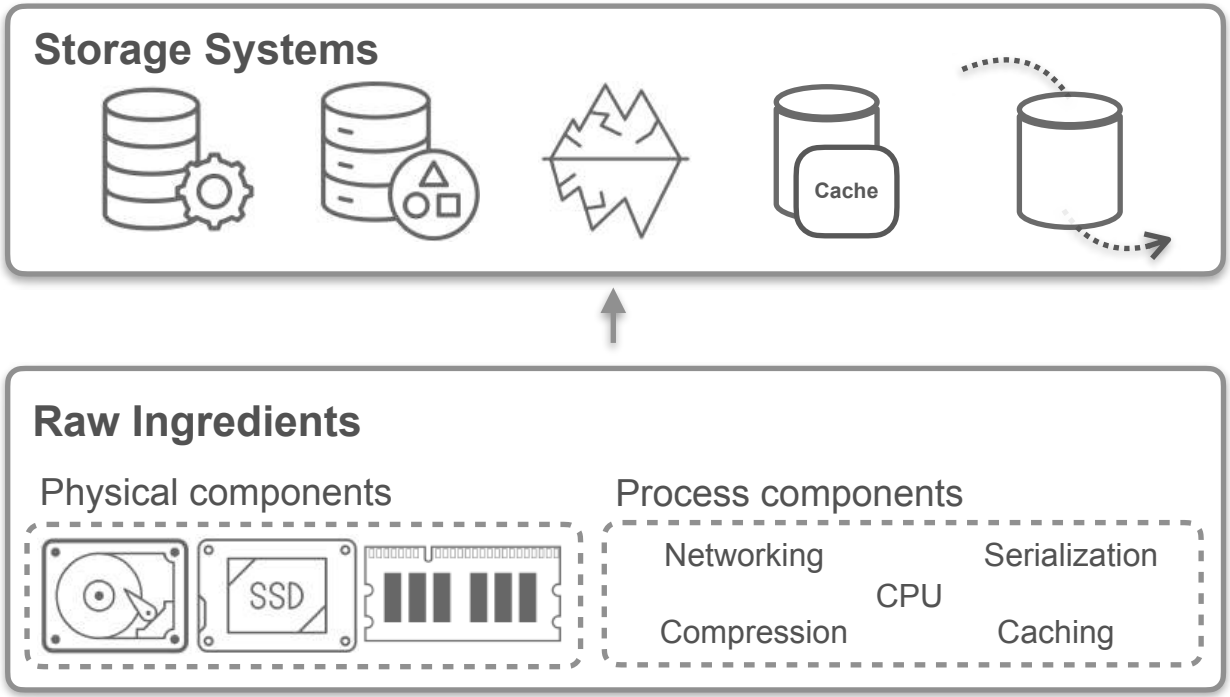



Raw Ingredients
Physical components
Process components
SSD
Networking
Serialization
CPU
Compression
Caching

Storage Systems



Storage Systems



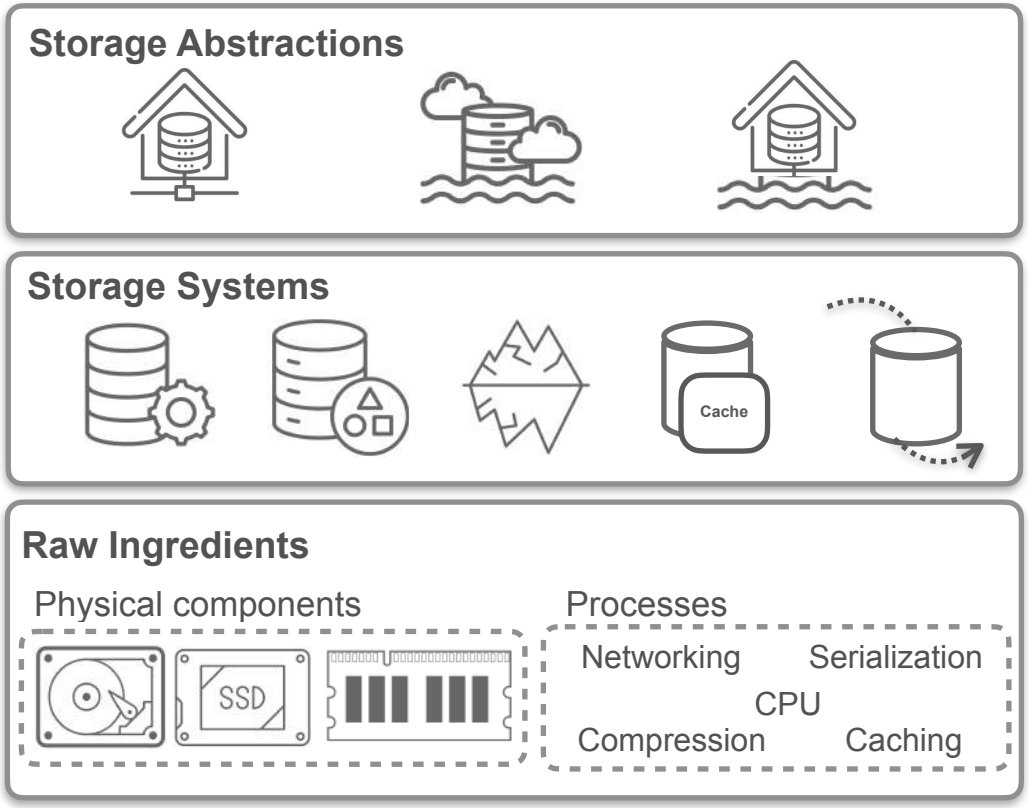
Storage Abstractions

Storage abstractions: combinations of storage systems

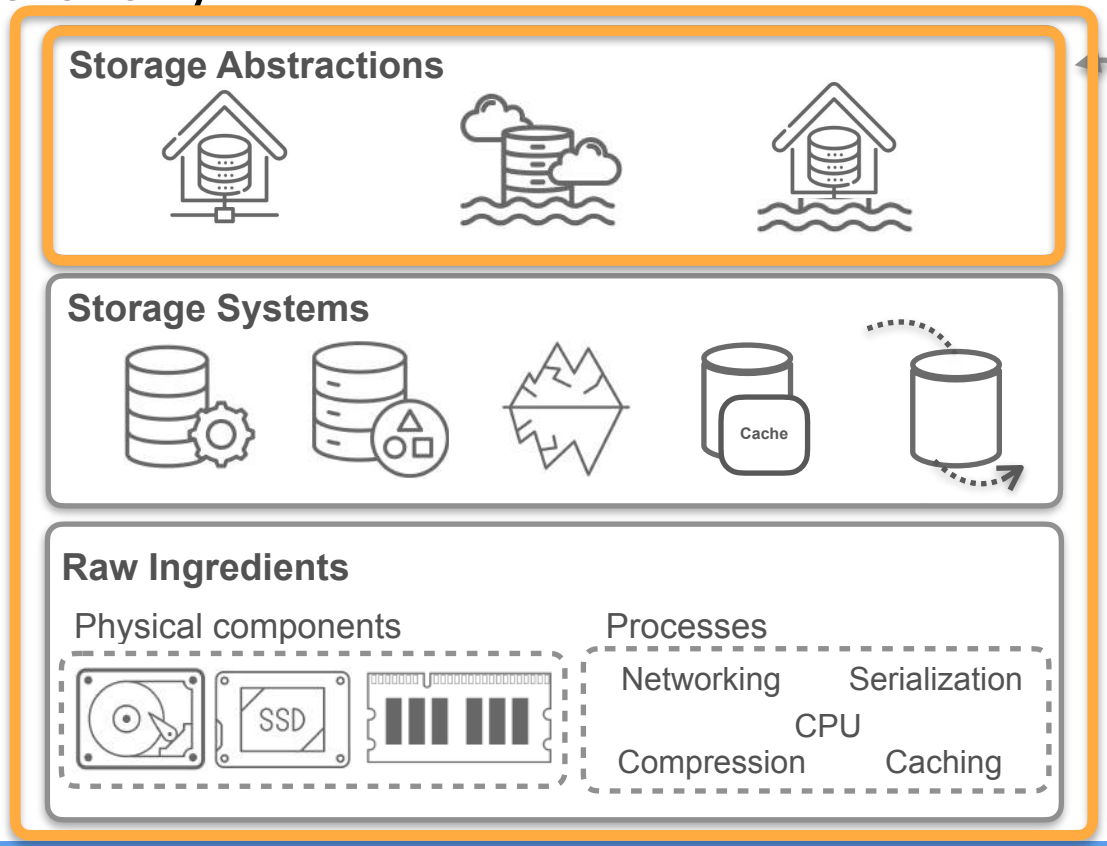
Choose configuration parameters:

- Latency
- Scalability
- Cost

Storage Hierarchy



Storage Hierarchy



Work near or at the top

Understand the details of your entire storage solution

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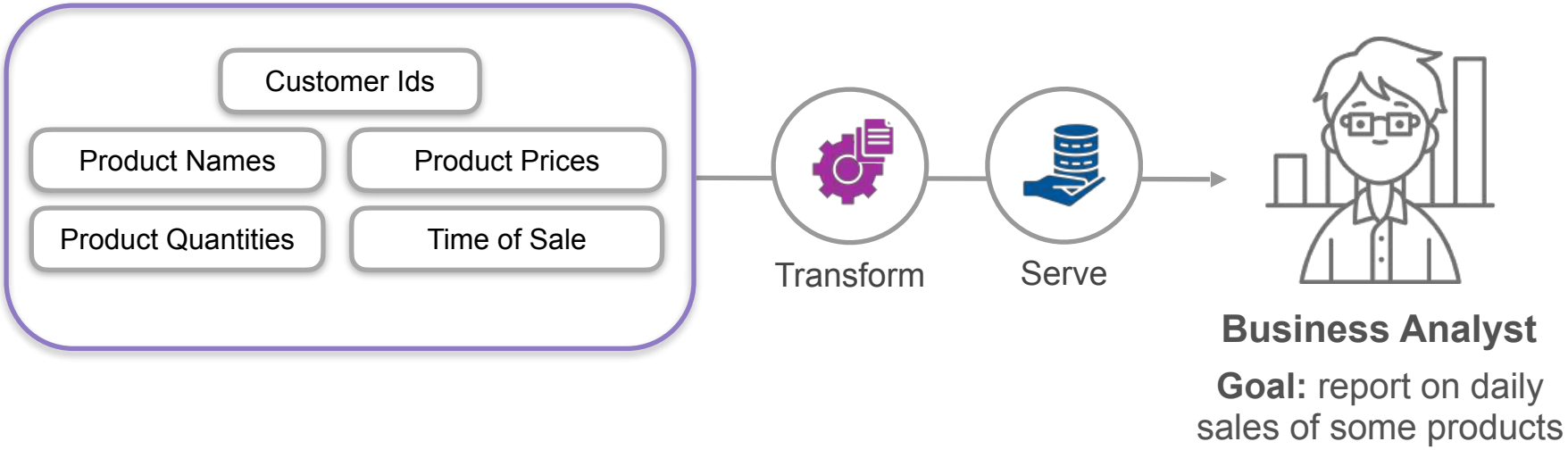
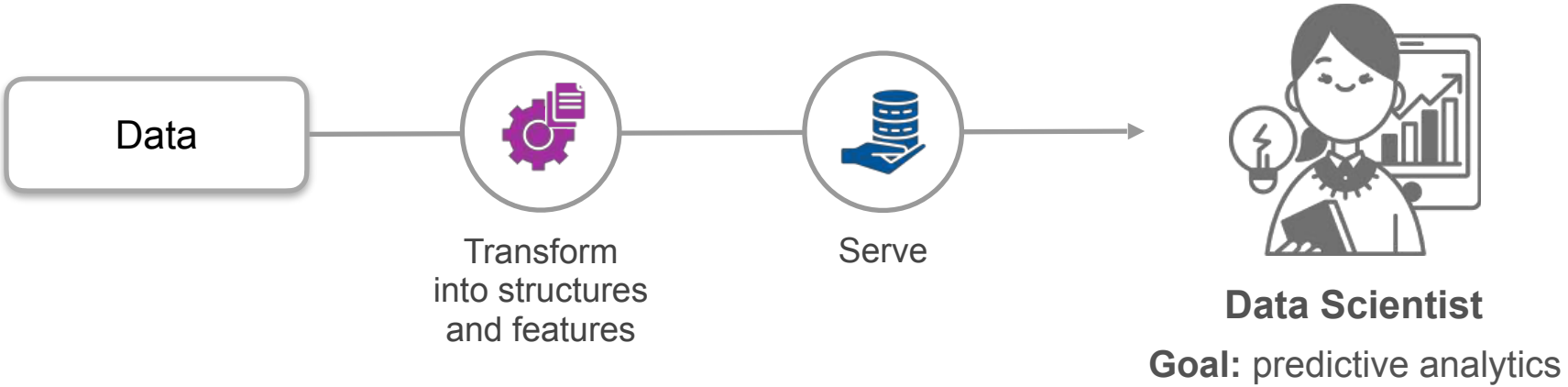
The Data Engineering Lifecycle

Queries, Modeling and Transformation

Transformation



Transformation



Query

Issuing a request to read records from a database or other storage system.

Data Warehouse

Query

- Tabular data
- Semi-structured data

Query

Issuing a request to read records from a database or other storage system.

Query Language

SQL Commands

Data Cleaning

DROP
TRUNCATE
TRIM
REPLACE
SELECT DISTINCT

Data Joining

INNER JOIN
LEFT JOIN
RIGHT JOIN
FULL JOIN
UNION

Data Aggregating

SUM
AVG
COUNT
MAX
MIN
GROUP BY

Data Filtering

WHERE
AND
OR
IS NULL
IS NOT NULL
IN
LIKE

Query

Issuing a request to read records from a database or other storage system.

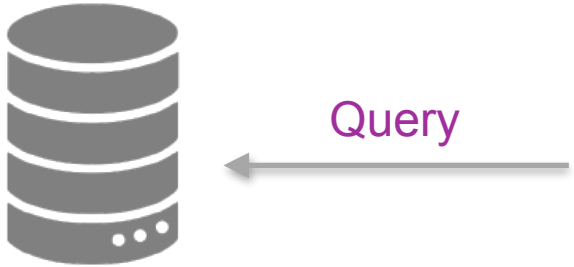
Poor queries: negative impact on the source database

Source Database

Query

Issuing a request to read records from a database or other storage system.

Poor queries: cause row explosion in your database

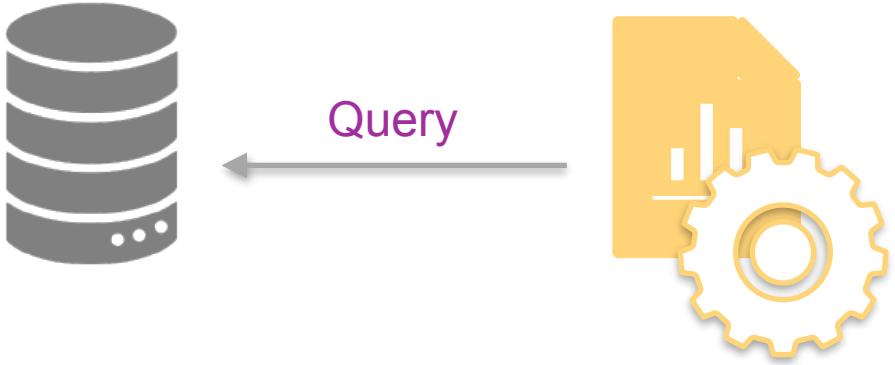


You database

Query

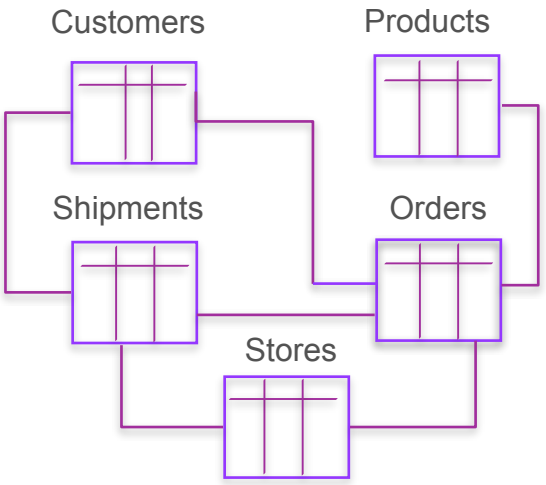
Issuing a request to read records from a database or other storage system.

Poor queries: cause downstream delays

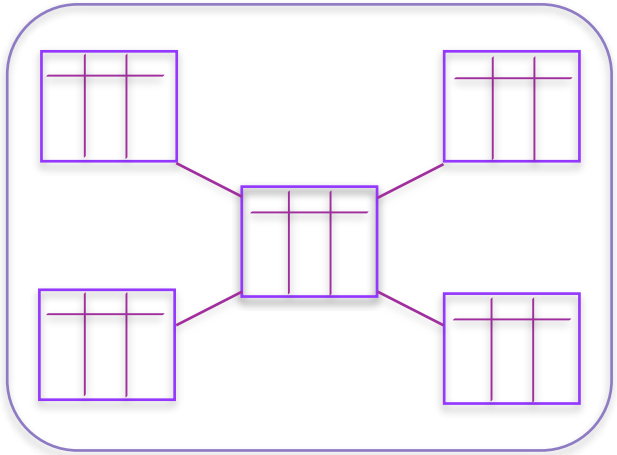


Data modeling

Choosing a coherent structure for your data to make it useful for the business.



Modeling



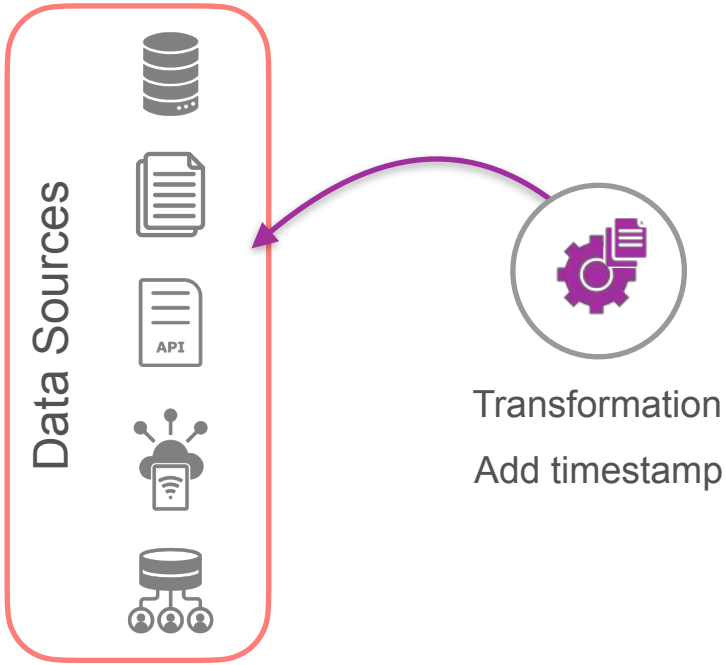
Query

Business Analyst

Goal: Product sales reports

Data transformation

Data manipulated, enhanced and saved for downstream use.



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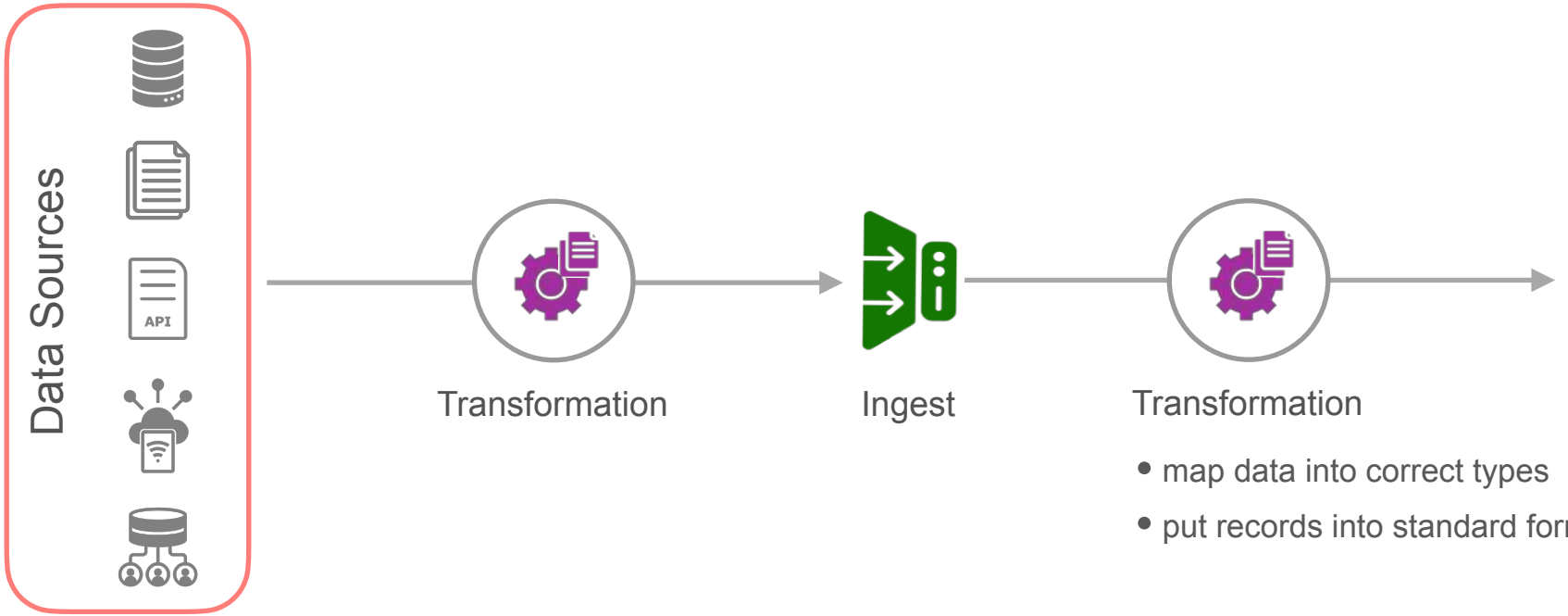

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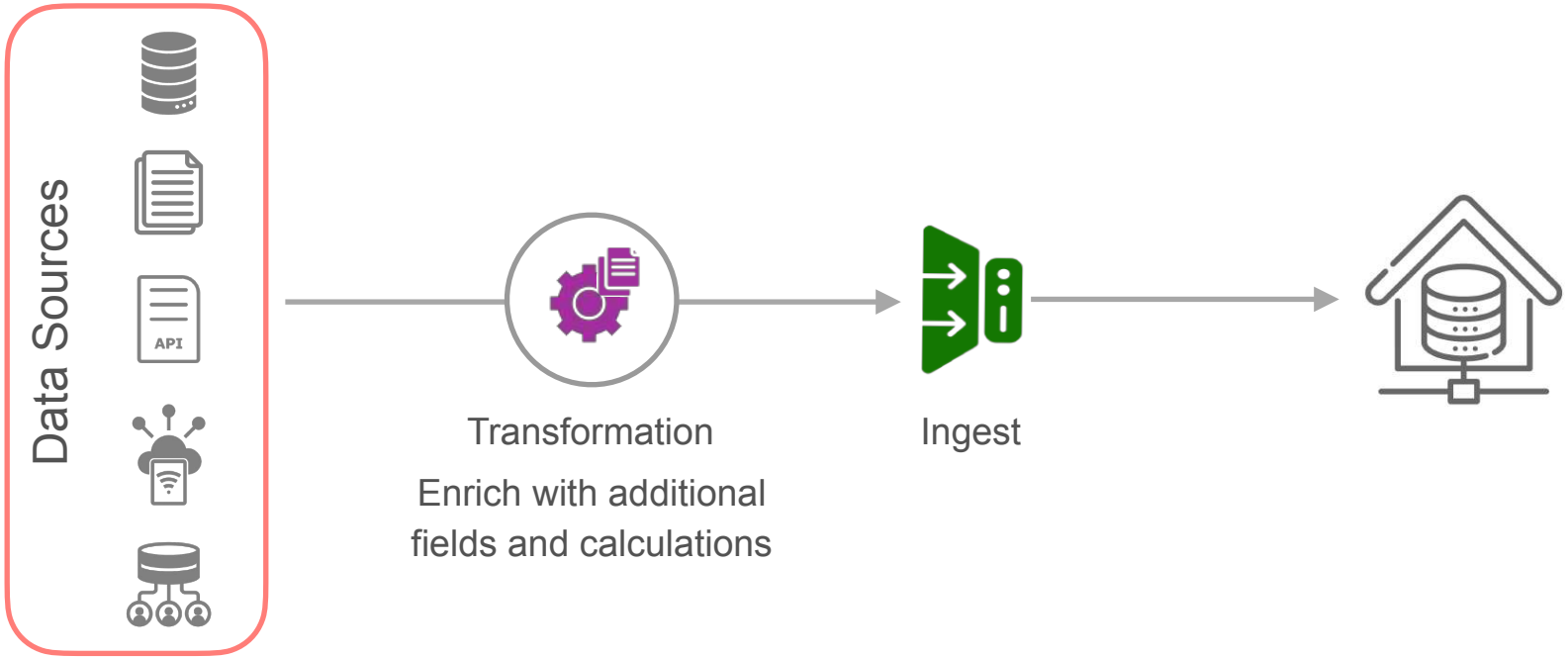

