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Data Engineering

Welcome!

Data Engineering Professional Certificate Program

Course 1	Introduction to Data Engineering
Course 2	Source Systems, Data Ingestion, and Pipelines
Course 3	Data Storage and Queries
Course 4	Data Modeling, Transformation, and Serving

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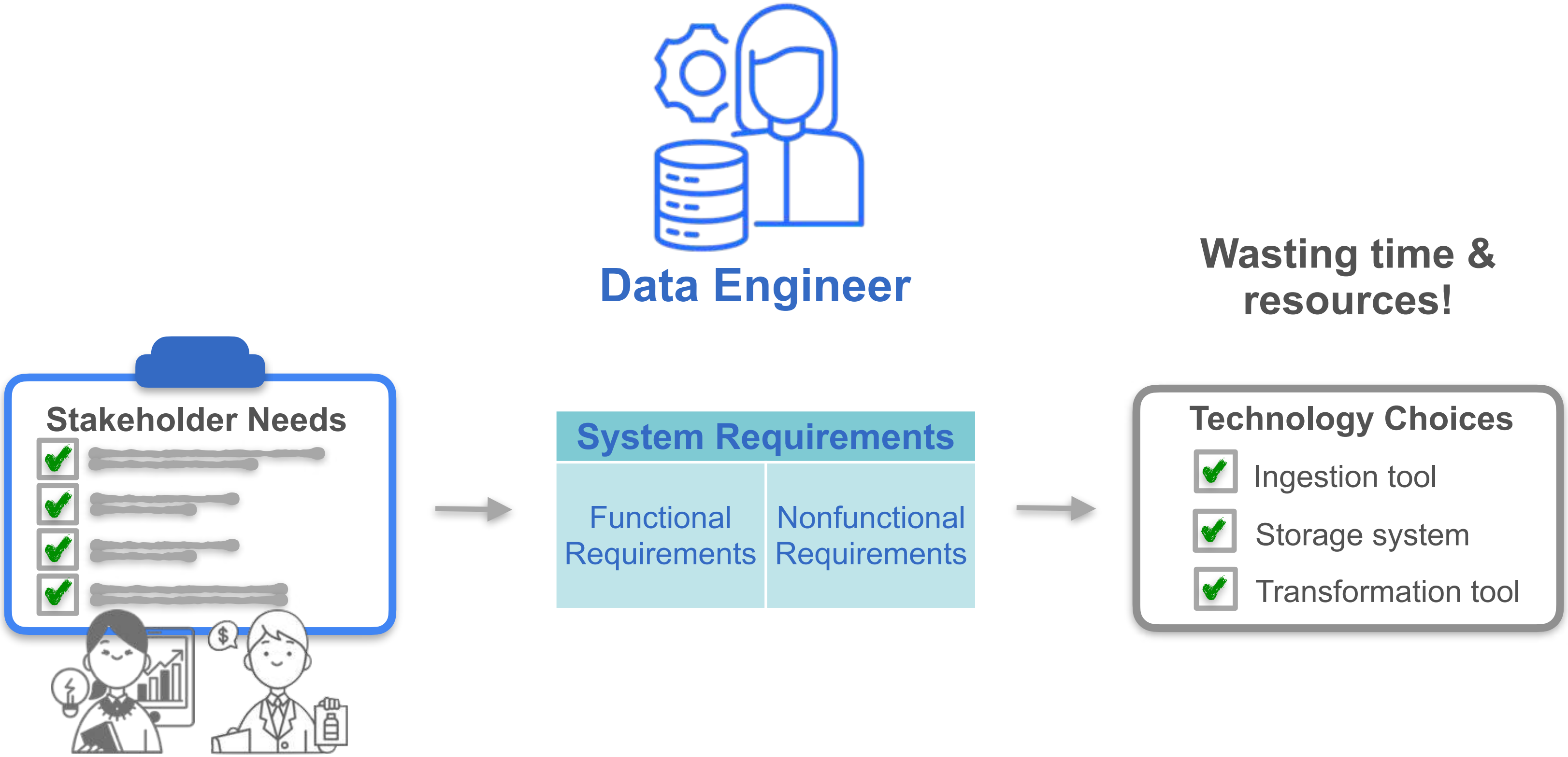
Introduction to Data Engineering

Course 1 Overview

Scenario



Data Engineer

Stakeholder Needs

System Requirements

Functional Requirements

Nonfunctional Requirements

Wasting time & resources!