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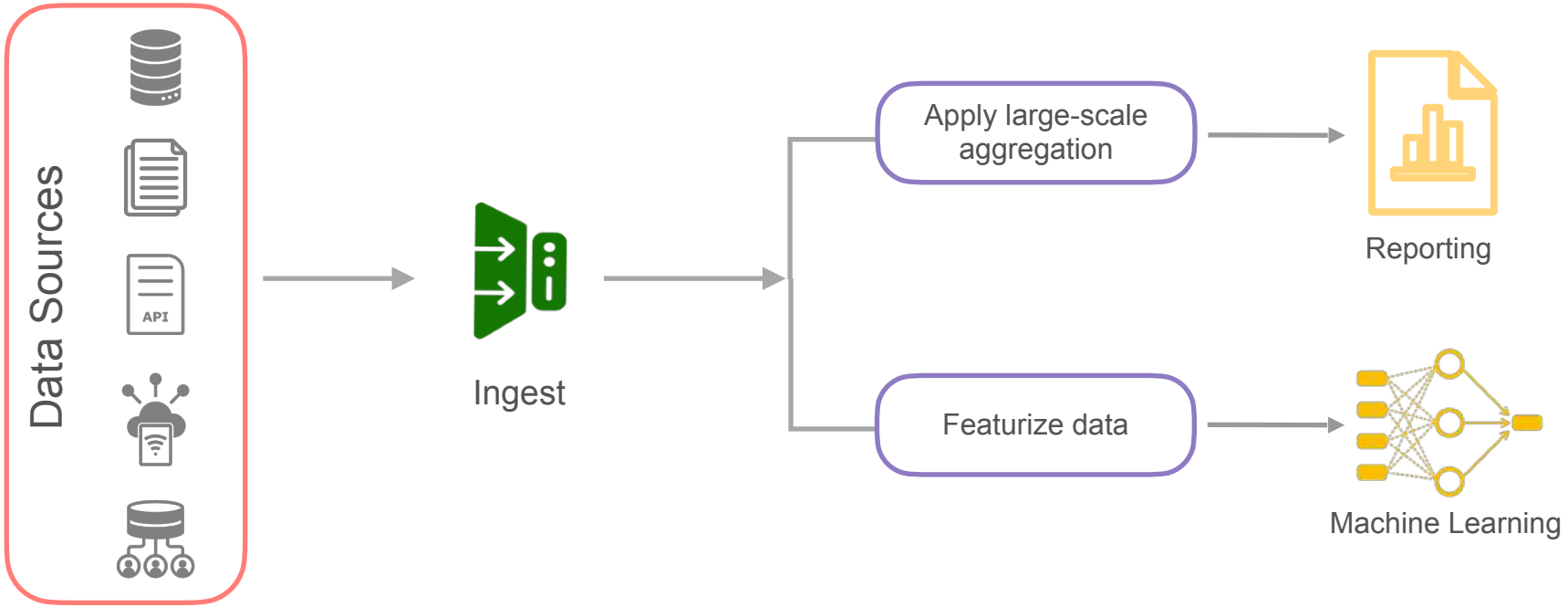

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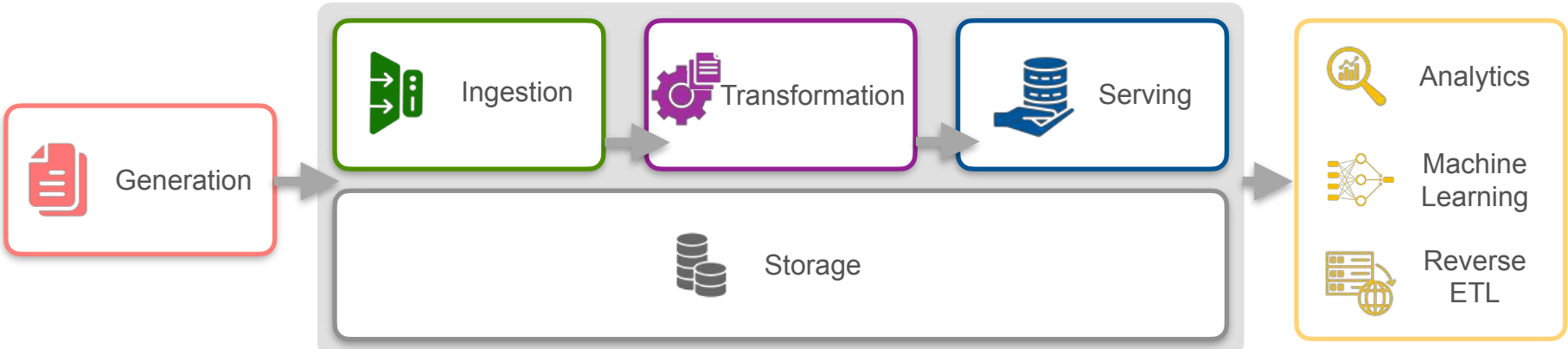
The Data Engineering Lifecycle

Serving Data

The Data Engineering Lifecycle



Analytics

Analytics is the process of identifying key insights and patterns within data.

Business Intelligence

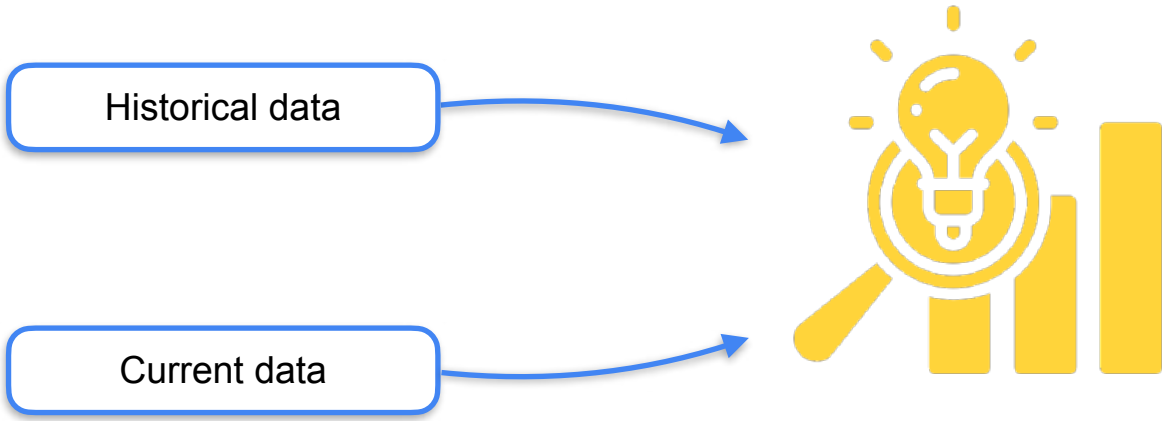
Operational Analytics

Embedded Analytics

Analytics

Business Intelligence

Explore historical and current business data to discover insights



Analytics

Business Intelligence

Explore historical and current business data to discover insights

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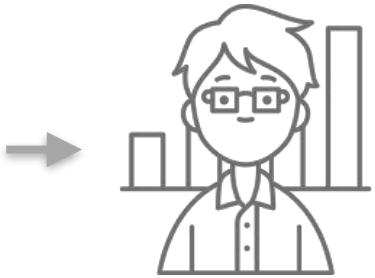
Business Intelligence

Explore historical and current business data to discover insights



Spot patterns and trends

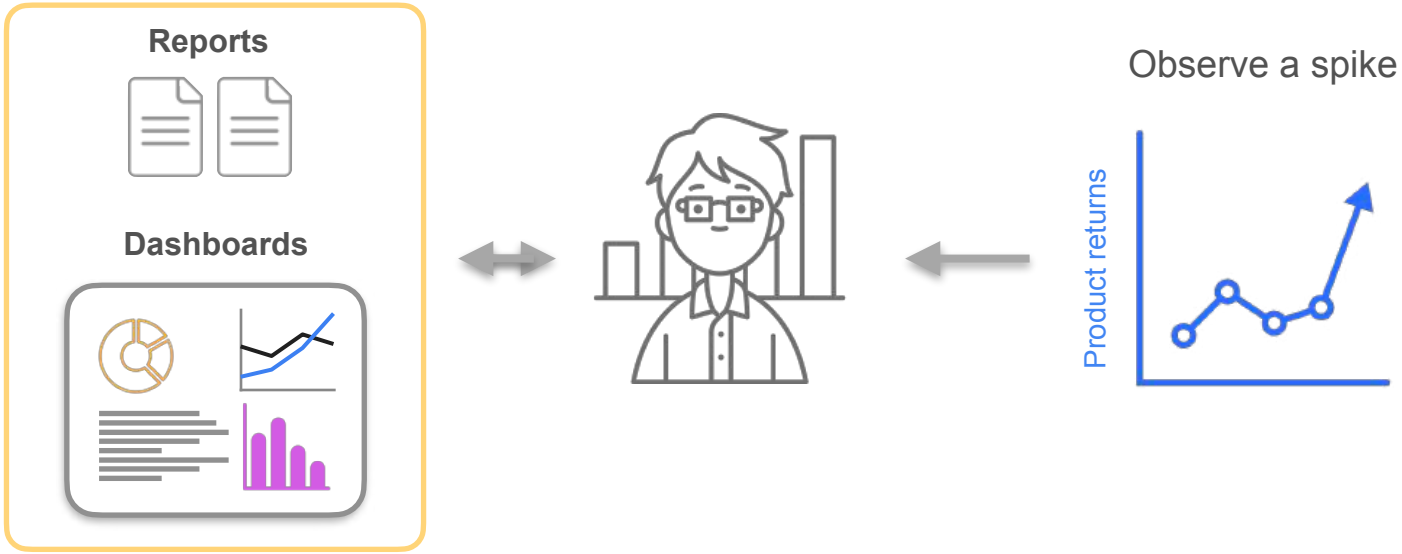
Monitor:

- Campaign engagement
- Regional sales
- Customer experience metrics

Analytics

Business Intelligence

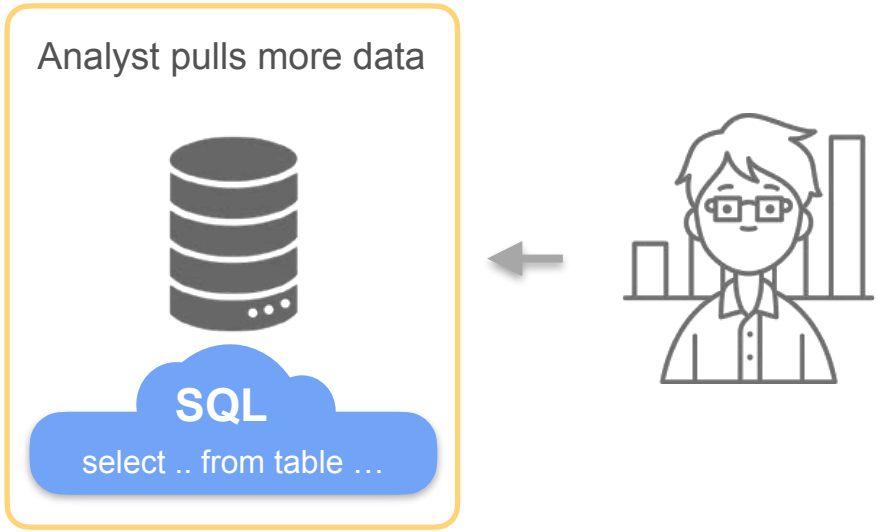
Explore historical and current business data to discover insights



Analytics

Business Intelligence

Explore historical and current business data to discover insights



Analytics

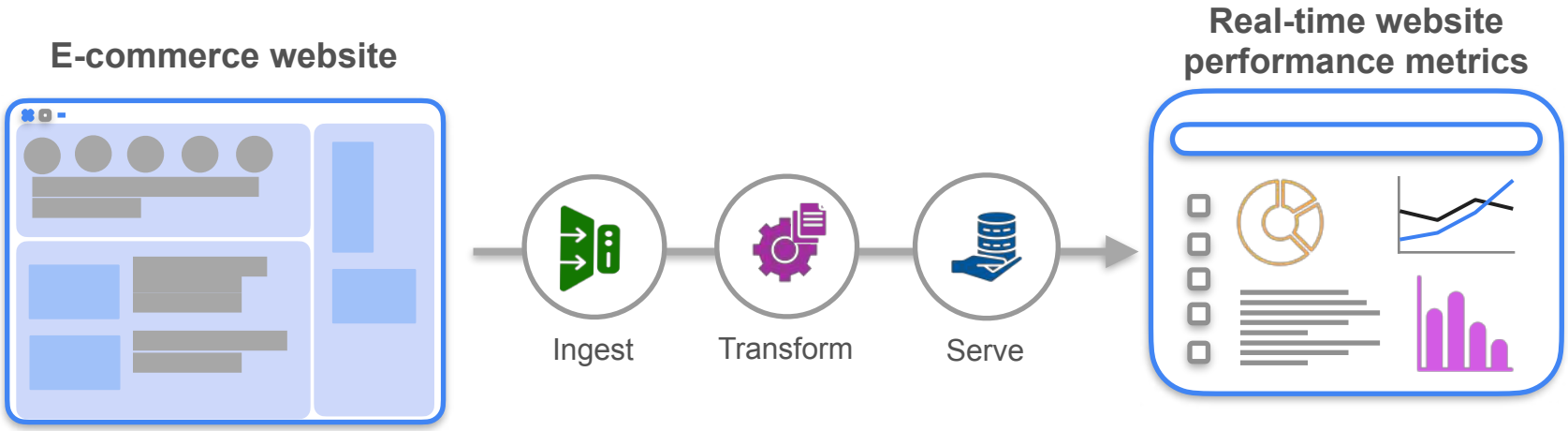
Operational Analytics

Monitoring real-time data for immediate action

Analytics

Operational Analytics

Monitoring real-time data for immediate action

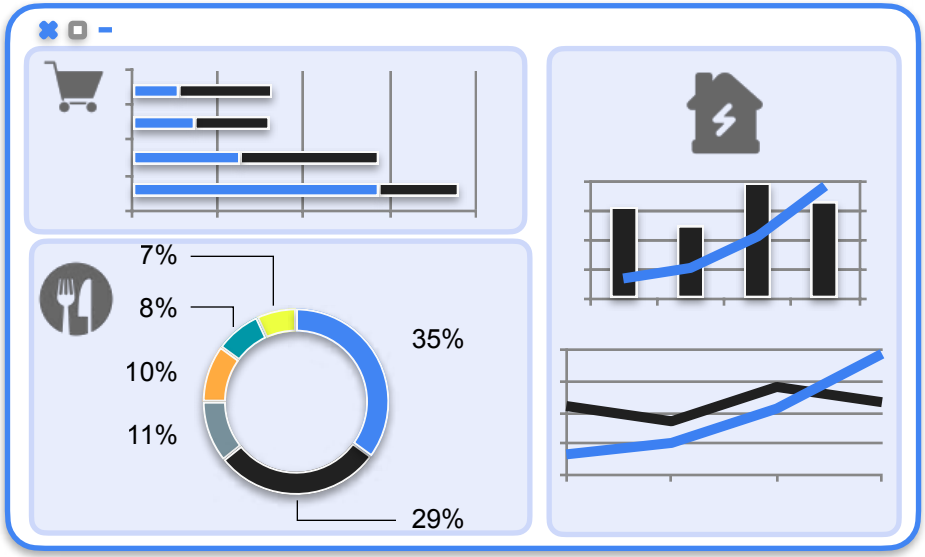


Analytics

Embedded Analytics

External or customer-facing analytics

Customer-facing dashboards



Analytics

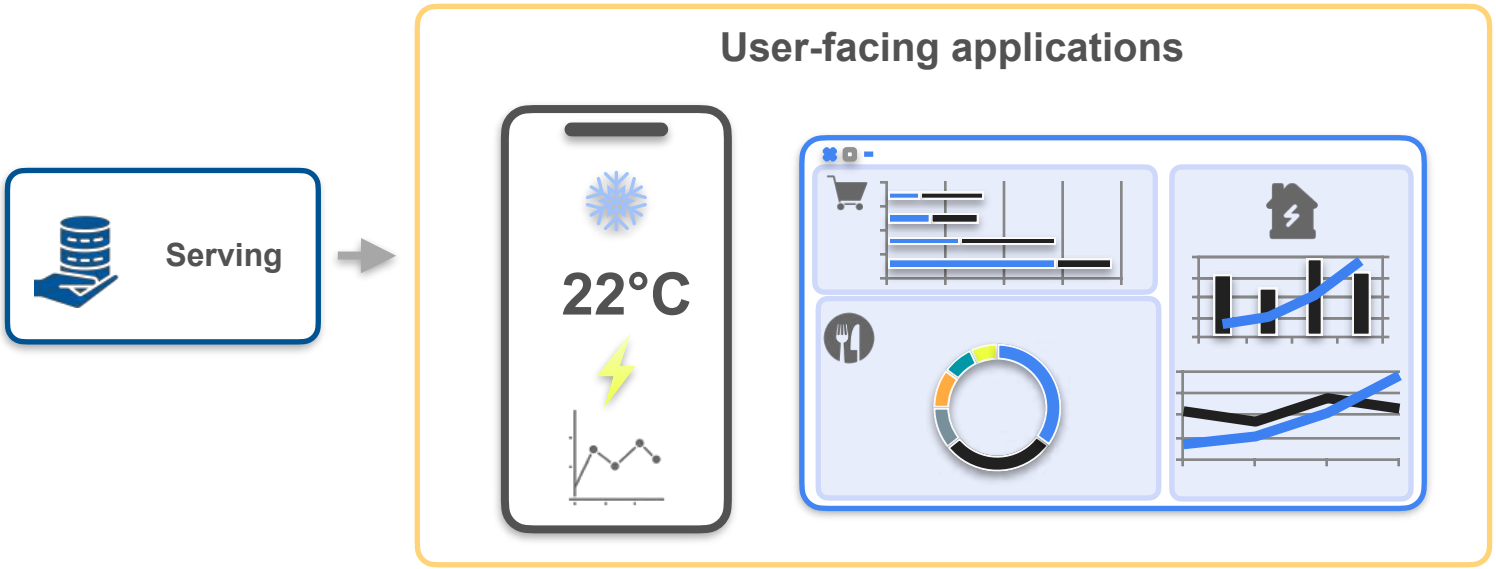
Embedded Analytics

External or customer-facing analytics

Analytics

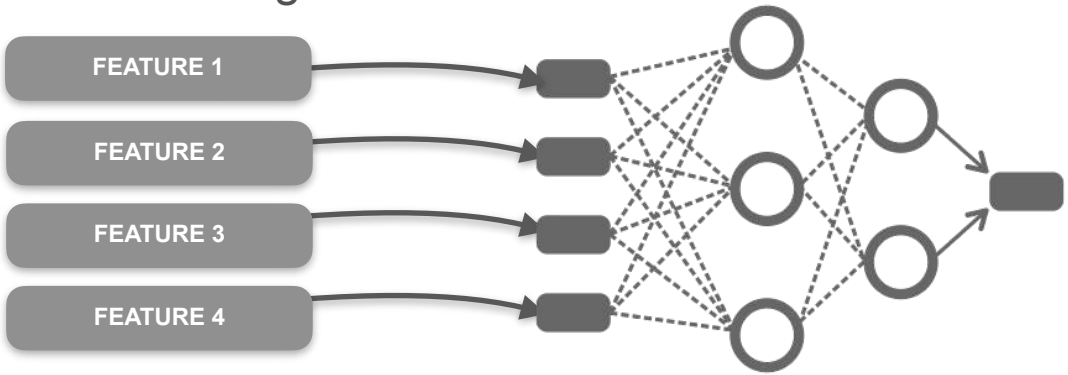
Embedded Analytics

External or customer-facing analytics



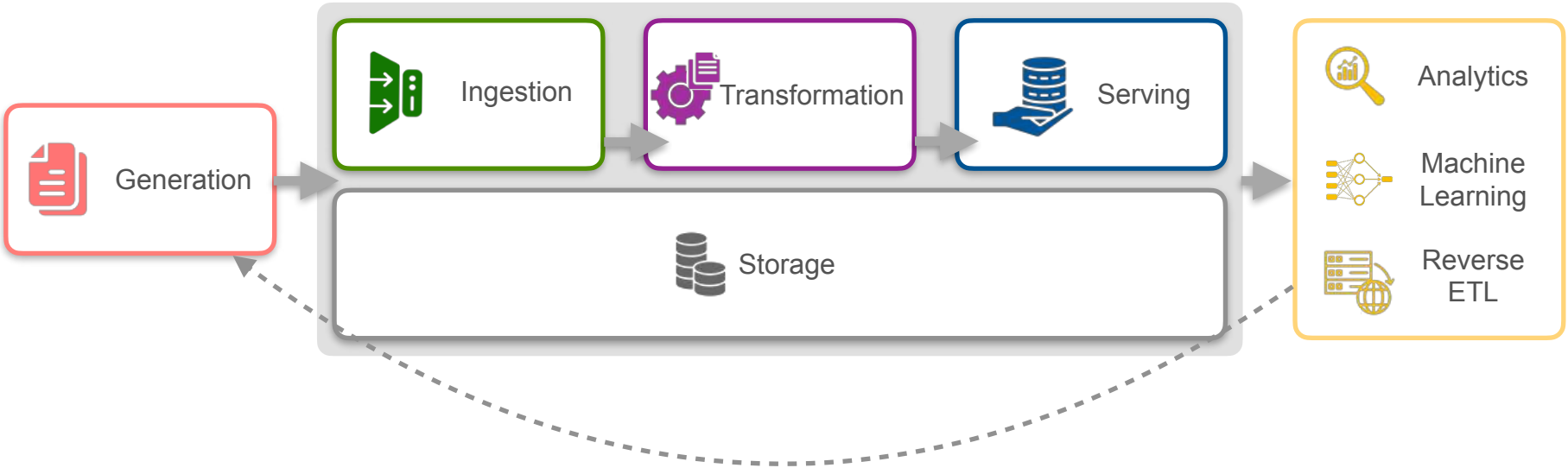
Machine Learning

- Model training

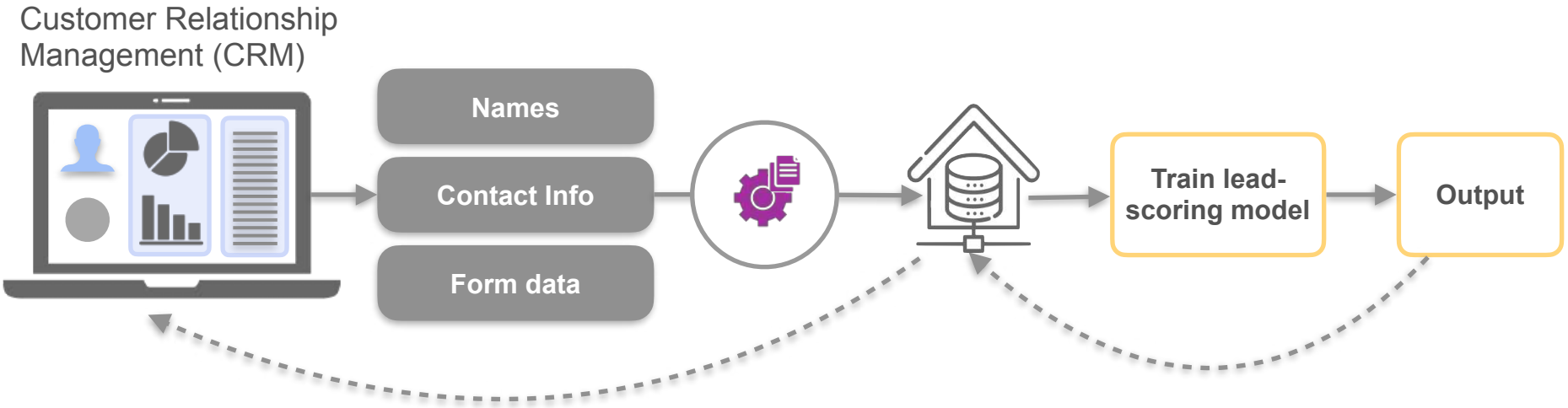


- Real-time inference
- Track data history and lineage

The Data Engineering Lifecycle



Reverse ETL


Customer Relationship Management (CRM)
Names
Contact Info
Form data
Train lead-scoring model
Output

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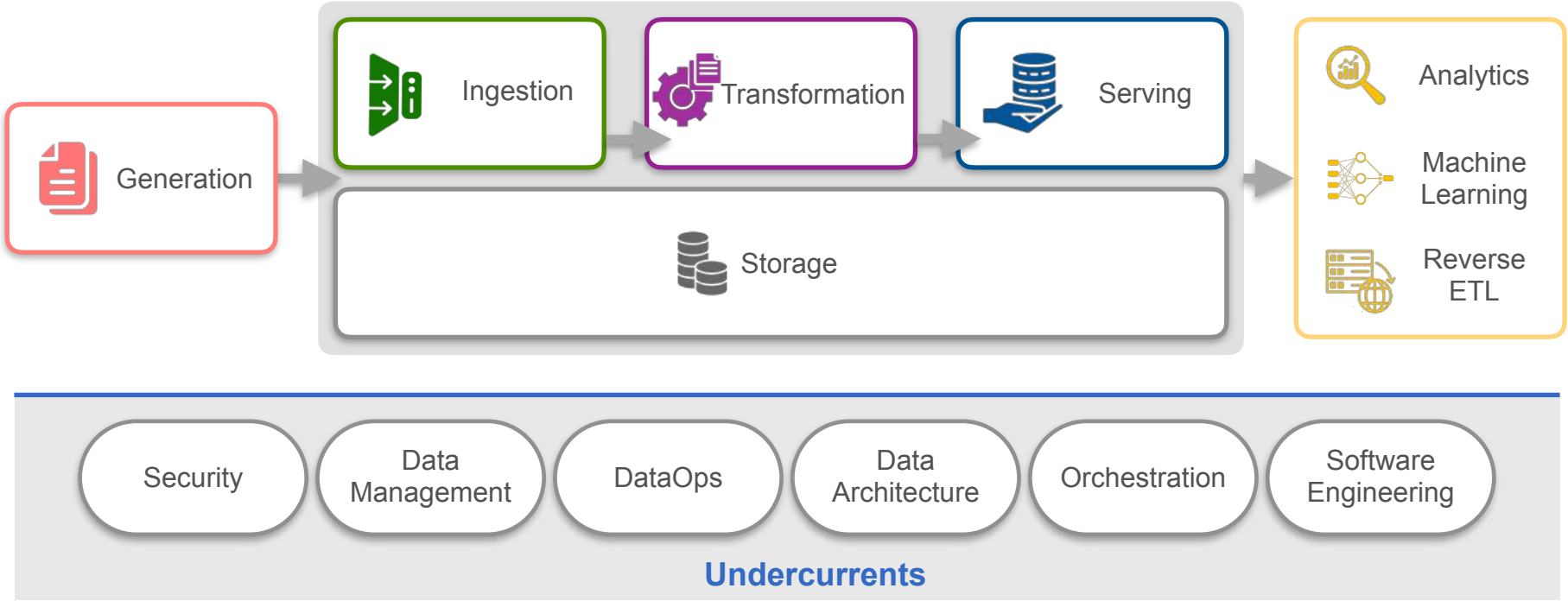
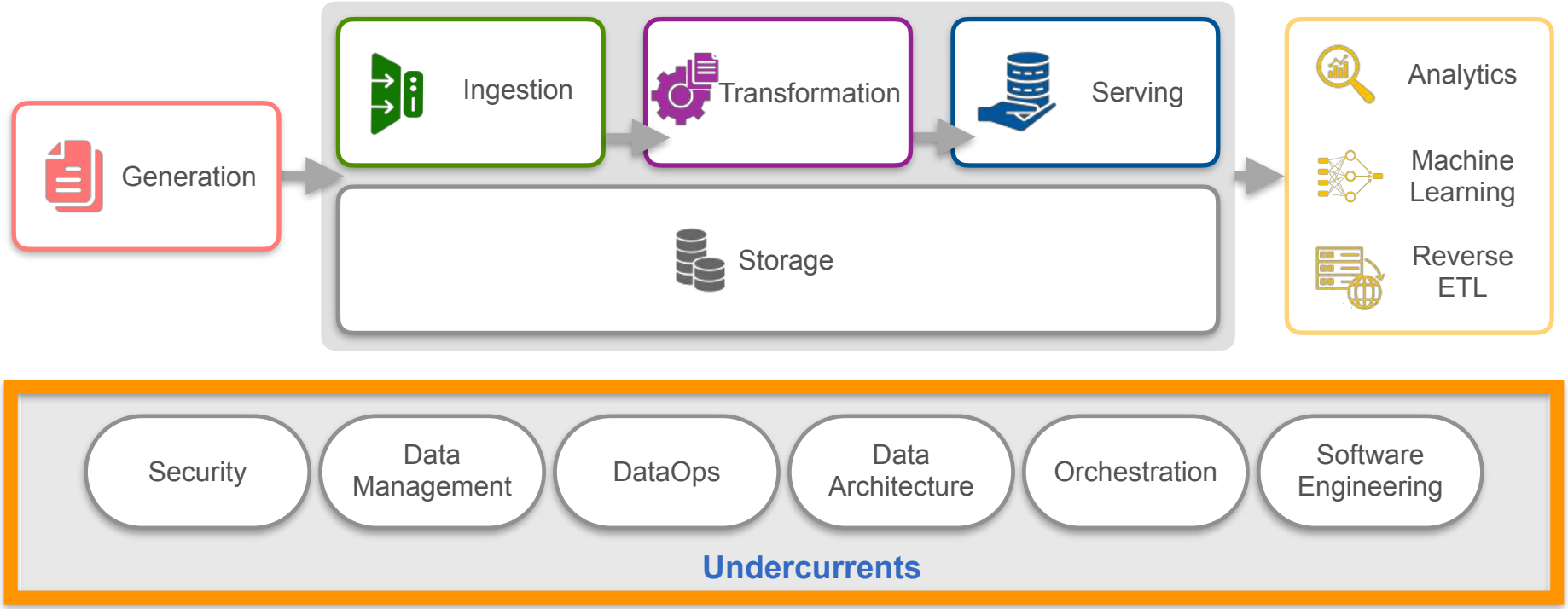
The Undercurrents of the Data Engineering Lifecycle

Intro to the Undercurrents

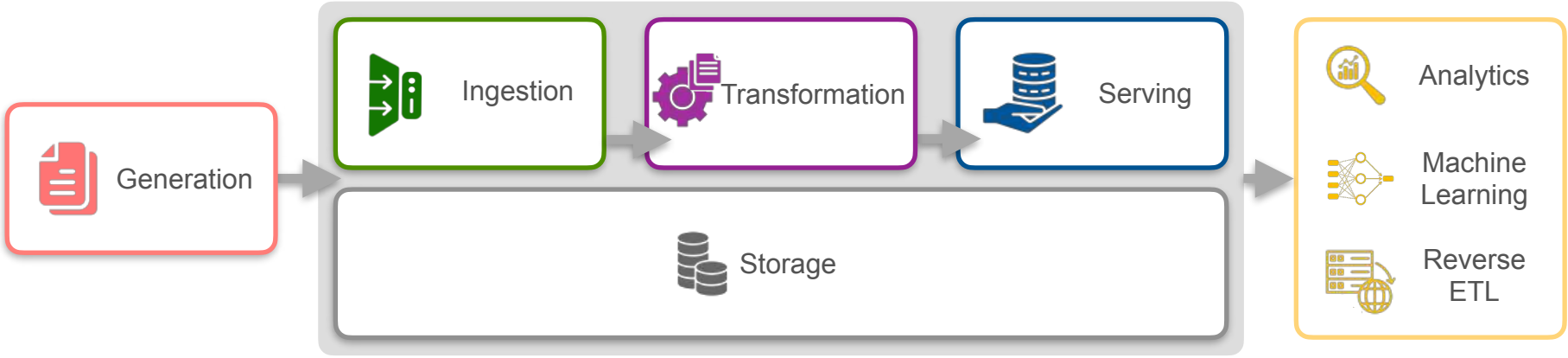
The Data Engineering Lifecycle & Undercurrents



The Data Engineering Lifecycle & Undercurrents



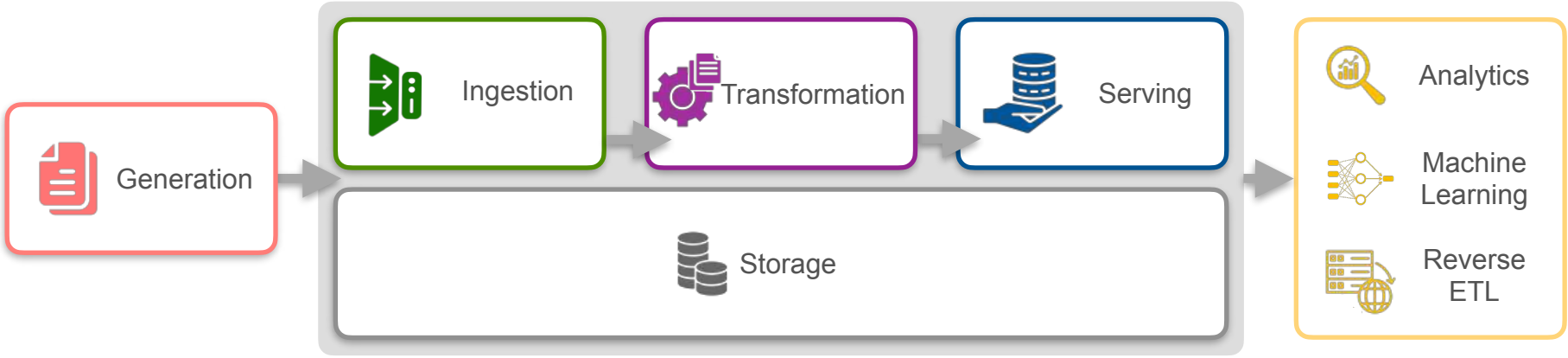
The Data Engineering Lifecycle & Undercurrents



Security | Data Management | DataOps | Data Architecture | Orchestration | Software Engineering

Undercurrents

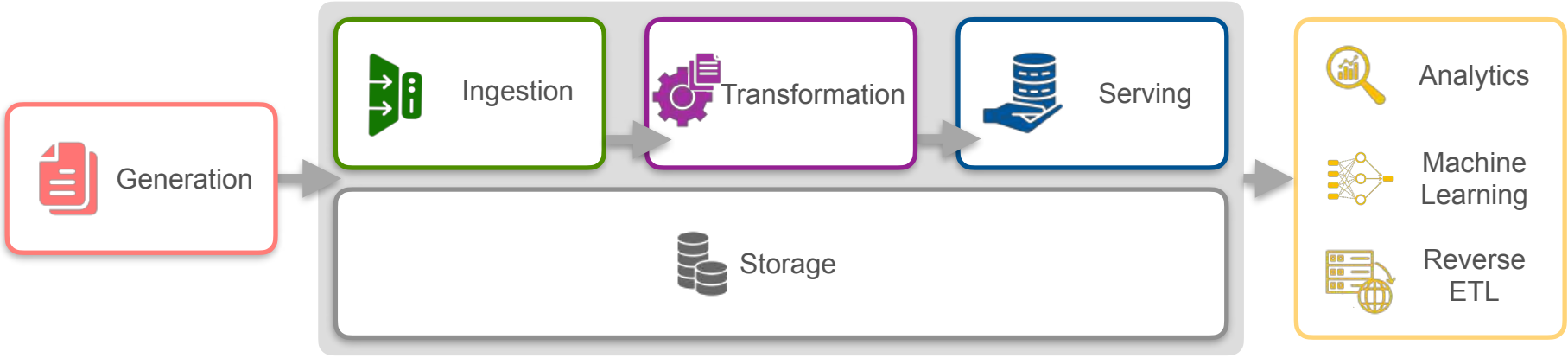
The Data Engineering Lifecycle & Undercurrents



Security
Data Management
DataOps
Data Architecture
Orchestration
Software Engineering

Undercurrents

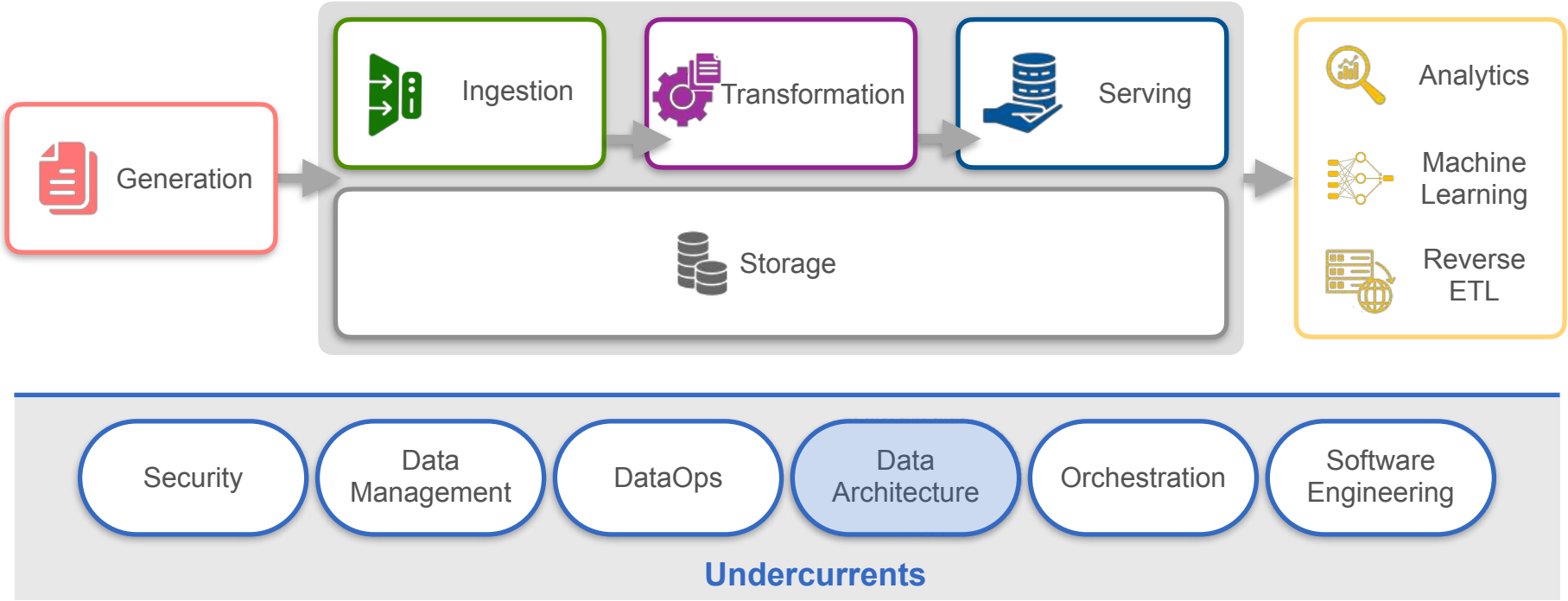
The Data Engineering Lifecycle & Undercurrents



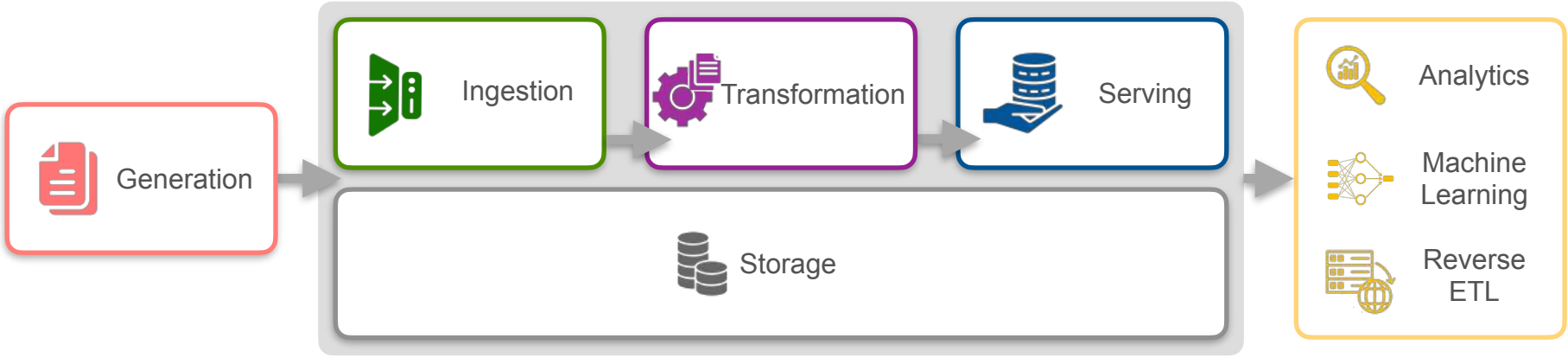
Security
Data Management
DataOps
Data Architecture
Orchestration
Software Engineering

Undercurrents

The Data Engineering Lifecycle & Undercurrents



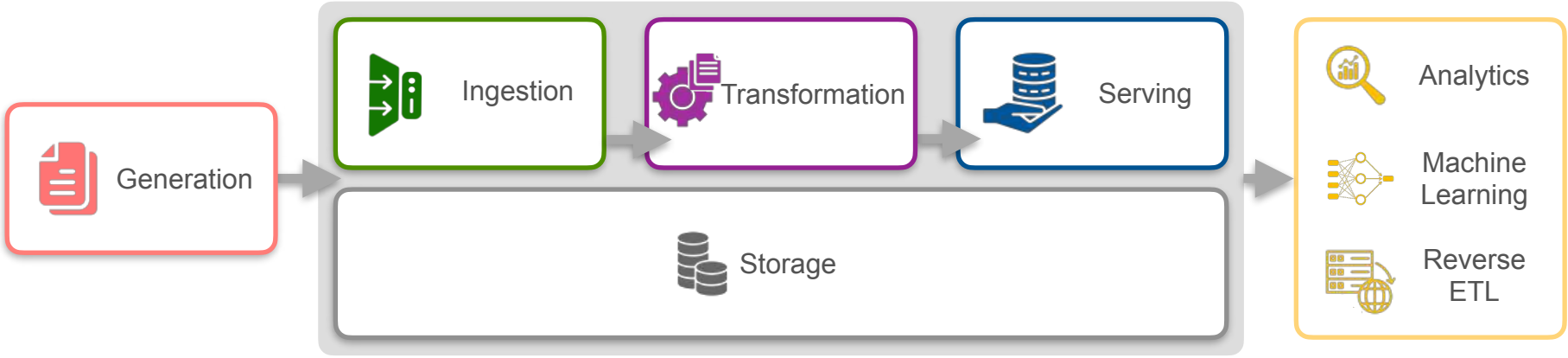
The Data Engineering Lifecycle & Undercurrents



Security
Data Management
DataOps
Data Architecture
Orchestration
Software Engineering

Undercurrents

The Data Engineering Lifecycle & Undercurrents



Security
Data Management
DataOps
Data Architecture
Orchestration
Software Engineering

Undercurrents

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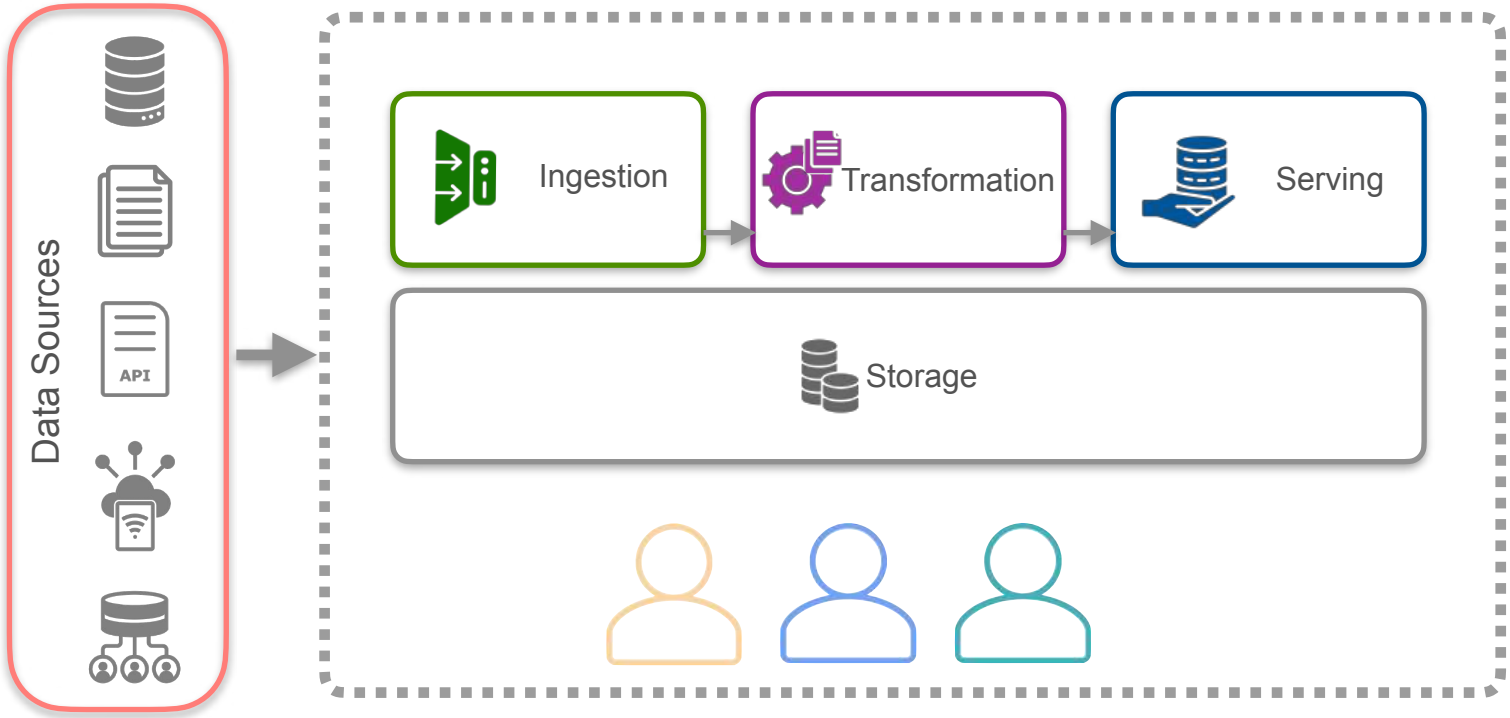
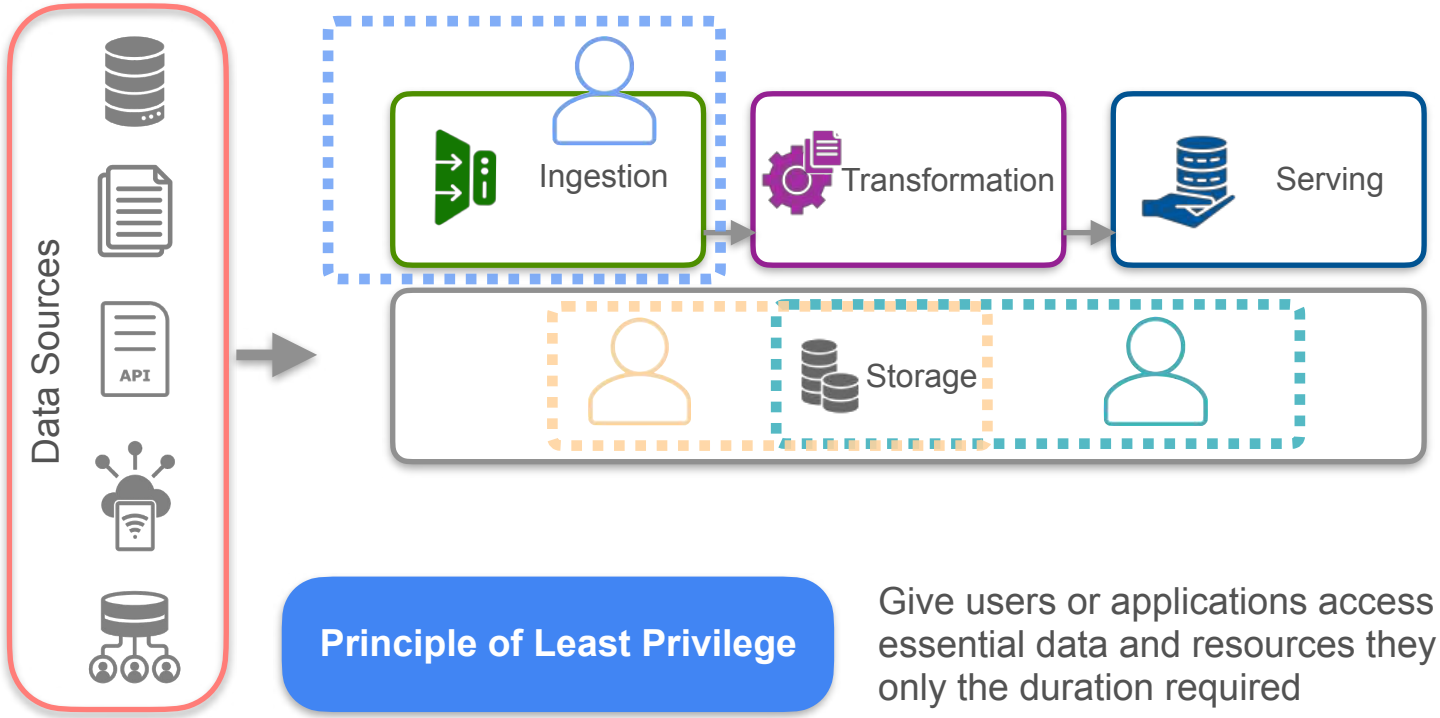
The Undercurrents of the Data Engineering Lifecycle

Security

Security


Data Sources
API
Ingestion
Transformation
Serving
Storage

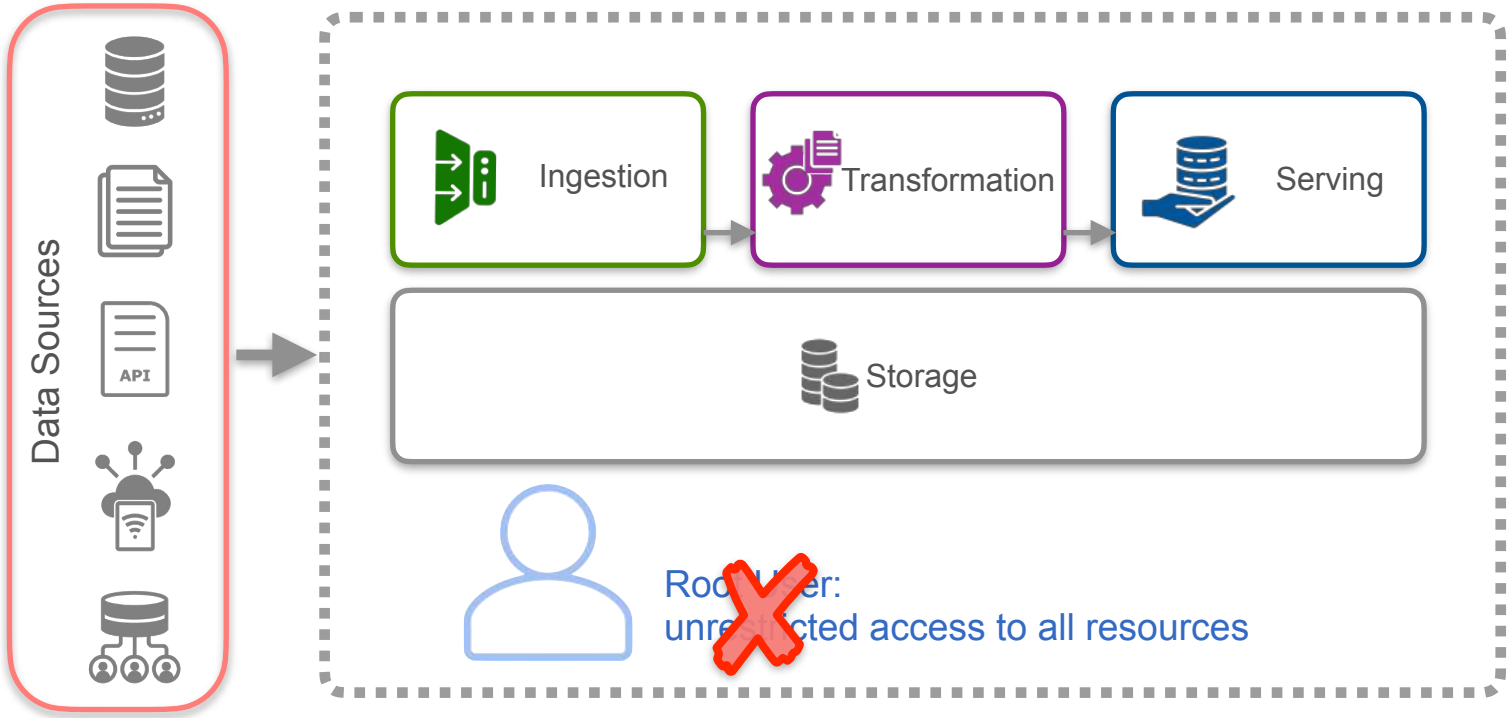
Security



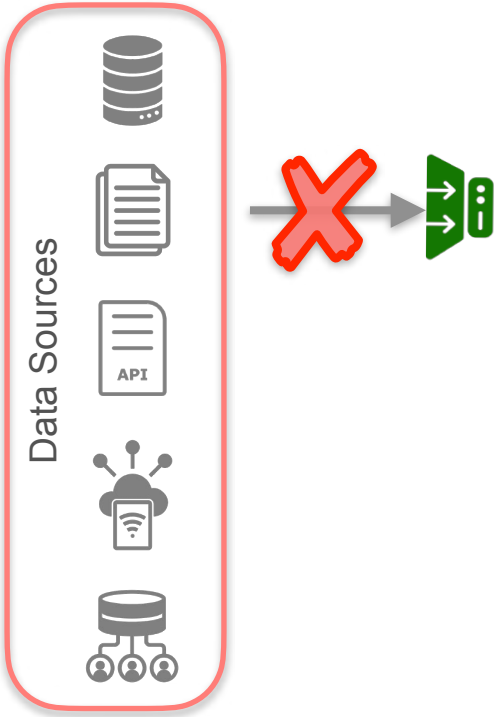
Principle of Least Privilege

Give users or applications access to only the essential data and resources they need for only the duration required

Security


Data Sources
API
Ingestion
Transformation
Serving
Storage
Root User:
unrestricted access to all resources

Data Sensitivity



Id	First Name	Last Name	Credit Card Number
25	John	Smith	457893
45	Lara	Jones	347891

Data sensitivity

Id	First Name	Last Name	Credit Card Number
25	J****	S****	****93
45	L****	J****	****91

Security in the Cloud

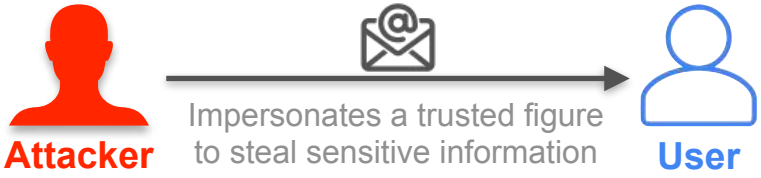
- Identity and Access Management (IAM)
- Encryption Methods
- Networking Protocols

Security

Defensive Mindset

Be cautious with sensitive data

Design for potential attacks



Security

Security Theater

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The Undercurrents of the Data Engineering Lifecycle

Data Management

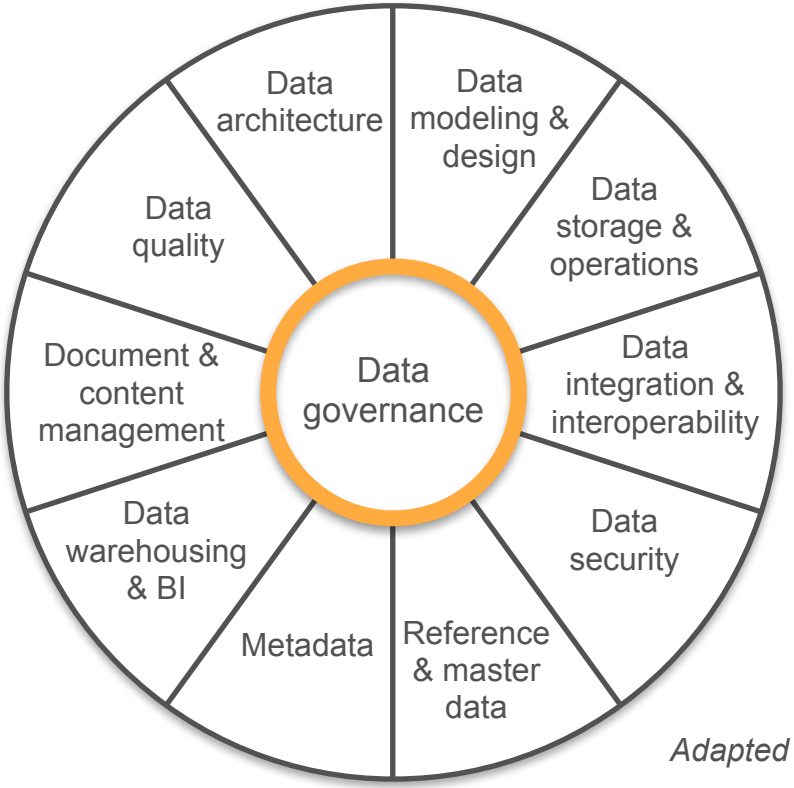
Data Management

"Data management is the development, execution, and supervision of plans, programs, and practices that deliver, control, protect, and enhance the value of data and information assets throughout their life cycles."

DMBOK's Definition

Data Management

11
Data Knowledge Areas



Adapted from: DAMA International

Data Governance

“Data governance is, first and foremost, a data management function to ensure the quality, integrity, security, and usability of the data collected by an organization.”

Data Governance: The definitive Guide

Data Governance

"Data governance is, first and foremost, a data management function to ensure the quality, integrity, security, and usability of the data collected by an organization."

Data Governance: The definitive Guide

Data Quality

High Quality Data

- Accurate
- Complete
- Discoverable
- Available in a timely manner

Exactly what stakeholders expect

Low Quality Data

- Inaccurate
- Incomplete
- Hard to find
- Late

Unusable

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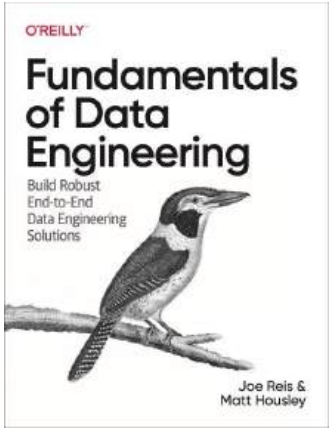
The Undercurrents of the Data Engineering Lifecycle

Data Architecture

Data Architecture

“Data architecture is the design of systems to support the evolving data needs of an enterprise, achieved by flexible and reversible decisions reached through a careful evaluation of trade-offs”



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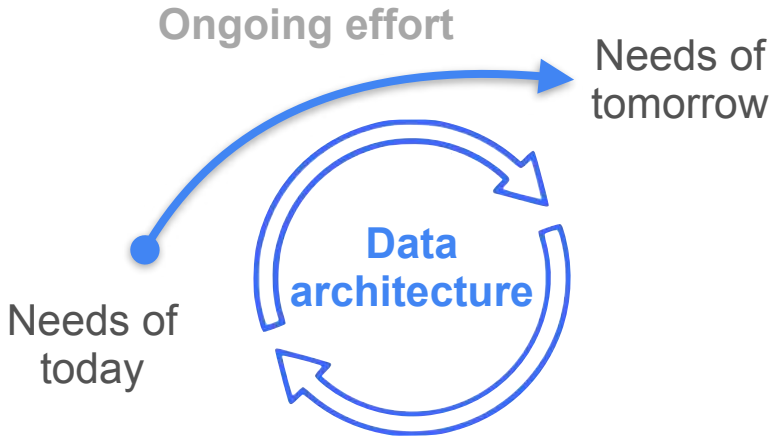

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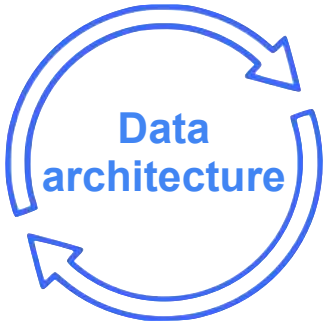
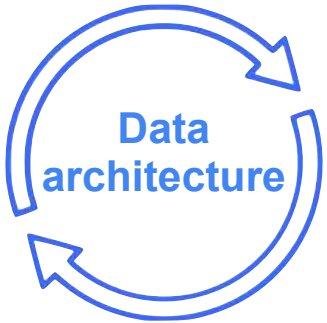


Data Architecture

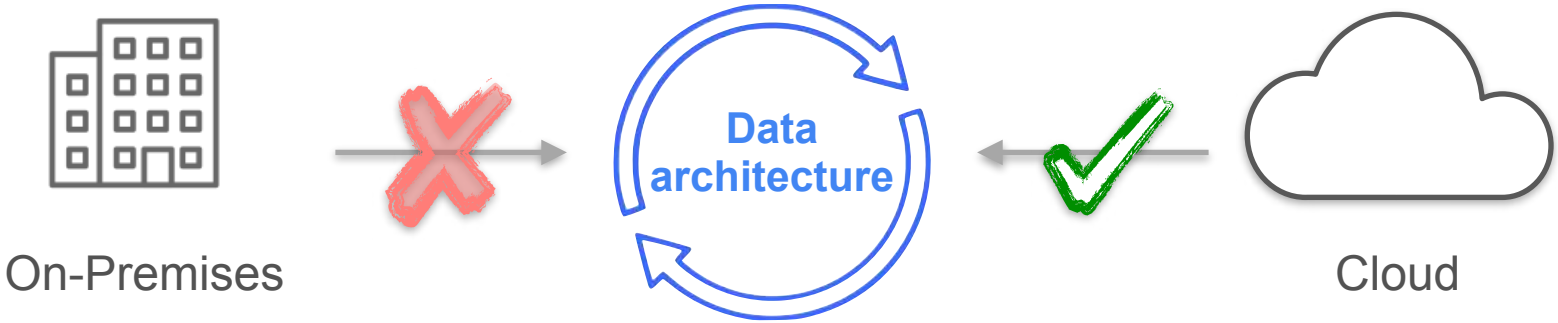
“Data architecture is the design of systems to support the evolving data needs of an enterprise, achieved by flexible and reversible decisions reached through a careful evaluation of trade-offs”

Trade-offs

- Performance
- Cost
- Scalability
- …

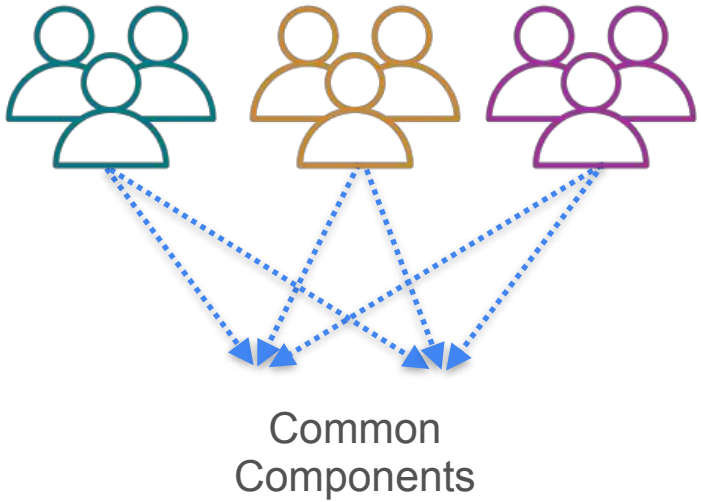


Data Architecture



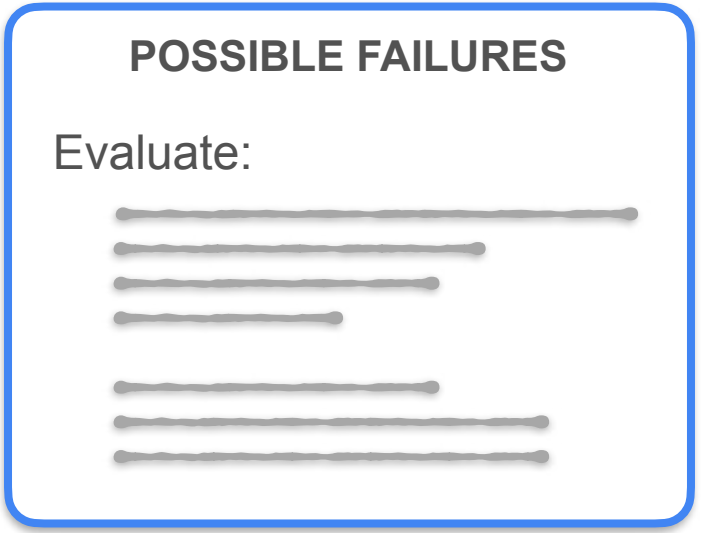
Principle of Good Data Architecture

1. Choose common components wisely



Principle of Good Data Architecture

1. Choose common components wisely
2. Plan for failure!

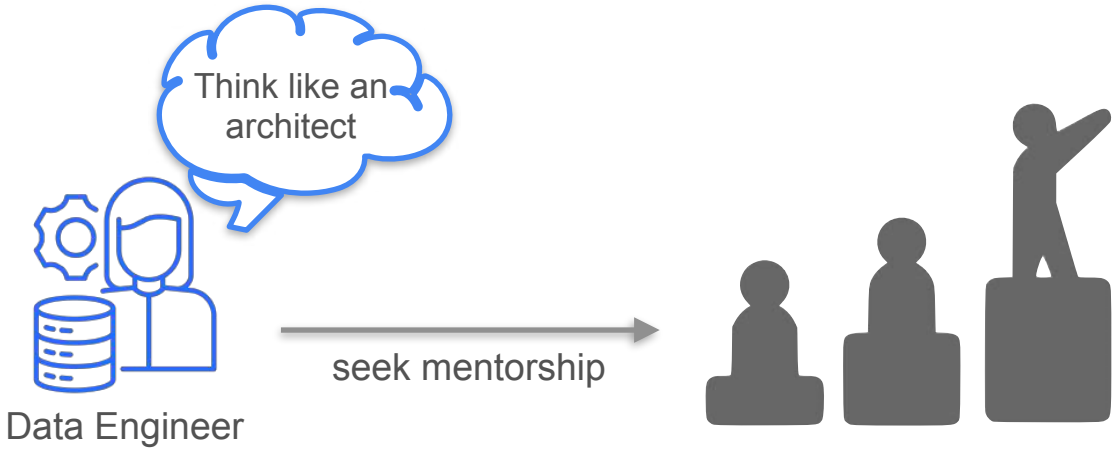


Principle of Good Data Architecture

1. Choose common components wisely
2. Plan for failure!
3. Architect for scalability

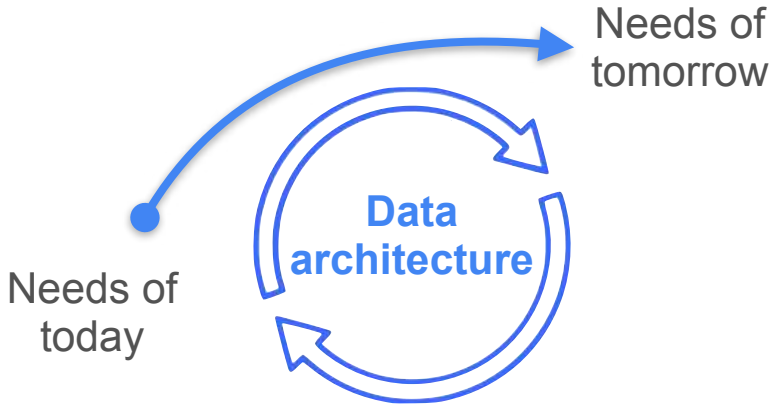
Principle of Good Data Architecture

1. Choose common components wisely
2. Plan for failure!
3. Architect for scalability
4. Architecture is leadership



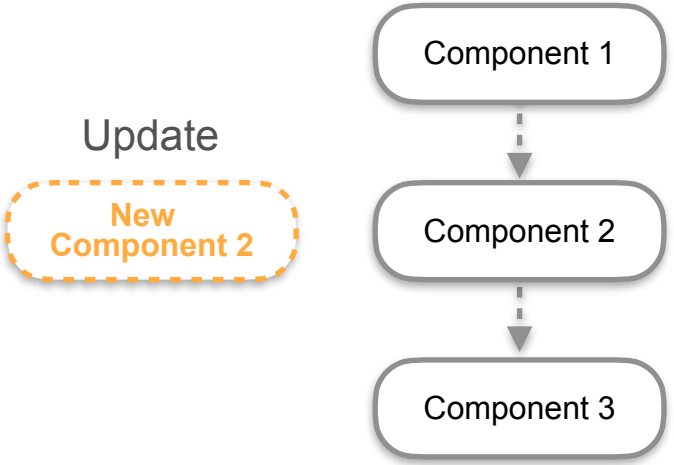
Principle of Good Data Architecture

1. Choose common components wisely
2. Plan for failure!
3. Architect for scalability
4. Architecture is leadership
5. Always be architecting



Principle of Good Data Architecture

1. Choose common components wisely
2. Plan for failure!
3. Architect for scalability
4. Architecture is leadership
5. Always be architecting
6. Build loosely coupled systems
7. Make reversible decisions



Principle of Good Data Architecture

1. Choose common components wisely
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3. Architect for scalability
4. Architecture is leadership
5. Always be architecting
6. Build loosely coupled systems
7. Make reversible decisions
8. Prioritize security

Principle of least privilege

Zero-trust principle

Principle of Good Data Architecture

1. Choose common components wisely
2. Plan for failure!
3. Architect for scalability
4. Architecture is leadership
5. Always be architecting
6. Build loosely coupled systems
7. Make reversible decisions
8. Prioritize security
9. Embrace FinOps

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The Undercurrents of the Data Engineering Lifecycle

DataOps

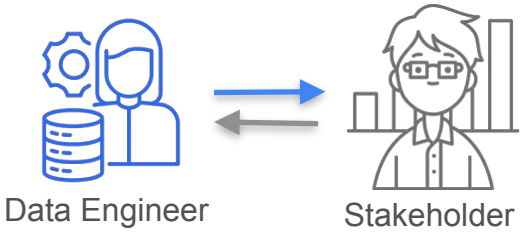
DataOps

DataOps

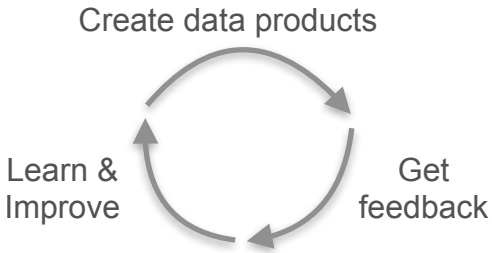
Improves the development process and quality of data products.

It's a set of cultural habits and practices.

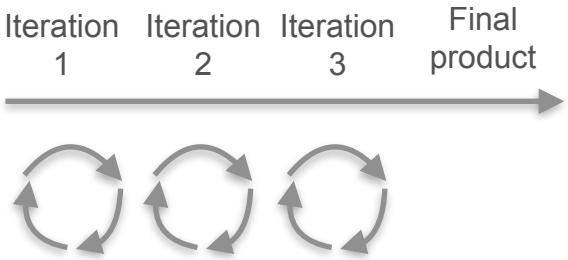
Communication & Collaboration



Continuous Improvement

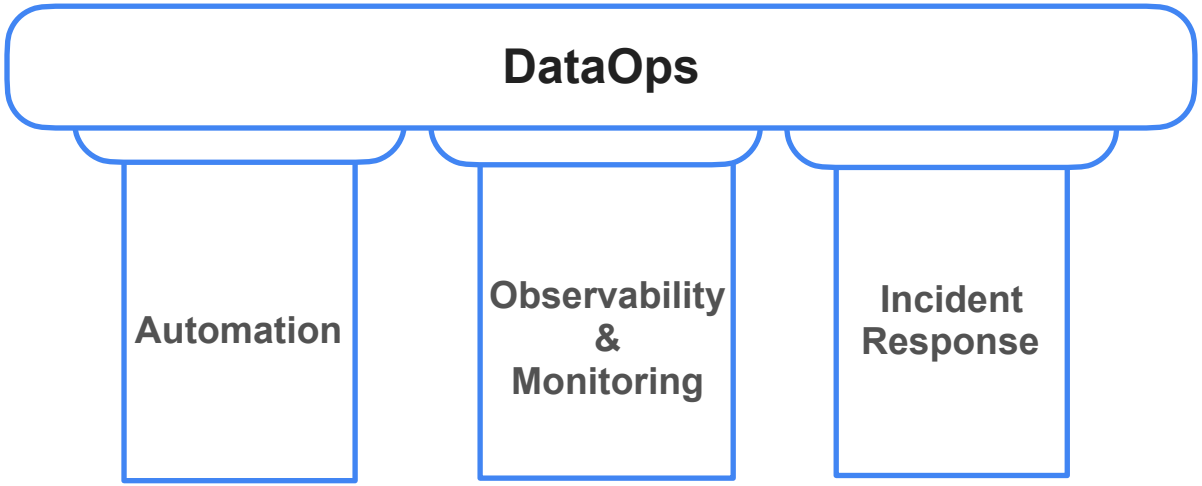


Rapid Iteration



DevOps practices ⟵ **Agile methodology**

Pillars of DataOps



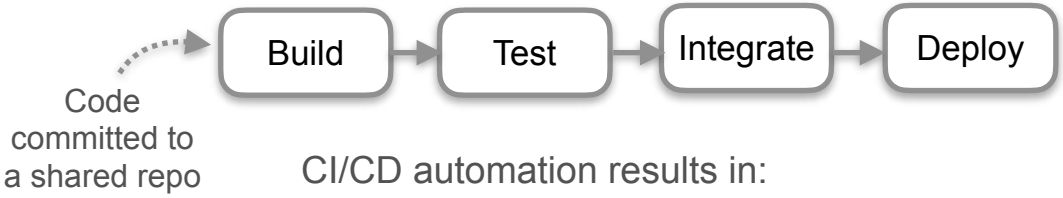
Goal: Provide high-quality data products

Pillar 1: Automation

DevOps
(Applies to software build)

DataOps

Continuous Integration and Continuous Delivery (CI/CD)



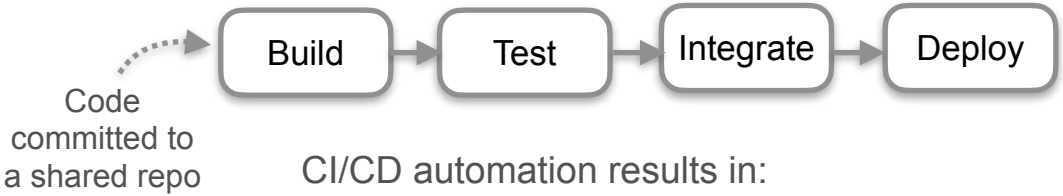
CI/CD automation results in:

- faster deployment
- fewer errors

Pillar 1: Automation

DevOps
(Applies to software build)

Continuous Integration and Continuous Delivery (CI/CD)



CI/CD automation results in:

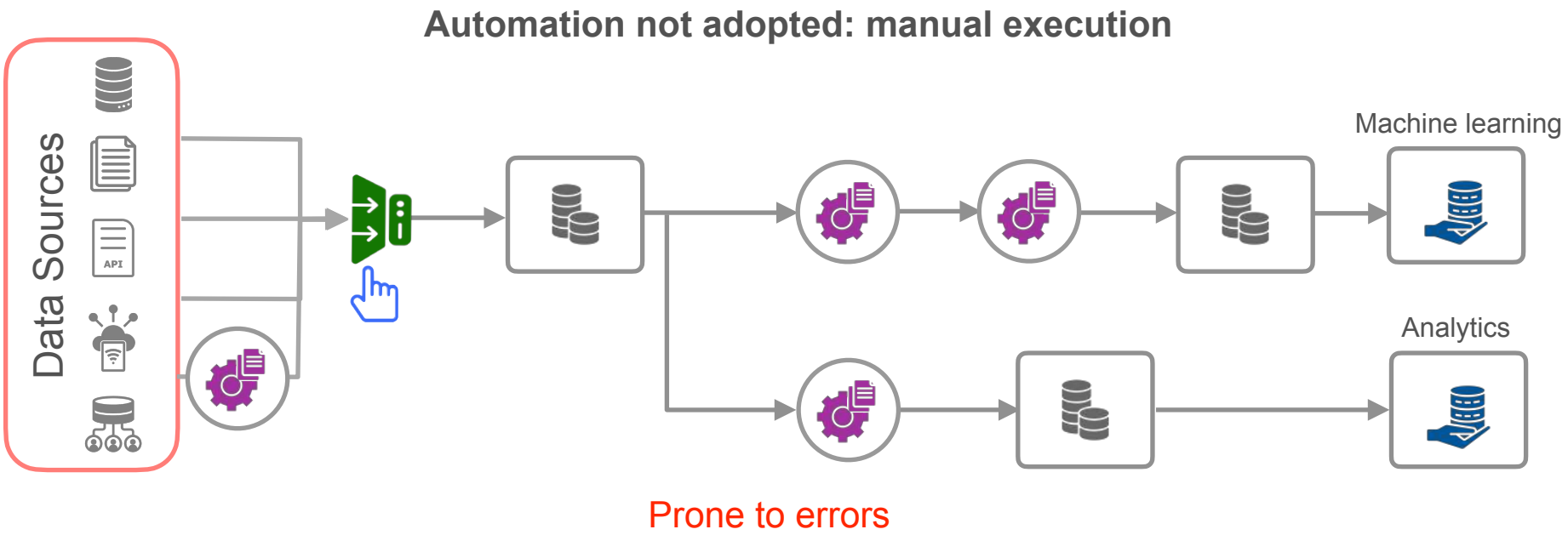
- faster deployment
- fewer errors

DataOps
(Applies to data processing)

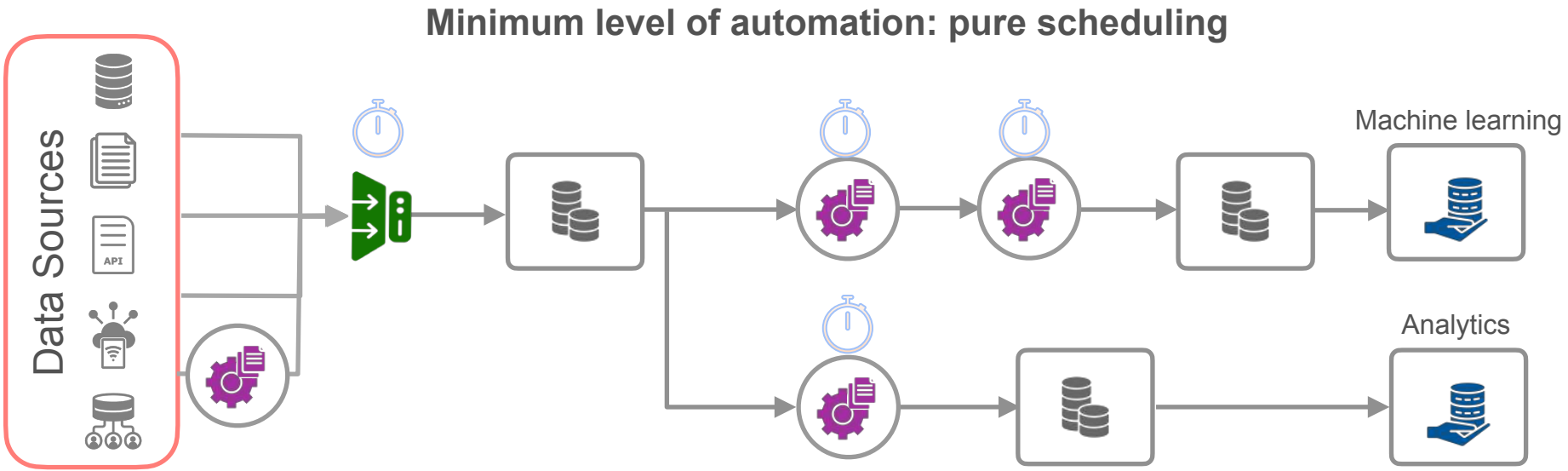
Automated change management:

- Code
- Configuration
- Environment
- Data processing pipelines
- Data

Pillar 1: Automation

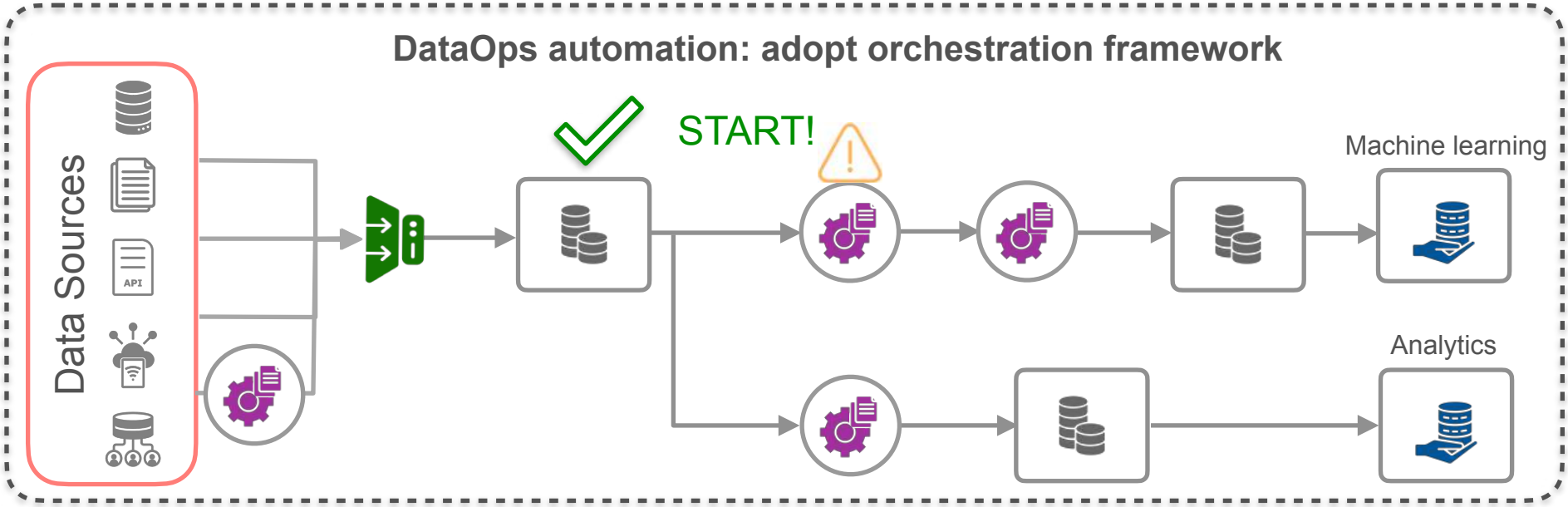


Pillar 1: Automation



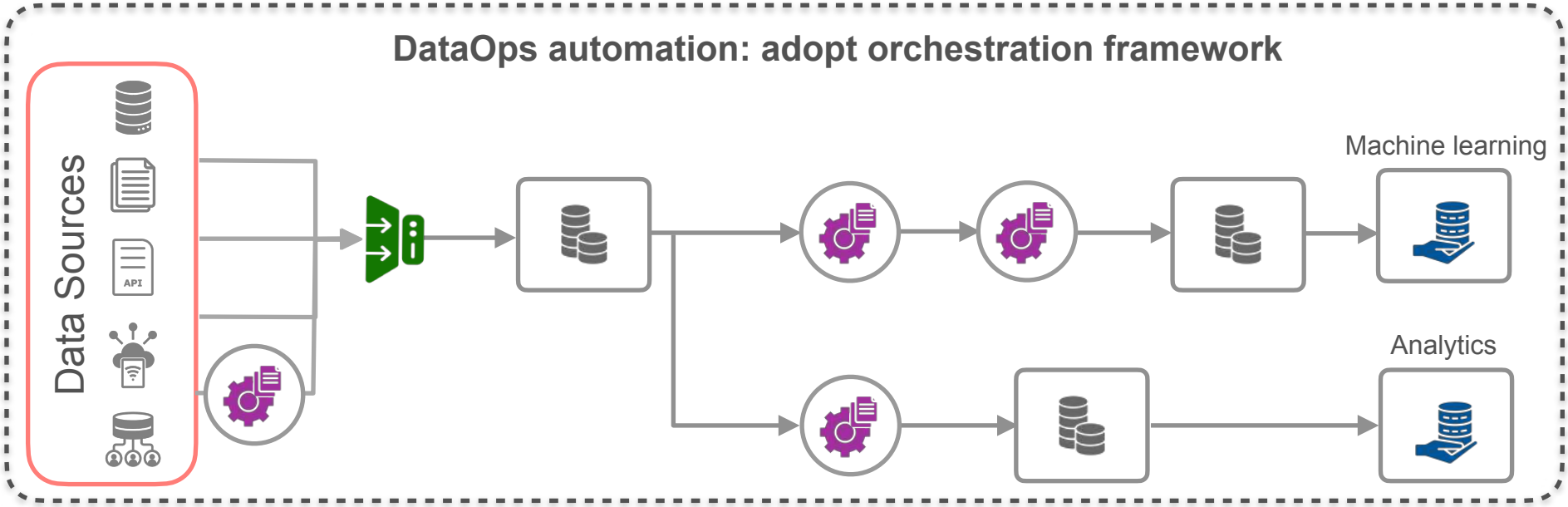
Prone to failure as the number of jobs grows

Pillar 1: Automation



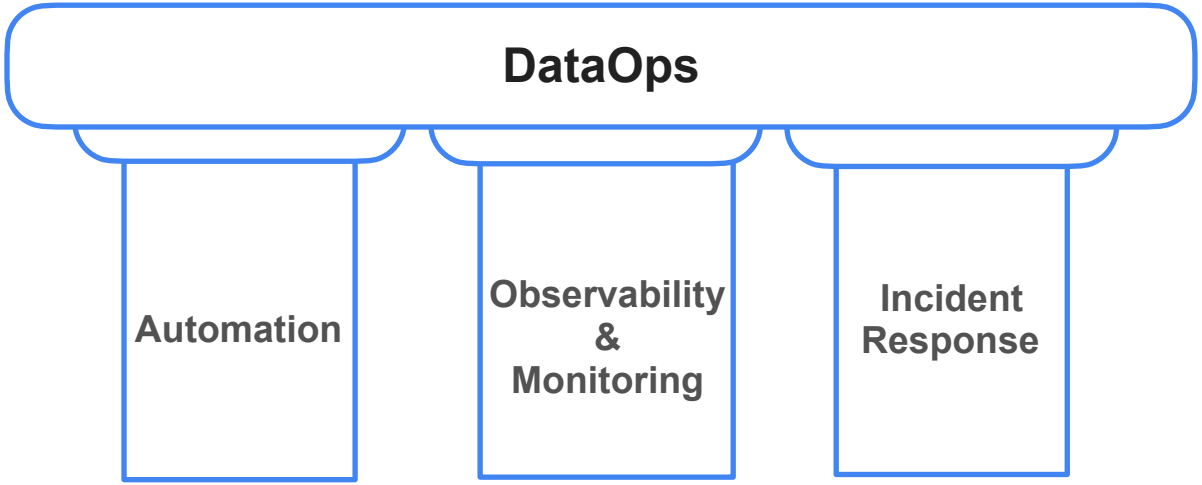
Checks the dependencies between tasks before each task is run

Pillar 1: Automation



Automatic verification and deployment of new aspects

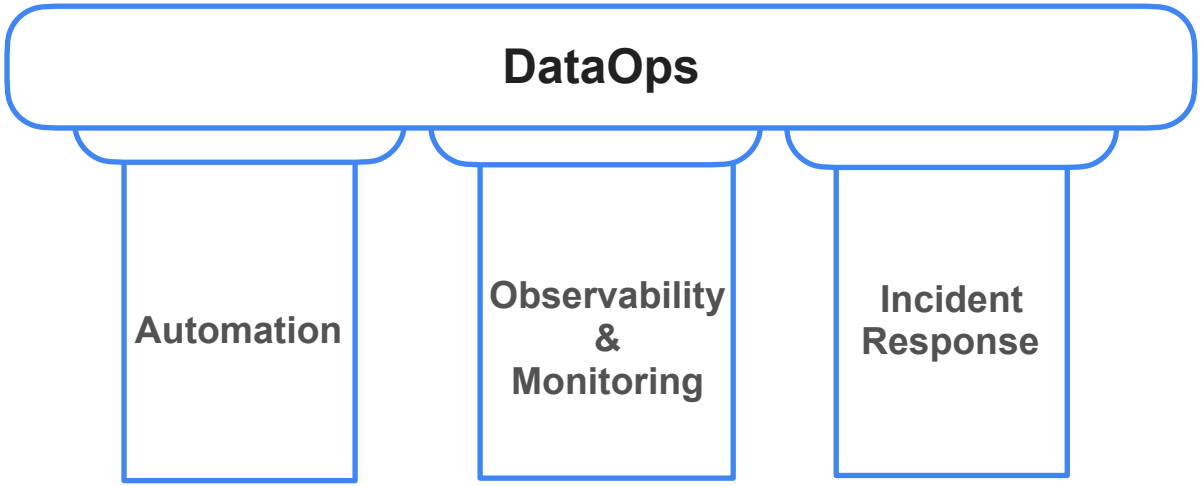
Pillar 2: Observability & Monitoring



"Everything fails all the time"

- Werner Vogels

Pillar 3: Incident Response



- ✓ Rapidly identify the incident's root causes
- ✓ Quickly resolve an incident
- ✓ Identify technology and tools
- ✓ Coordinate the efforts of the data team

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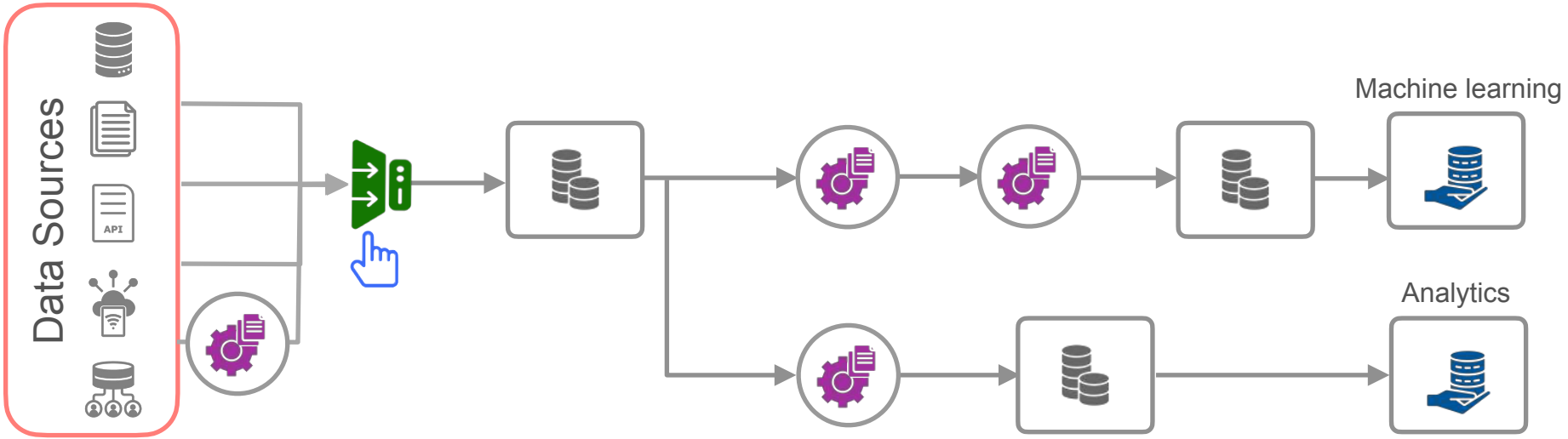
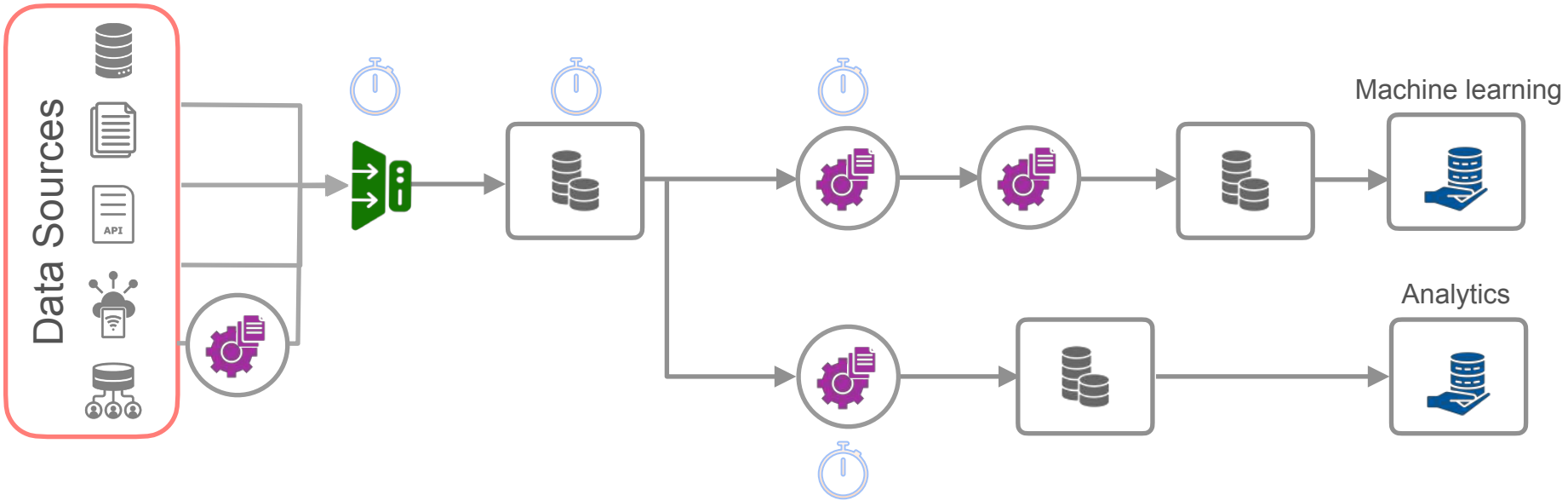
The Undercurrents of the Data Engineering Lifecycle

Orchestration

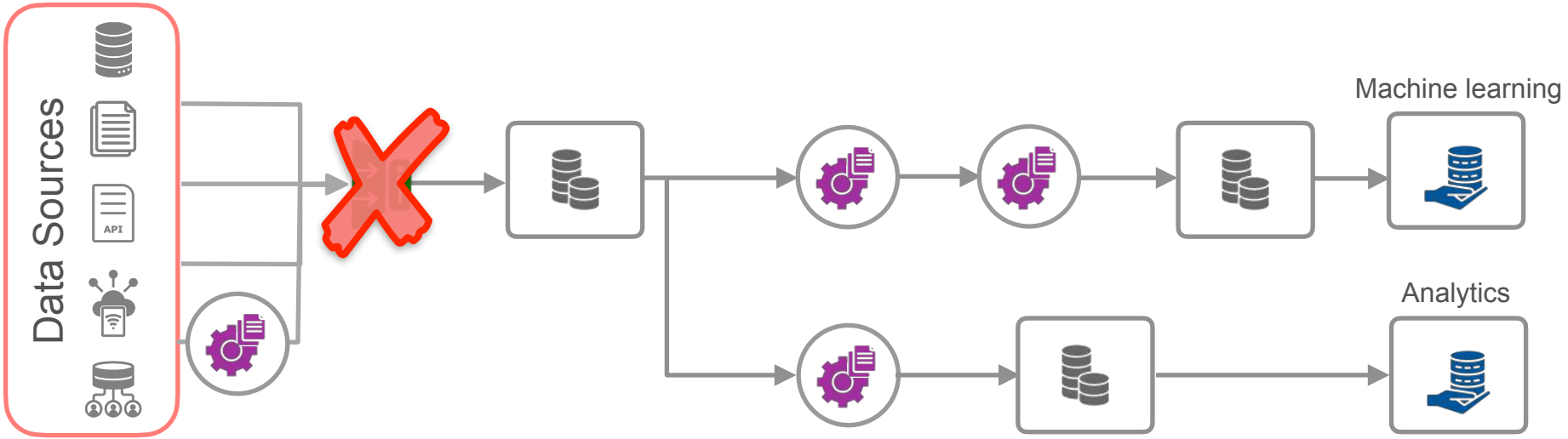
Manual Execution



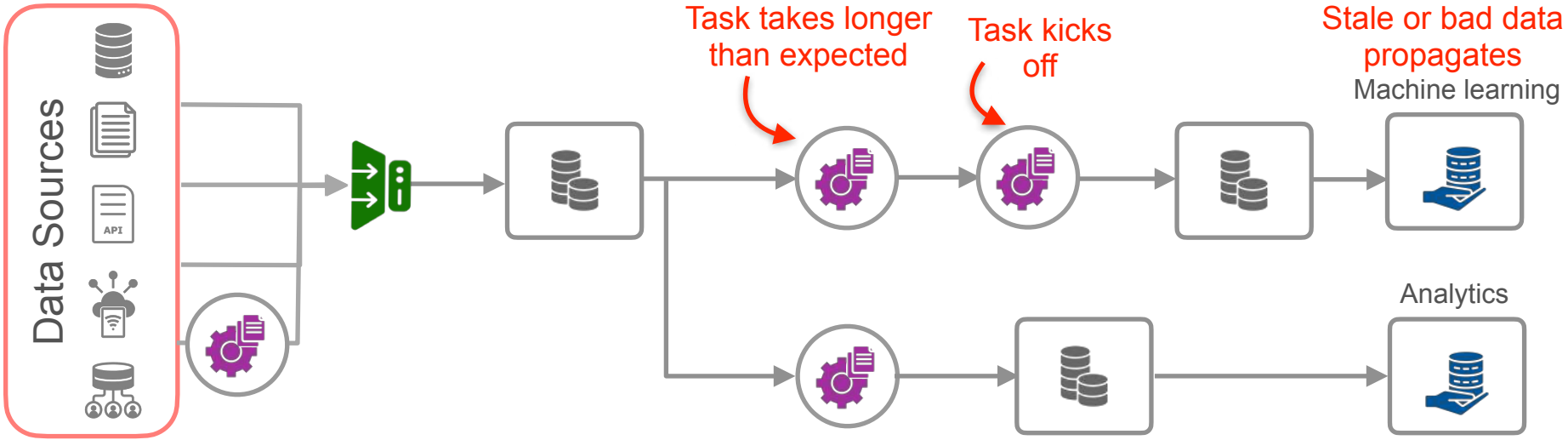
Pure Scheduling



Pure Scheduling

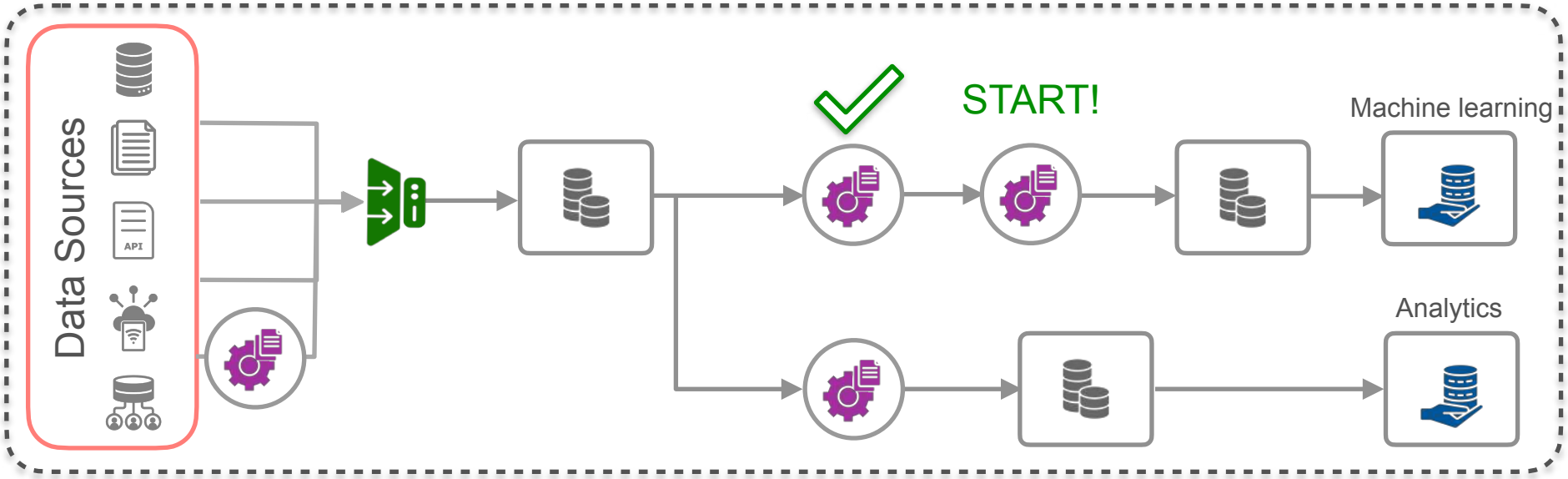


Pure Scheduling



Orchestration Frameworks

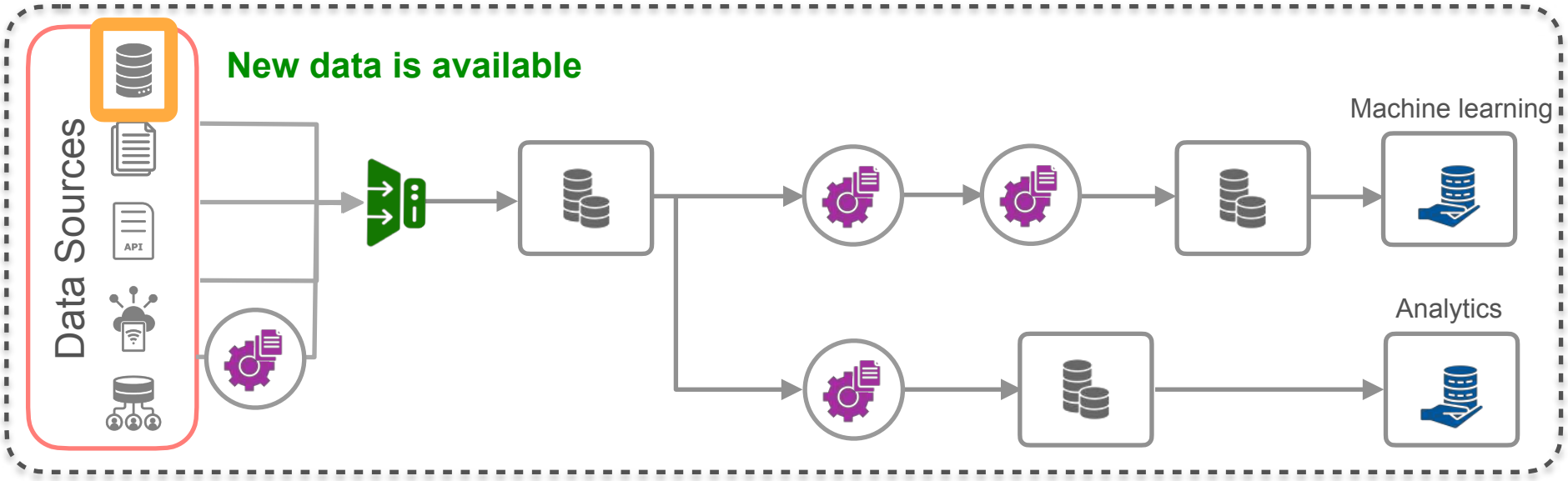
Time-based scheduling



Orchestration frameworks:

- Automate pipeline with complex dependencies
- Monitor pipeline

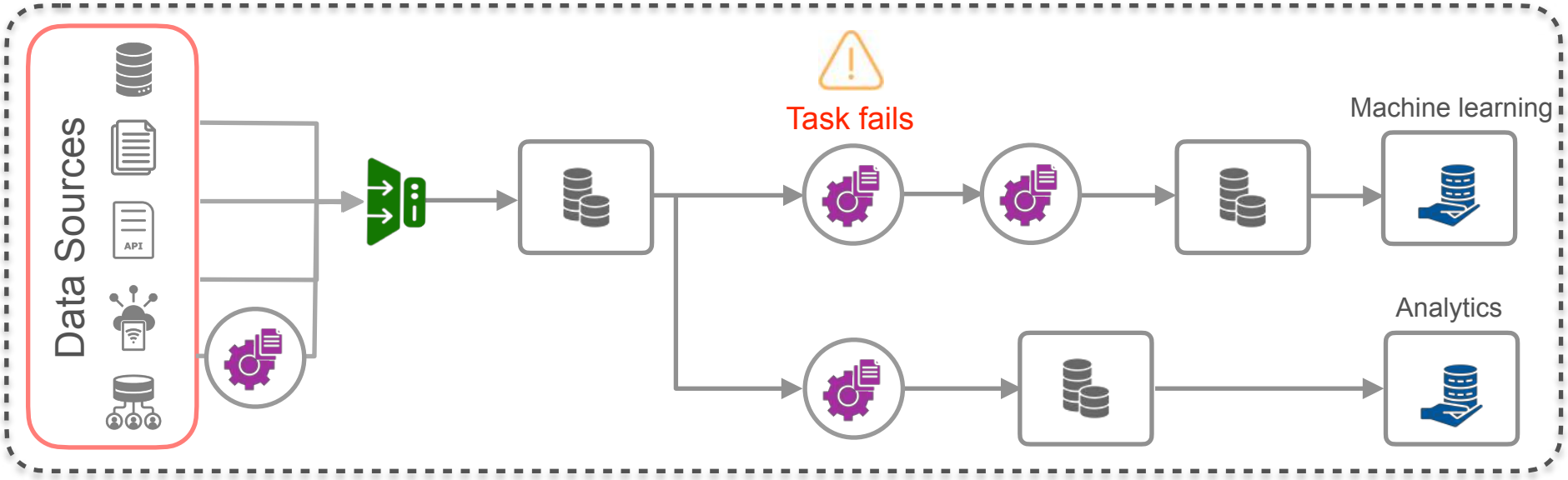
Event-based triggers



Orchestration frameworks:

- Automate pipeline with complex dependencies
- Monitor pipeline

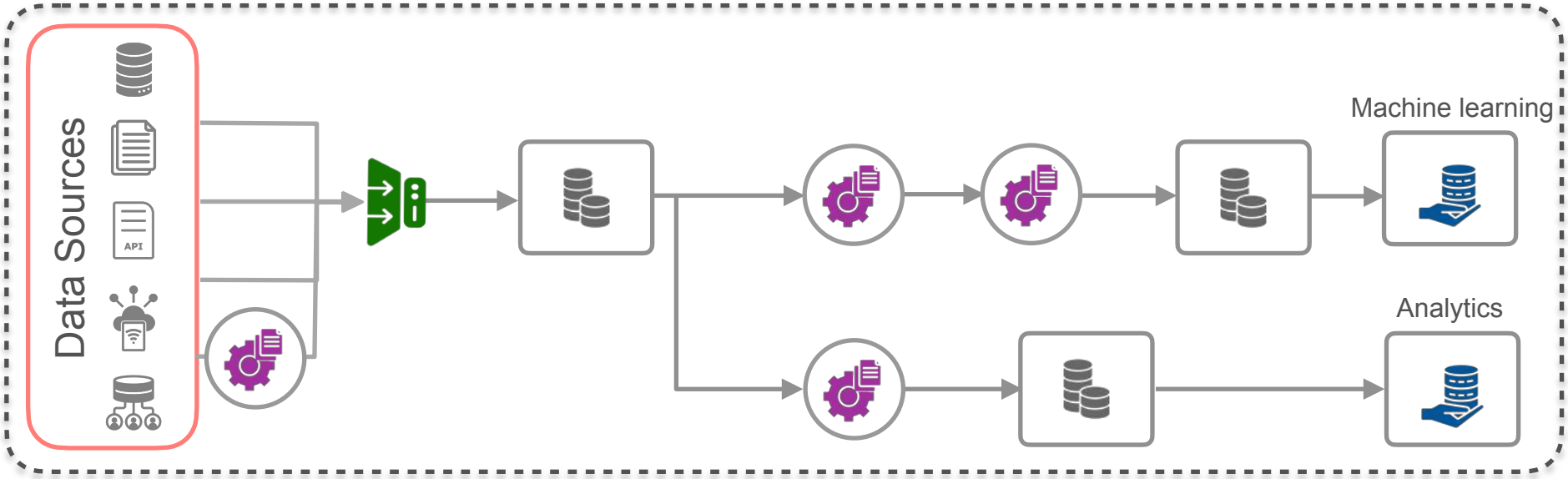
Set up monitoring & alerts



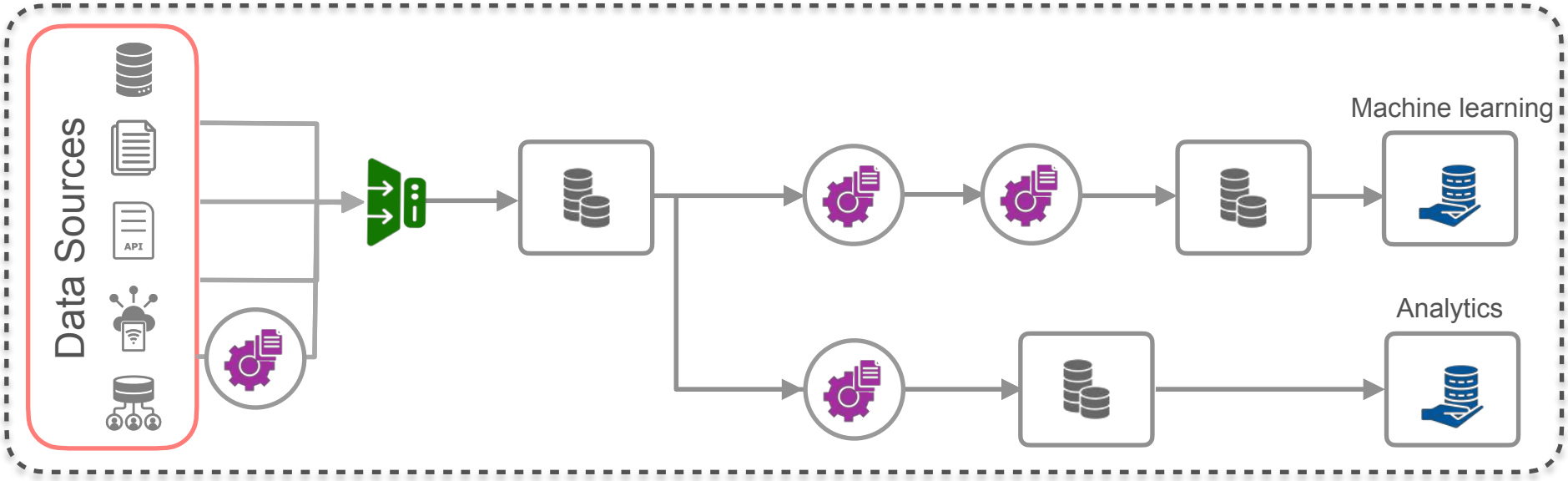
Orchestration frameworks:

- Automate pipeline with complex dependencies
- Monitor pipeline

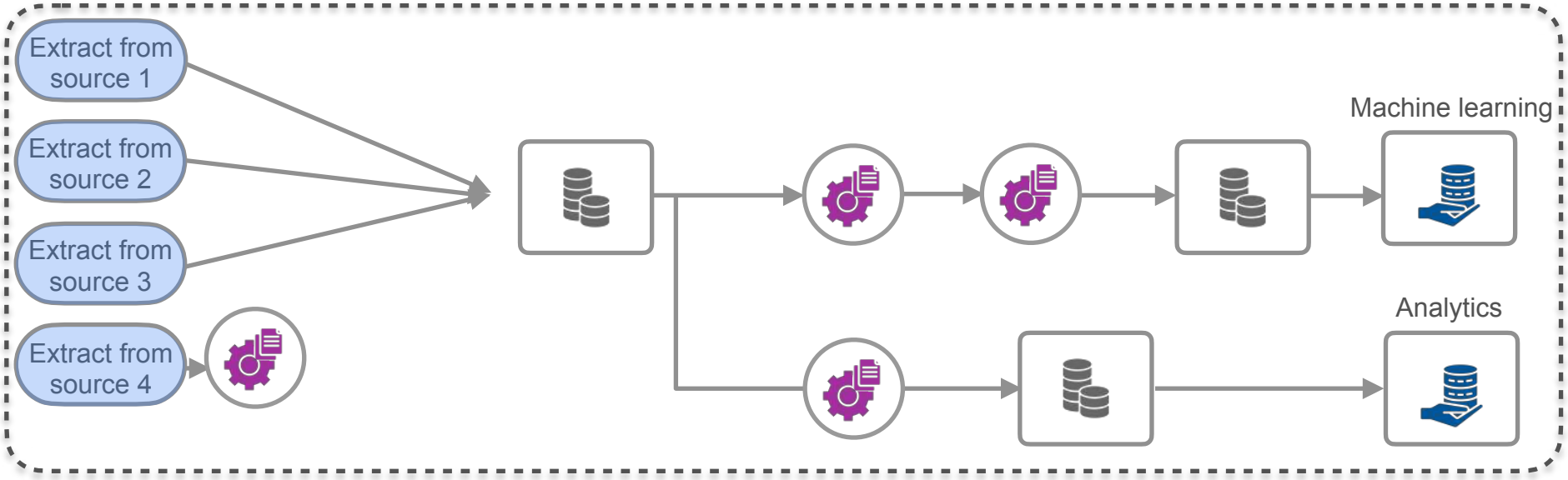
Directed Acyclic Graph



Directed Acyclic Graph (DAG)



Directed Acyclic Graph (DAG)



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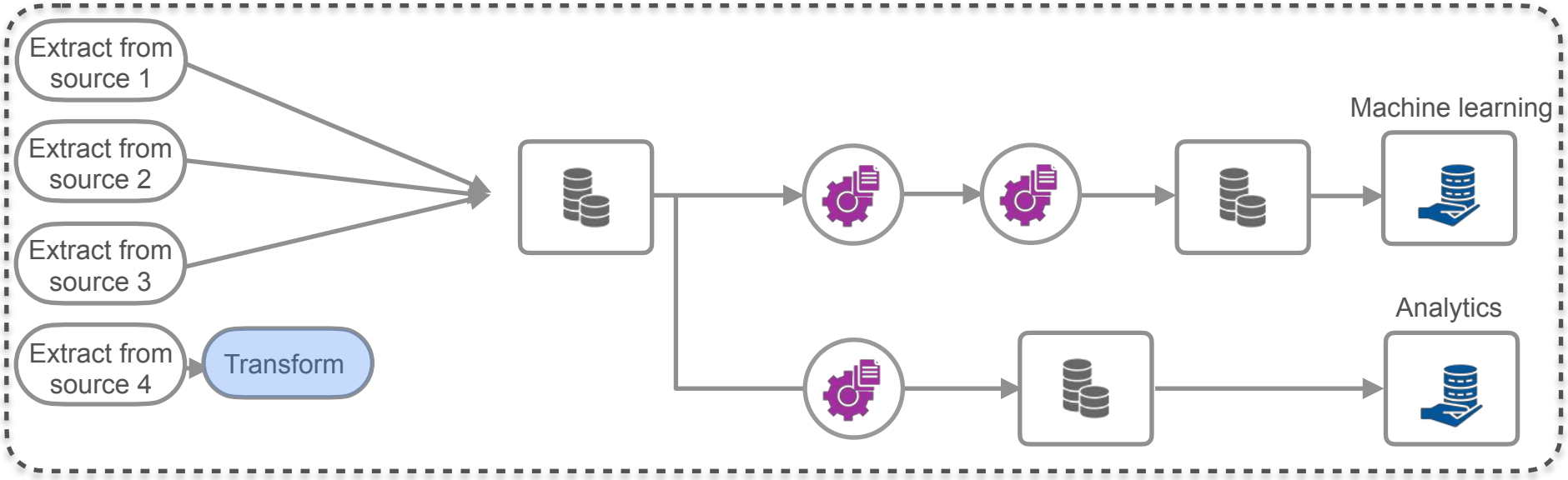

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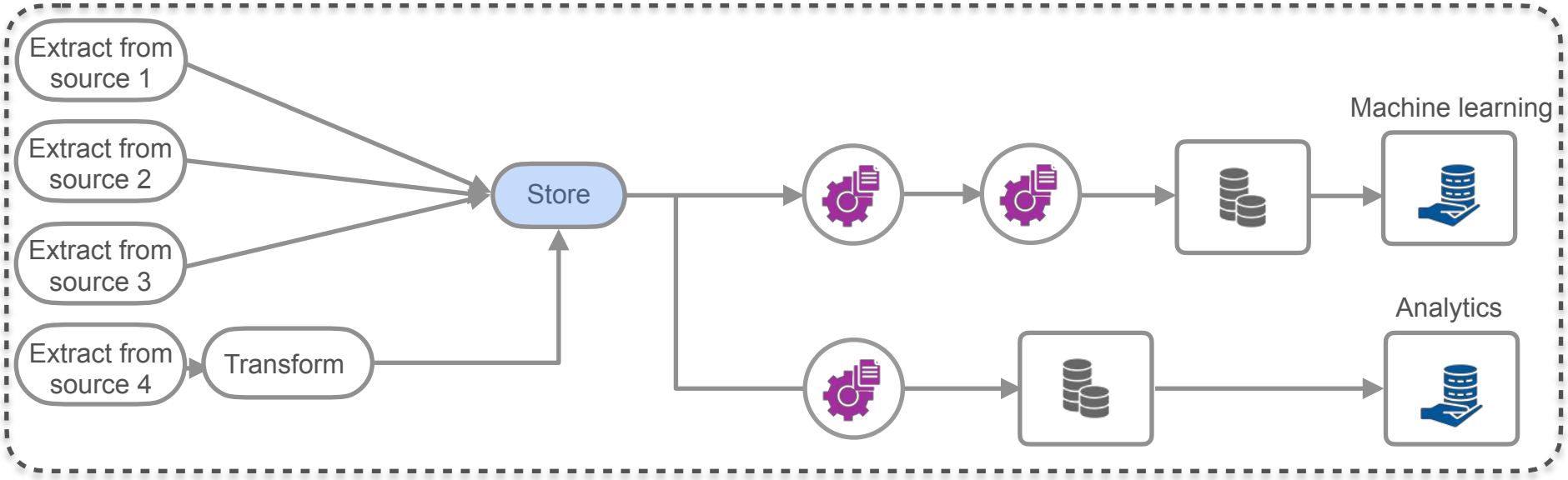

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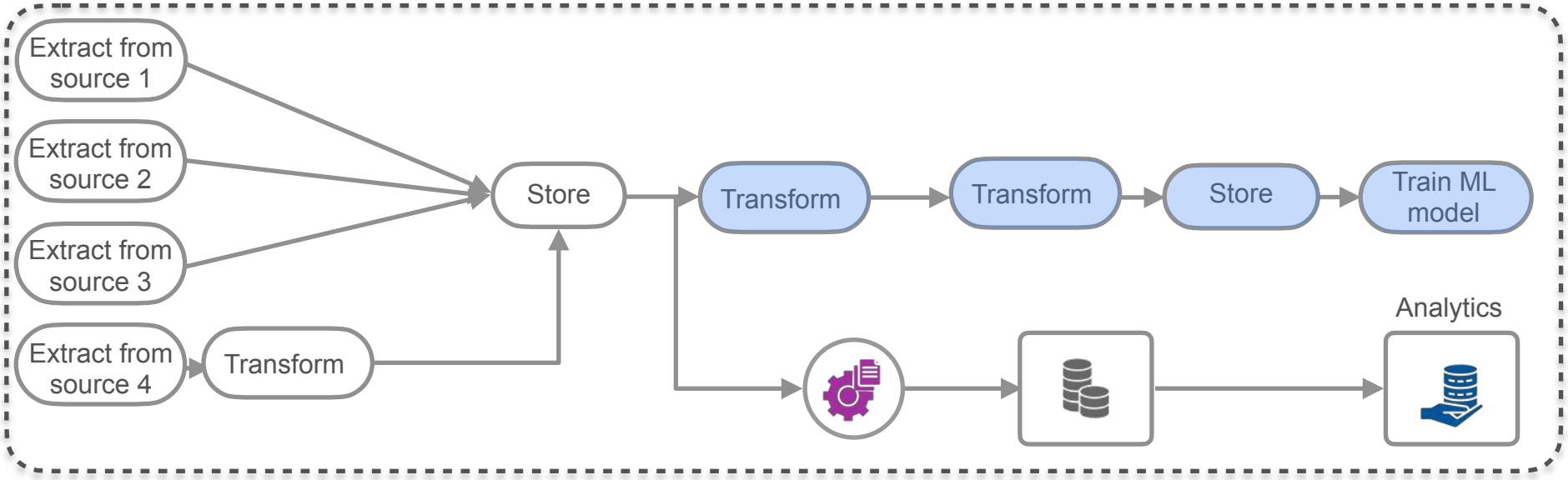
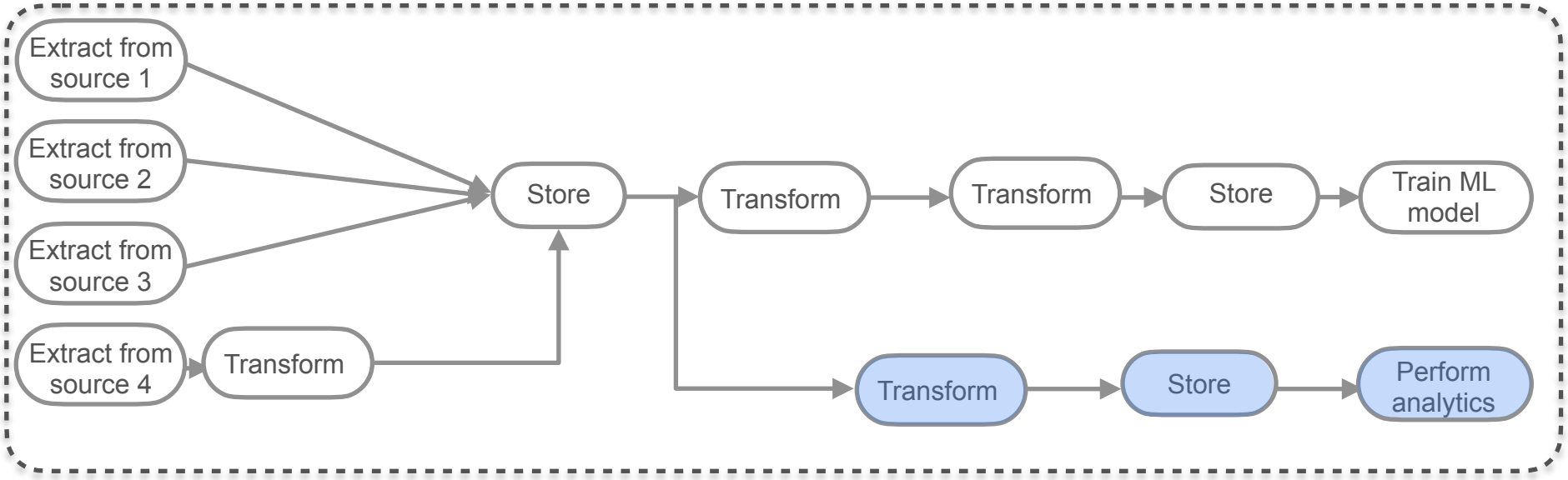
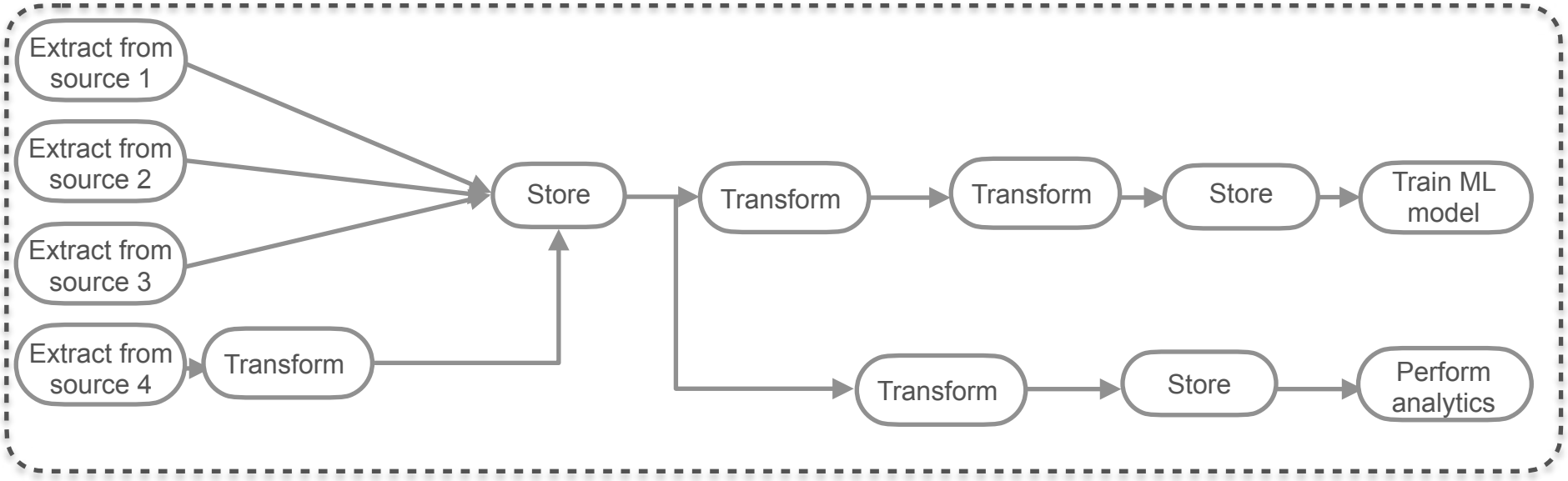


Directed Acyclic Graph (DAG)

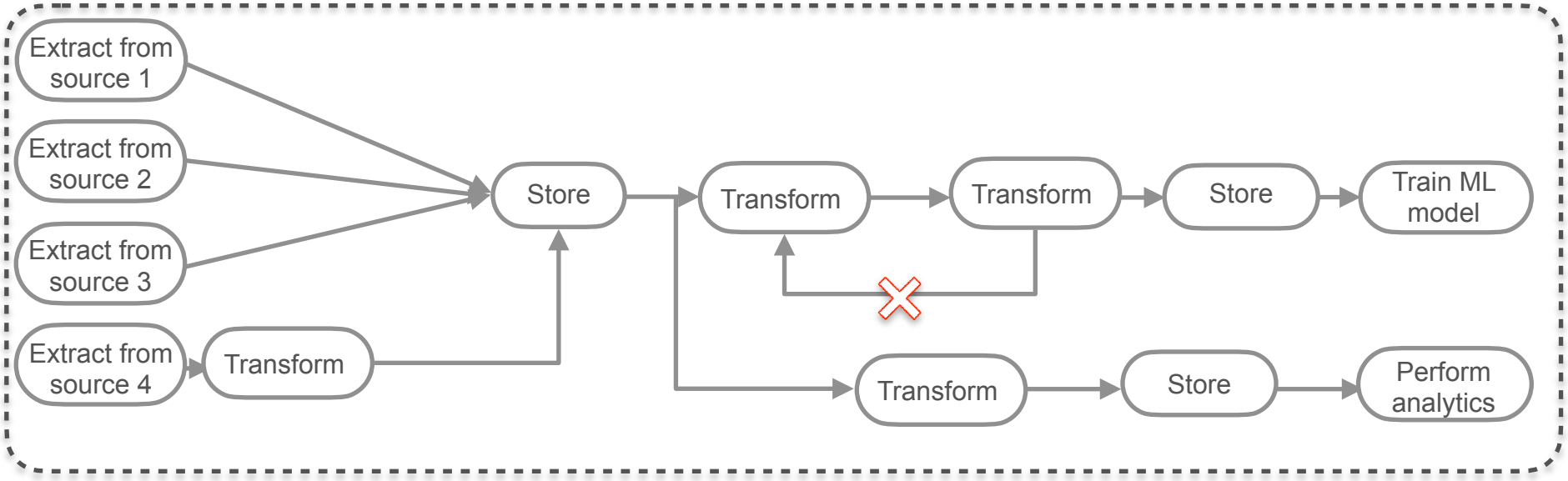


Directed Acyclic Graph (DAG)



Directed Data flows in one direction

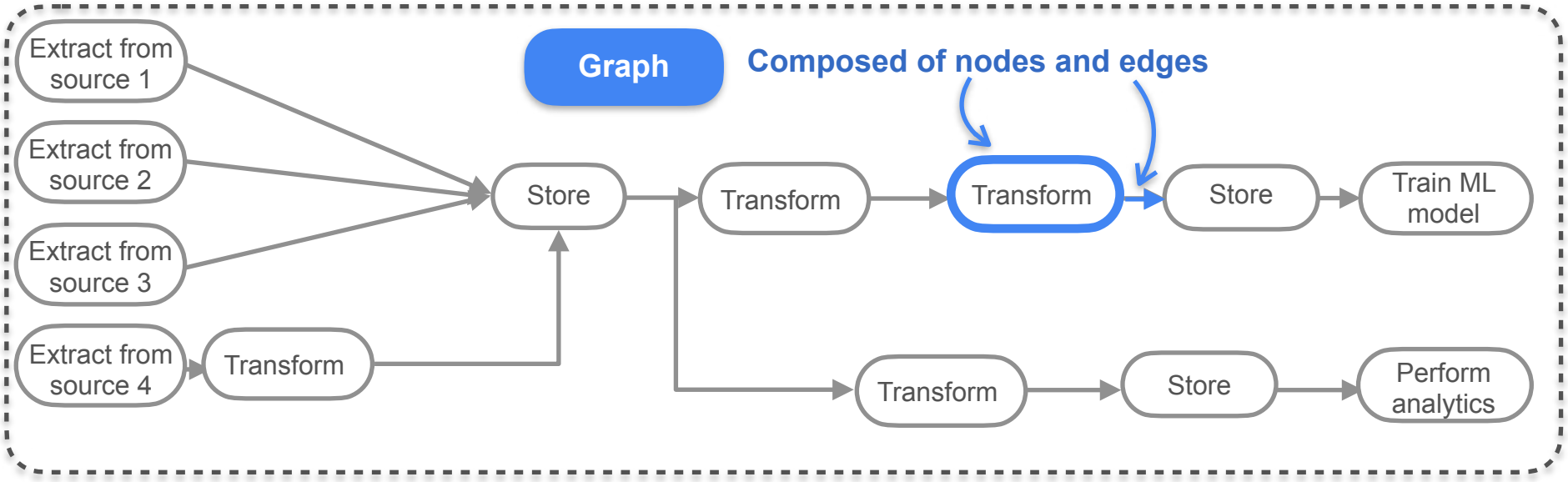
Directed Acyclic Graph (DAG)



Directed Data flows in one direction

Acyclic Data doesn't flow backward

Directed Acyclic Graph (DAG)



Directed Data flows in one direction

Acyclic Data doesn't flow backward

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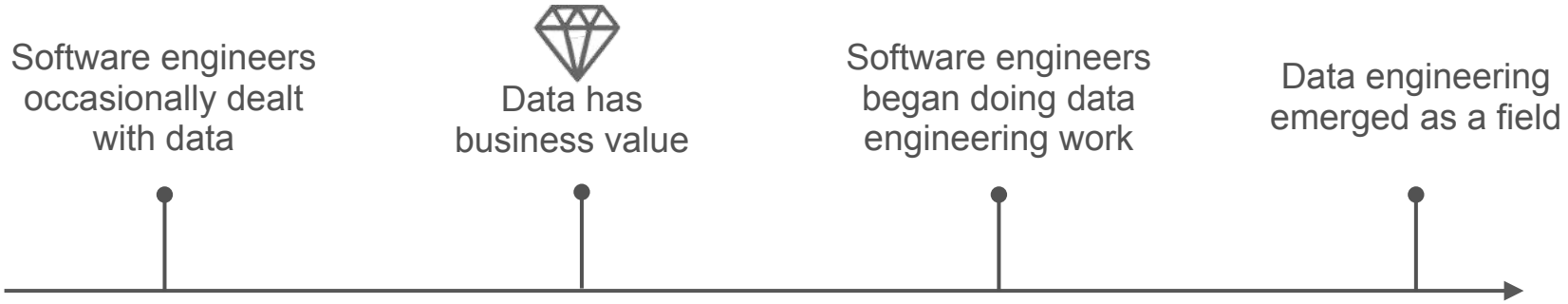
The Undercurrents of the Data Engineering Lifecycle

Software Engineering

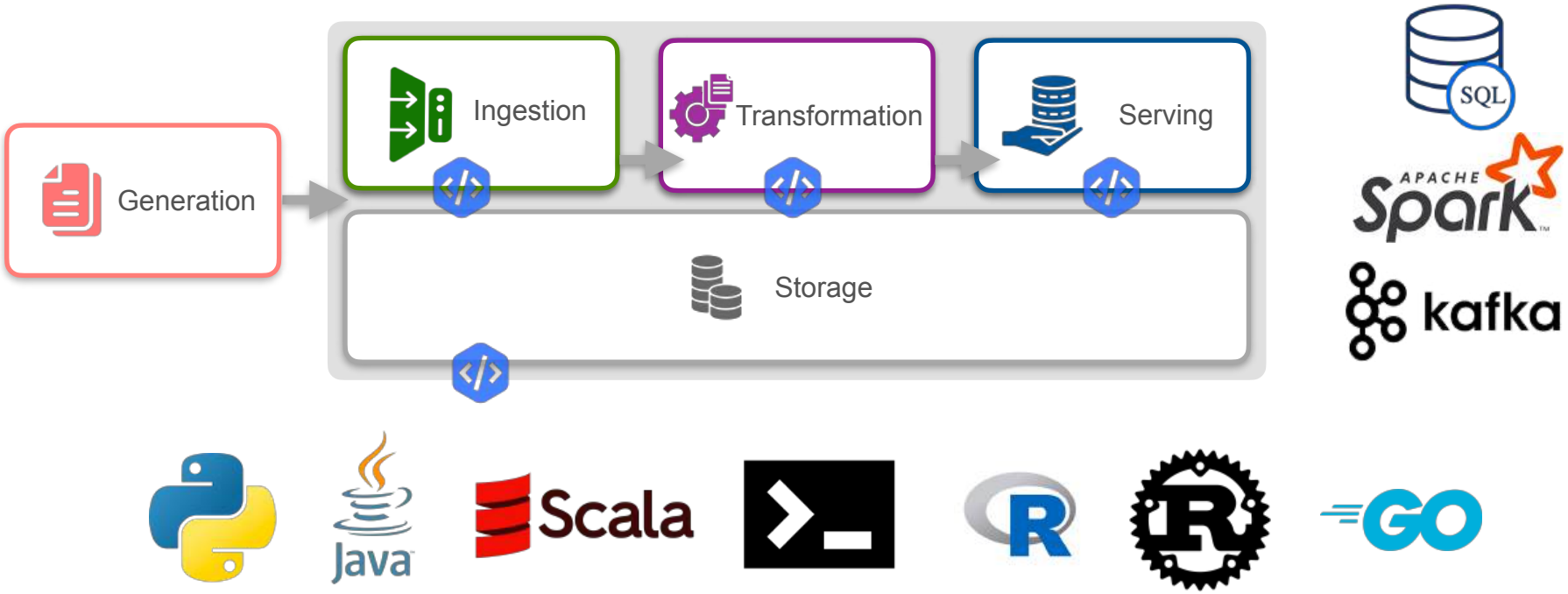
Software Engineering

Software engineering

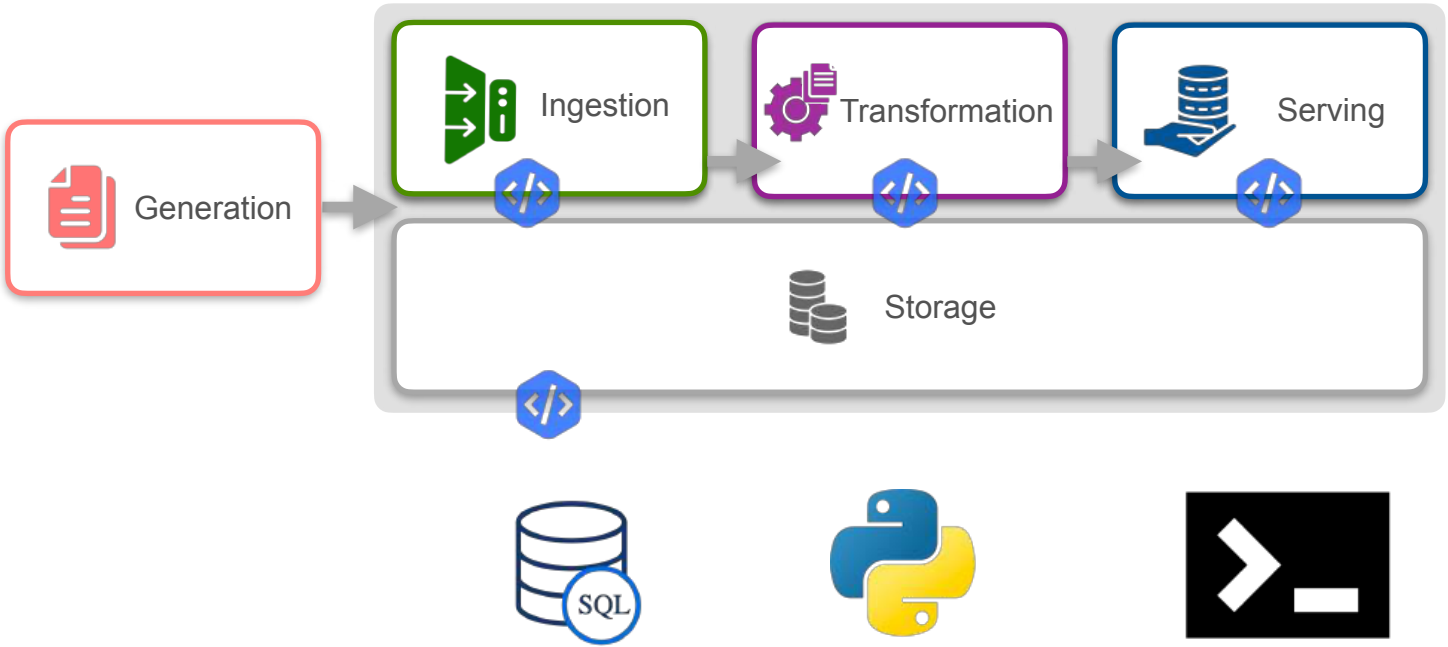
The design, development, deployment, and maintenance of software applications.



Writing Code as a Data Engineer



Writing Code as a Data Engineer



Writing Code as a Data Engineer

Other coding use cases:

- Open source frameworks
- Infrastructure as code
- Pipeline as code
- Everyday general-purpose problem solving

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Practical Examples on AWS

The Data Engineering Lifecycle on AWS

Databases

Amazon Relational Database Service (RDS)

- Provisions database instances with the relational database engine of your choice
- Simplifies the operational overhead involved with provisioning and hosting a relational database

Amazon DynamoDB

- A serverless NoSQL database option
- Create stand-alone tables that are virtually unlimited in their total size
- Has a flexible schema
- Best suited for applications that require low-latency access to large volumes of data

Source Systems

Streaming Sources

Source Systems

Amazon Kinesis Data Streams

- Set up as a source system streaming real-time user activities from a sales platform log

Amazon Simple Queue Service (SQS)

- Handle messages when building your own data pipelines outside of these courses.

Amazon Managed Streaming for Apache Kafka (MSK)

- Makes it easier to run Kafka workloads on AWS because the underlying infrastructure is managed for you

From a Database

AWS Database migration Service (DMS)

- Can migrate and replicate data from a source to a target in an automated way

AWS Glue

- Offers features that support data integration processes

Ingestion

From a Streaming Source

Amazon Kinesis Data Streams

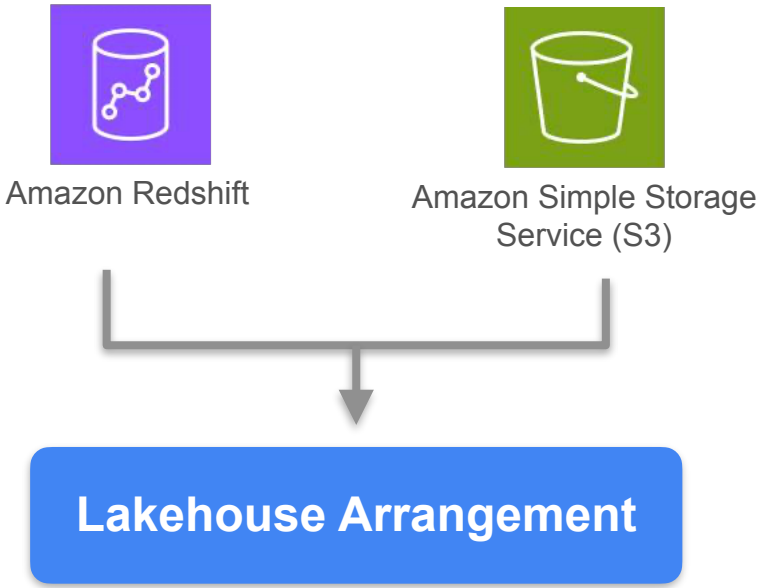
Amazon Data Firehose

Amazon SQS

Amazon MSK

Traditional Data Warehouse

Storage



Access structured data in your data warehouse and unstructured data in an object storage data lake.

Data Processing Tools

Transformation

AWS Glue

Business Intelligence or Analytics

Amazon Athena

Amazon Redshift

- For querying structured and unstructured data

Amazon QuickSight

- Dashboarding tools

AI or Machine Learning

- Serve batch data for model training, and work with some vector database

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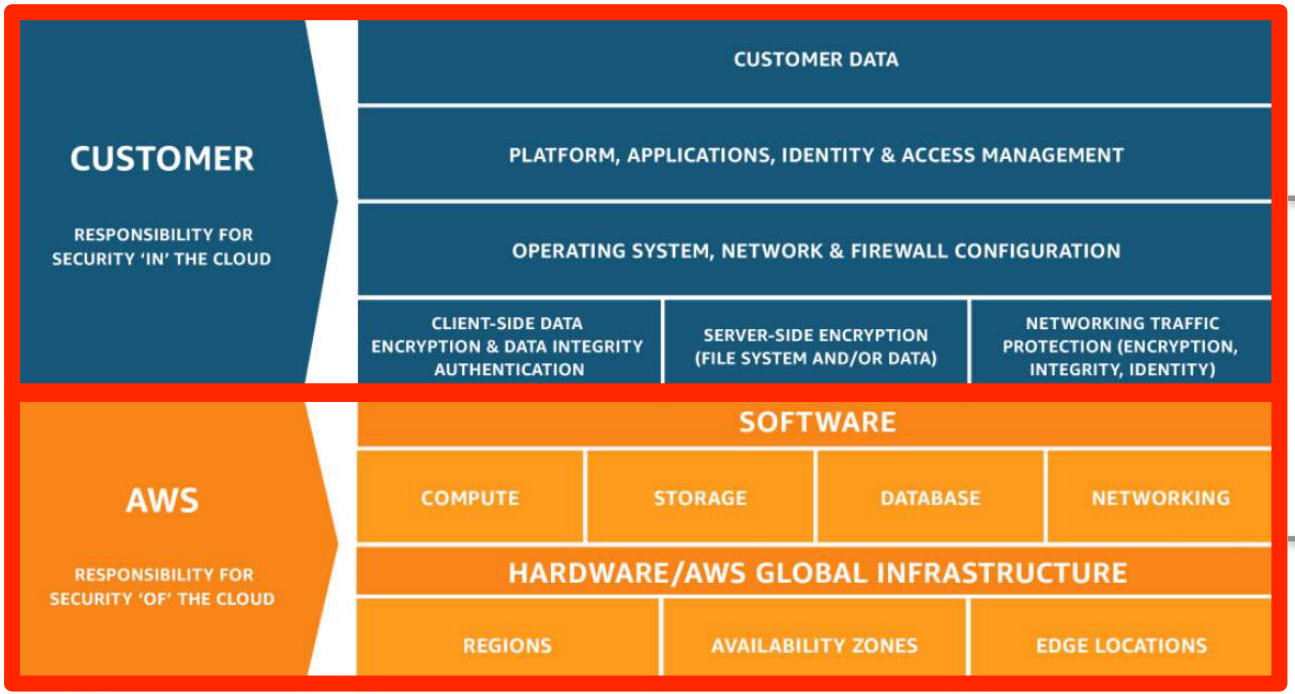
Practical Examples on AWS

The Undercurrents on AWS

Security



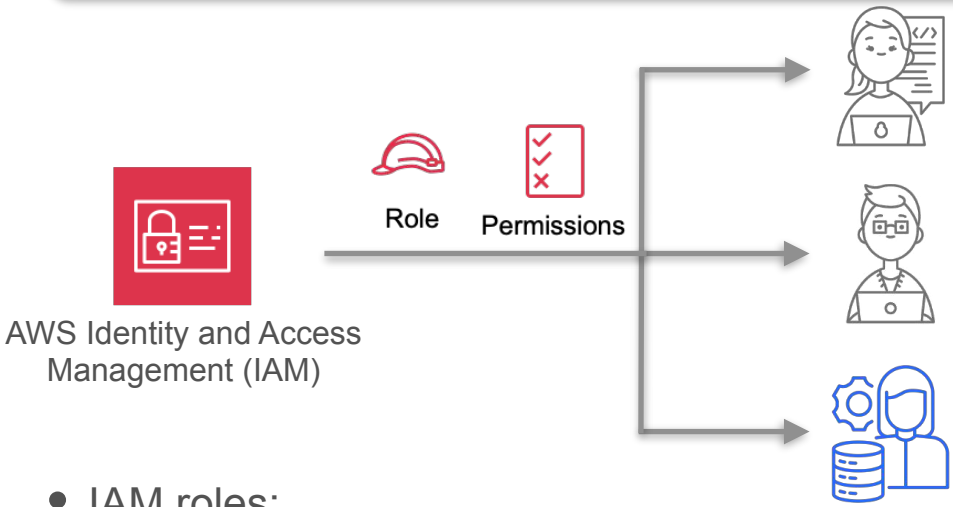
Set access permissions

Amazon Simple Storage Service (Amazon S3)

Shared Responsibility Model

Security

Identity and Access Management (IAM)



Amazon Virtual Private Cloud (VPC)

Security Groups

Instance level firewalls

- IAM roles:
  - Give users/applications access to temporary credentials
  - Provide appropriate AWS API permissions to various tools or data storage areas

Data Management

AWS Glue

AWS Glue Crawler

AWS Glue Data Catalog

- Discover, create, and manage metadata for data stored in Amazon S3 or other storage and database systems

AWS Lake Formation

- Centrally manage and scale fine-grained data access permissions

DataOps

Amazon CloudWatch

- Collects metrics and provides monitoring features for cloud resources, applications, and on-premises resources

Amazon CloudWatch Logs

- Store and analyze operational logs

Amazon Simple Notification Service (SNS)

- Sets up notifications between applications or via text/email that are triggered by events within your system

MC MONTE CARLO

Bigeye

Orchestration

Apache Airflow

dagster

PREFECT

MAGE

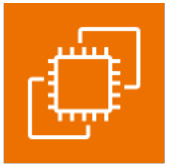
Architecture

Software Engineering

AWS Cloud9

IDE for development

hosted on



Amazon Elastic
Compute Cloud (EC2)

AWS CodeDeploy

Automate Code Deployment

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Lab Walkthrough

Introduction to the Lab

Lab Walkthrough Videos

Video 1

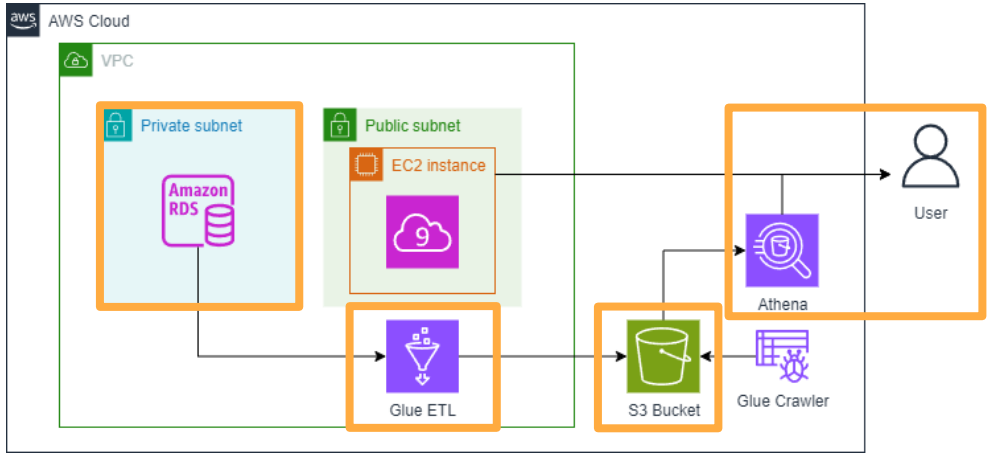
Introduction to the lab

Video 2

Setting up the lab

Video 3

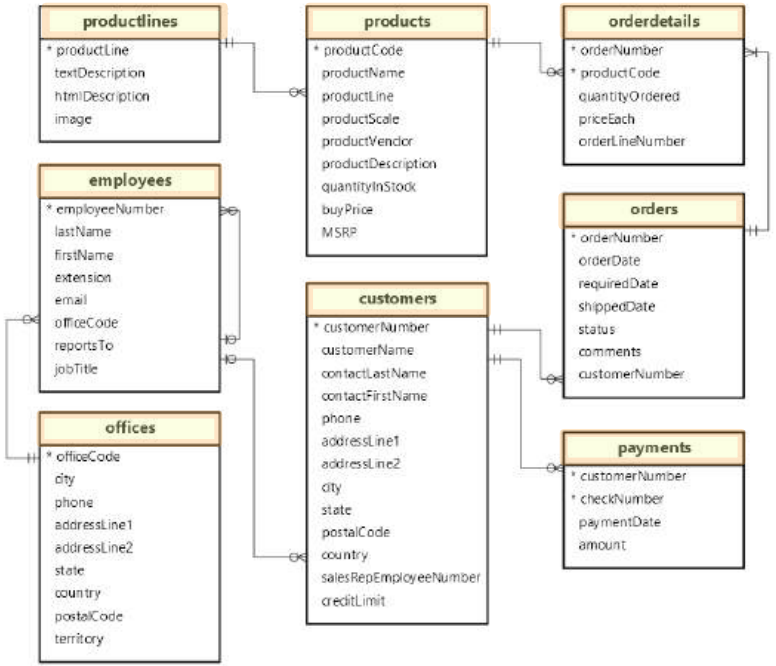
Preview of the lab content



You will learn more about all the tools in the upcoming courses.

Pipeline Scenario

Historical purchases & Customers' Info



Data Engineer

You work at a retailer for scale models of classic cars and other vehicles.

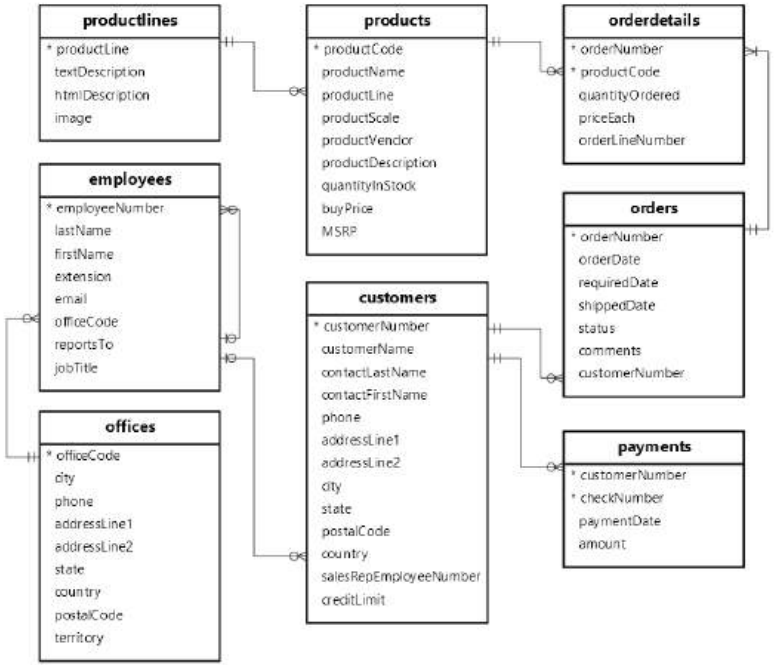
Transform and serve the data

Data Analyst

- Which product lines are more successful?
- How are the sales distributed across different countries?

Pipeline Scenario

Historical purchases & Customers' Info



Data Engineer

Data Analyst

- Extract the data the analyst needs

Data Modeling (course 4)

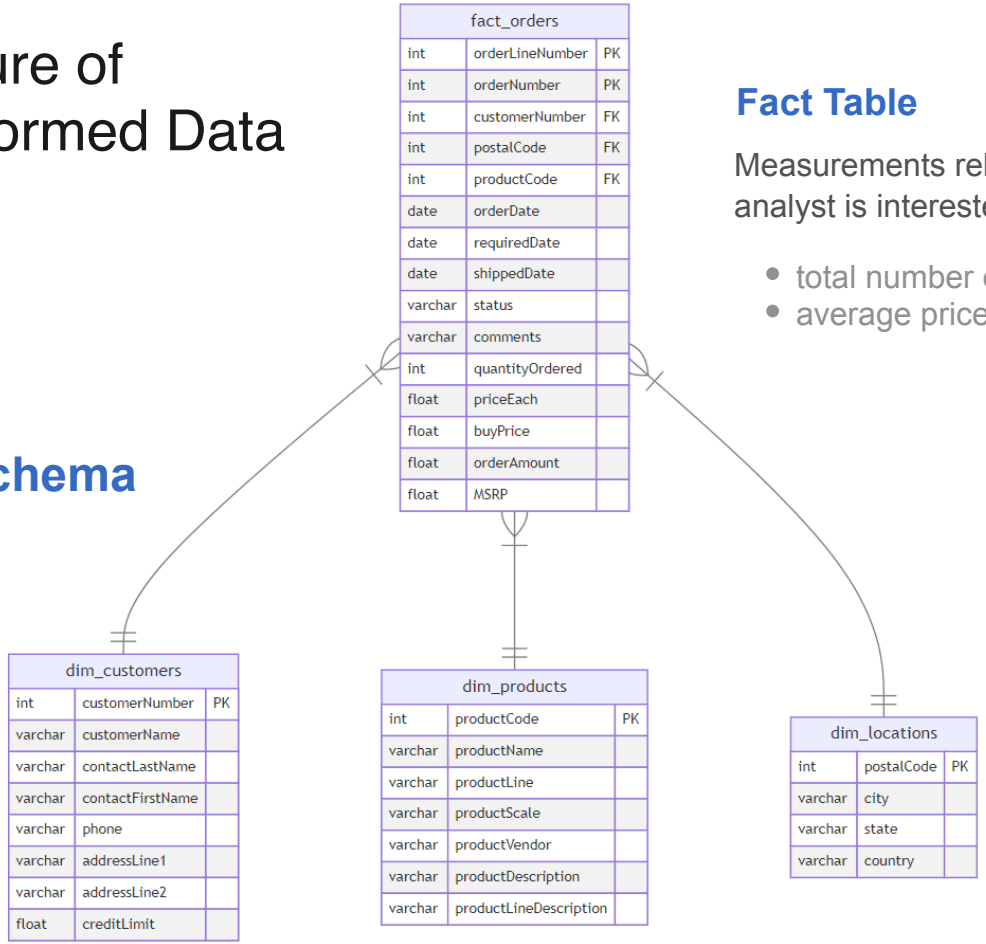
- Transform the data into a structure that is easier to understand and faster to query

Transformation script +
Structure of the data are given to you

- Store the data in a separate storage system

Structure of Transformed Data

Star schema



Fact Table

Measurements related to a sales order that the data analyst is interested in aggregating

- total number of sales
- average price

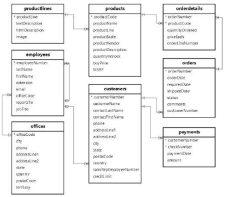
Dimension Tables

More context (customer locations, order details)

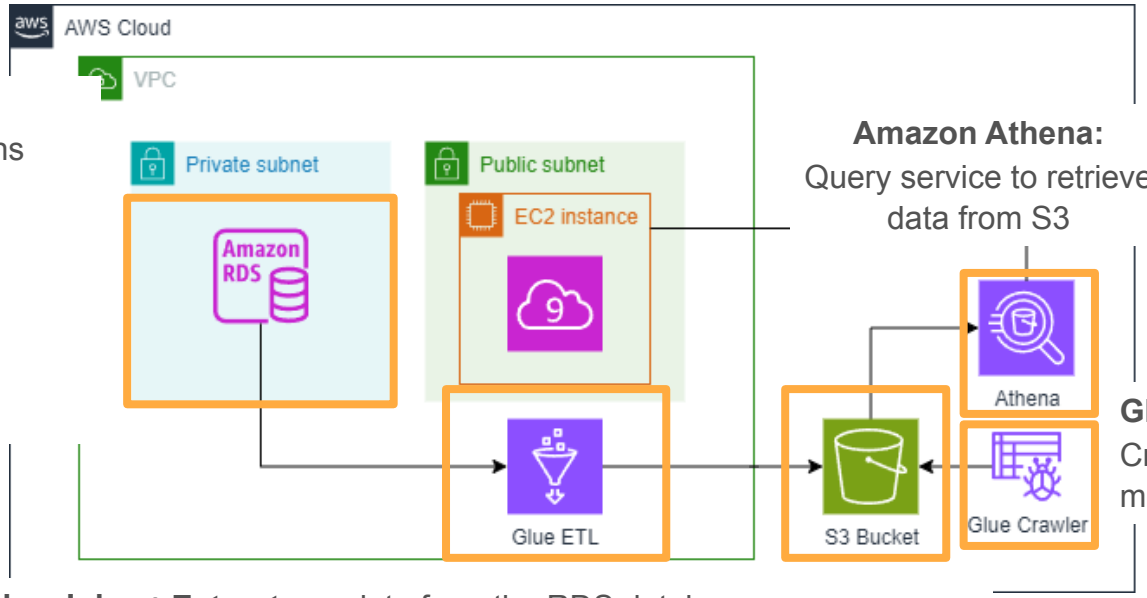
- total number of sales by country
- maximum quantities ordered for each product line

Architectural Diagram

RDS MySQL database:
source system that contains



Provided to you



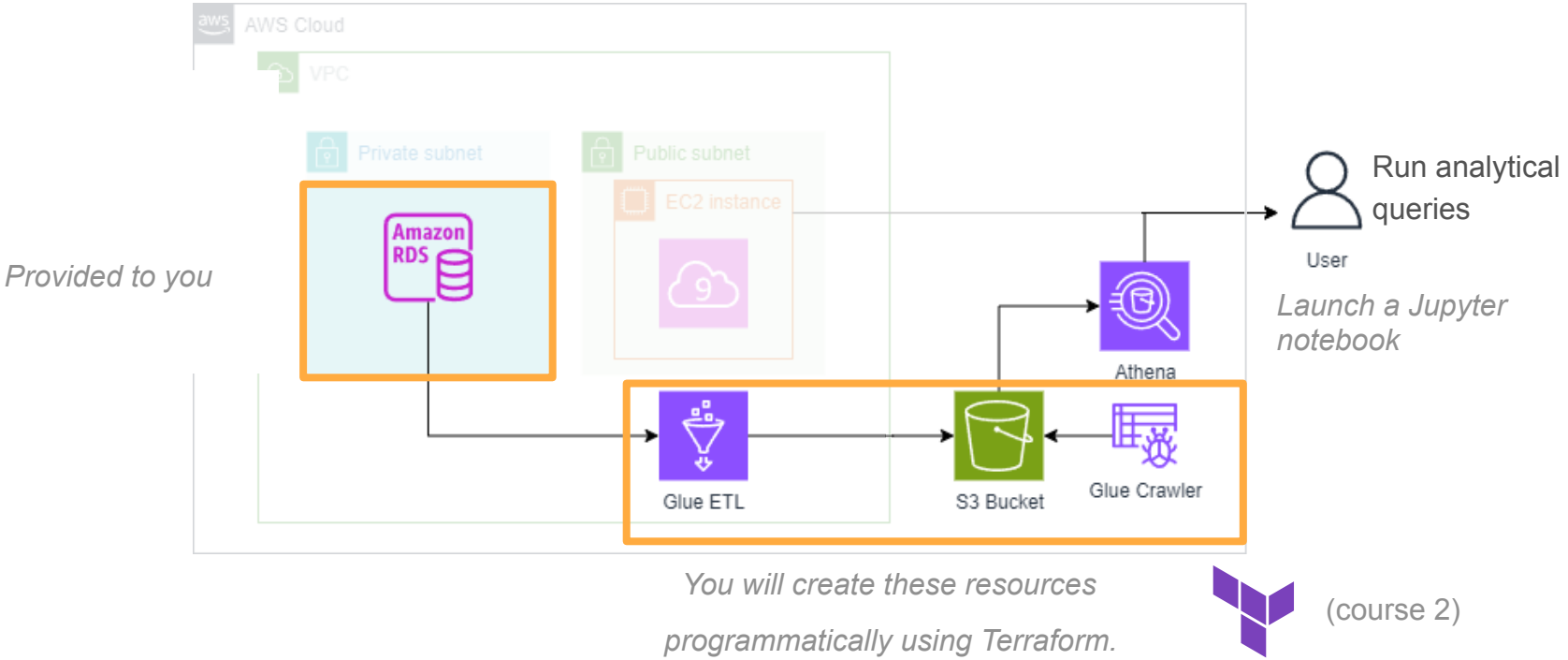
Amazon Athena:
Query service to retrieve data from S3

Glue crawler:
Crawl over S3 and write metadata to a data catalog

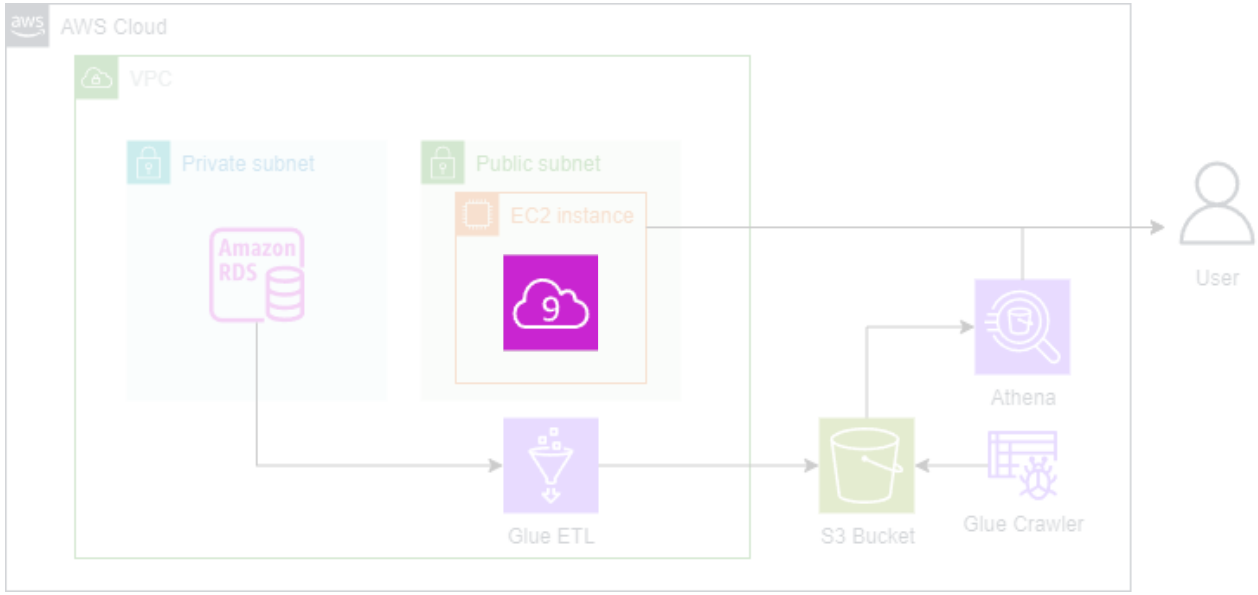
Glue Job ETL

- **Extract** raw data from the RDS database
- **Transform** the data by modeling it using the star schema
- **Load** the data into S3 bucket

Architectural Diagram



Architectural Diagram



AWS Cloud9

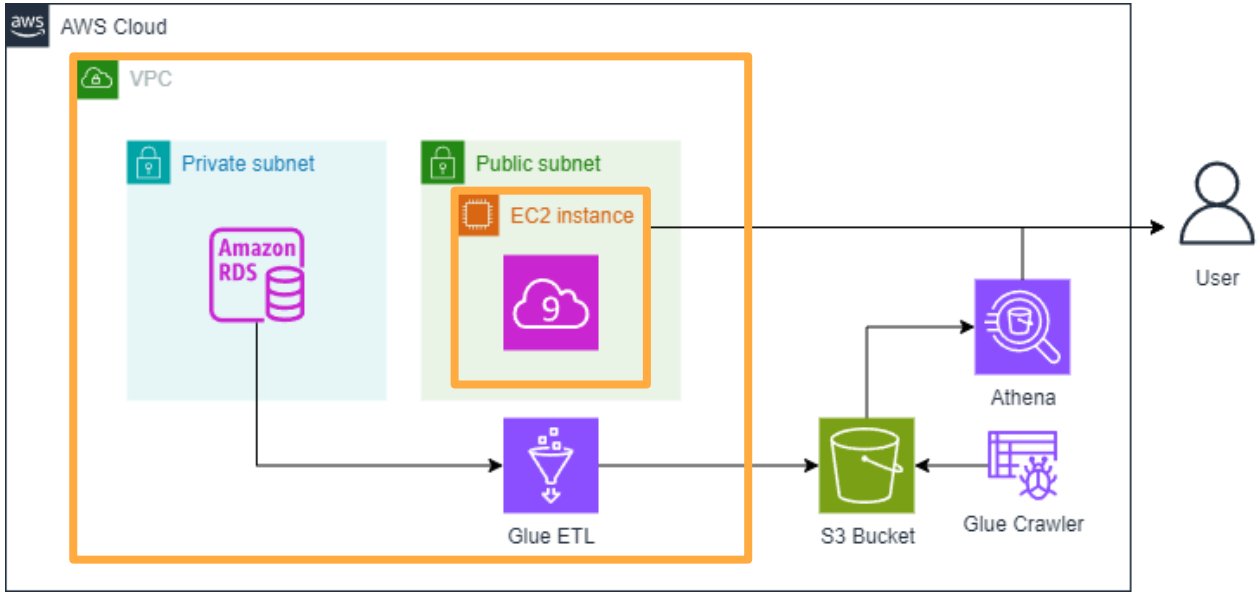
Integrated Development Environment (IDE)

Architectural Diagram

Video 2

Setting up the lab

- AWS Cloud9
- Jupyter Notebook



AWS Cloud9

Integrated Development Environment (IDE)

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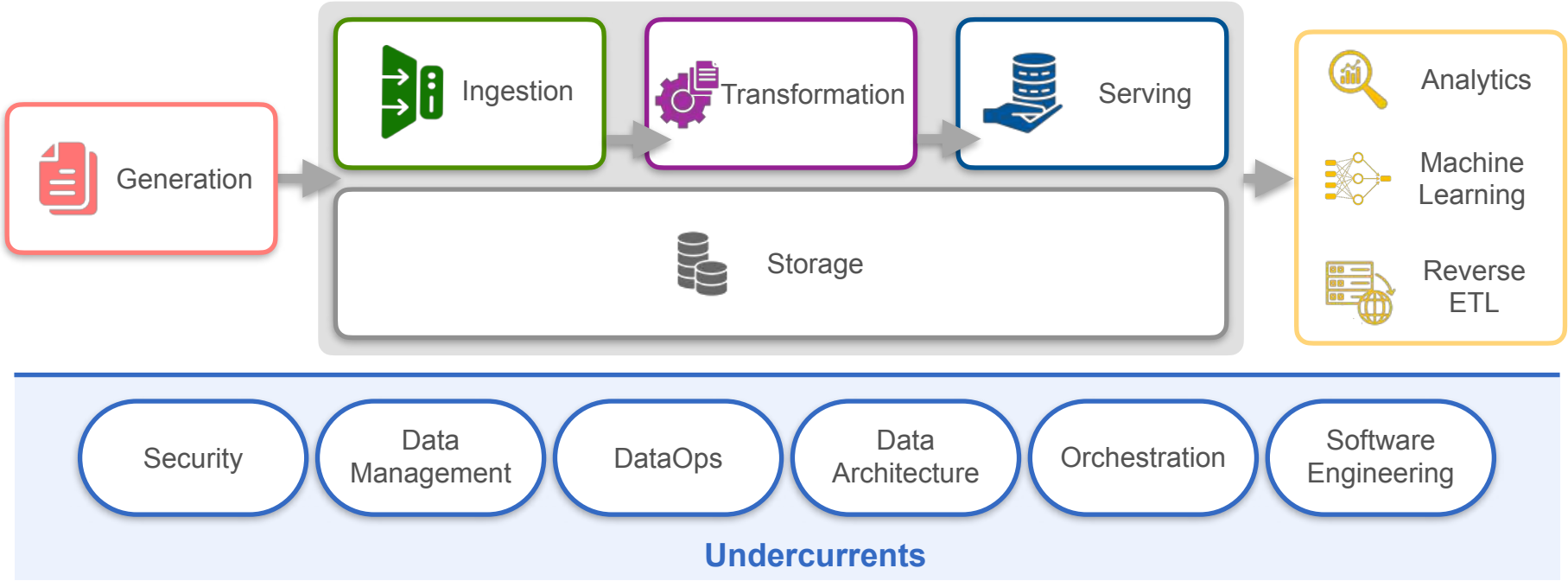
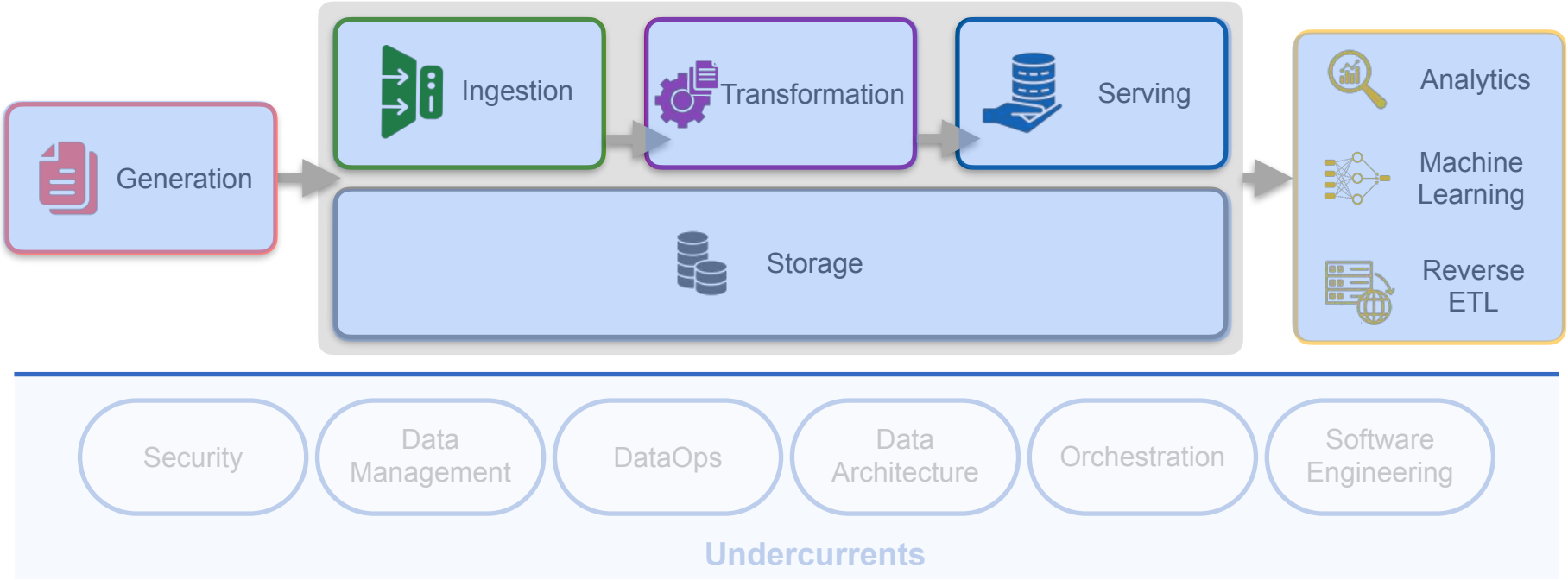
The Data Engineering Lifecycle & Undercurrents

Week 2 Summary

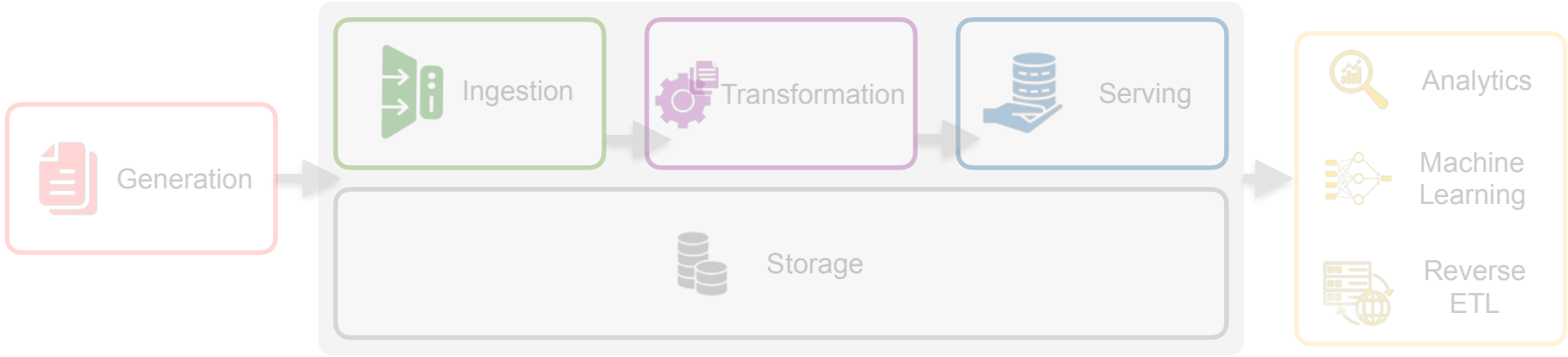
The Data Engineering Lifecycle



The Data Engineering Lifecycle



The Data Engineering Lifecycle



Security | Data Management | DataOps | Data Architecture | Orchestration | Software Engineering

Undercurrents

The Data Engineering Lifecycle