Technology Choices

☑ Ingestion tool

☑ Storage system

☑ Transformation tool

Plan for Course 1

Week 1	**High level look at the field of data engineering** ● Data Engineering lifecycle ● History of Data Engineering ● The Data Engineer among other stakeholders ● Business value ● Translation of stakeholder needs into requirements
Week 2	**Data engineering lifecycle and undercurrents**
Week 3	**Principles of good data architecture**
Week 4	**Design and build out a data architecture**

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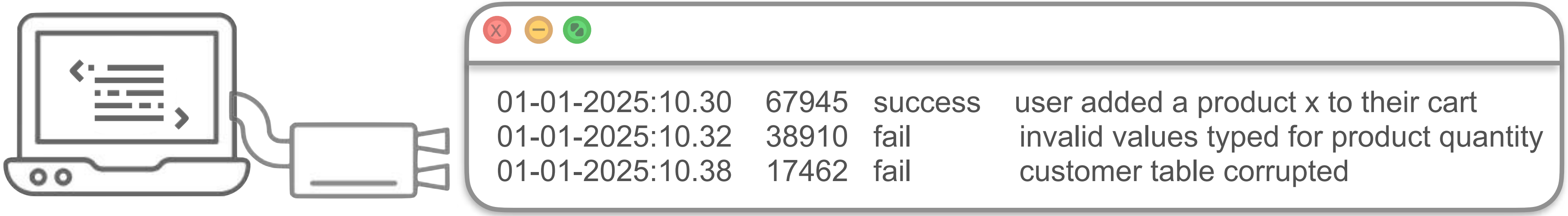
Introduction to Data Engineering

Data Engineering Defined

Data Engineering

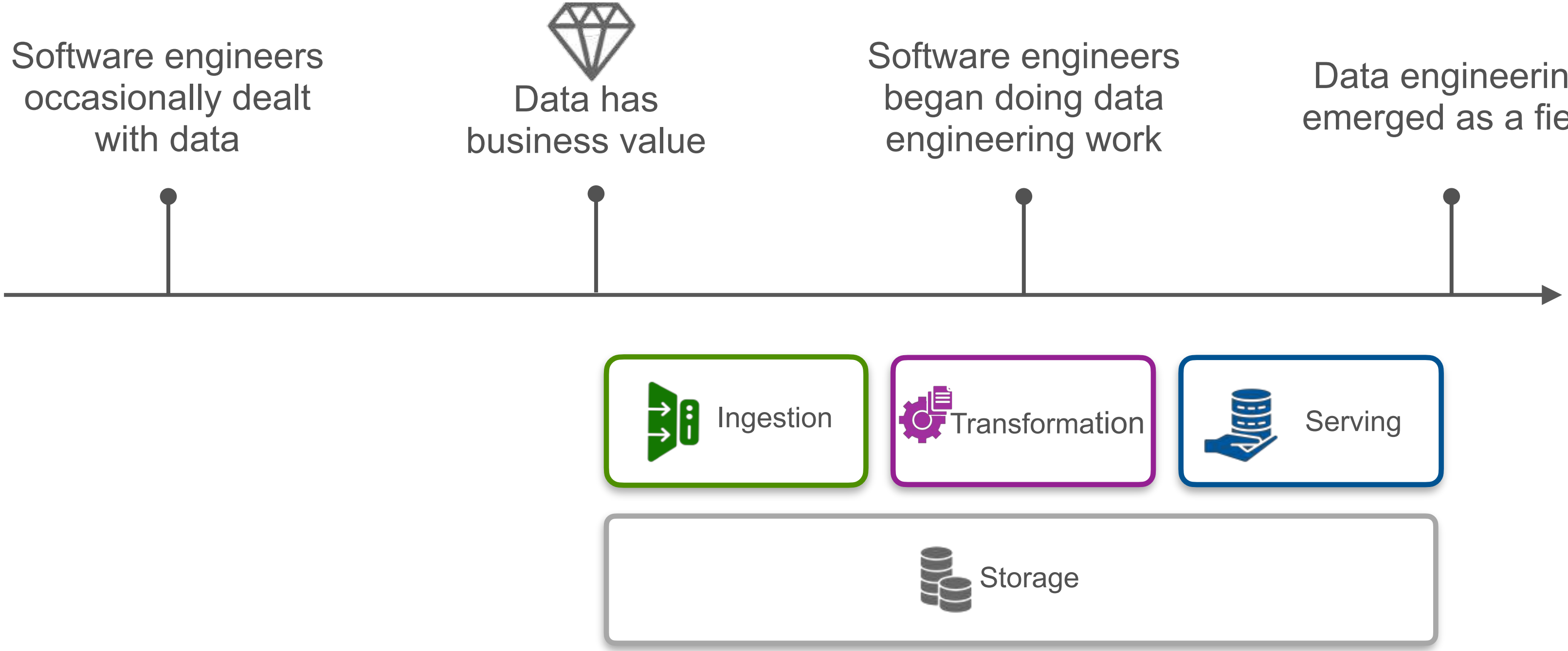


```
01-01-2025:10.30   67945   success    user added a product x to their cart
01-01-2025:10.32   38910   fail        invalid values typed for product quantity
01-01-2025:10.38   17462   fail        customer table corrupted
```

Software
Application

Exhaust / Byproduct

Software Engineering



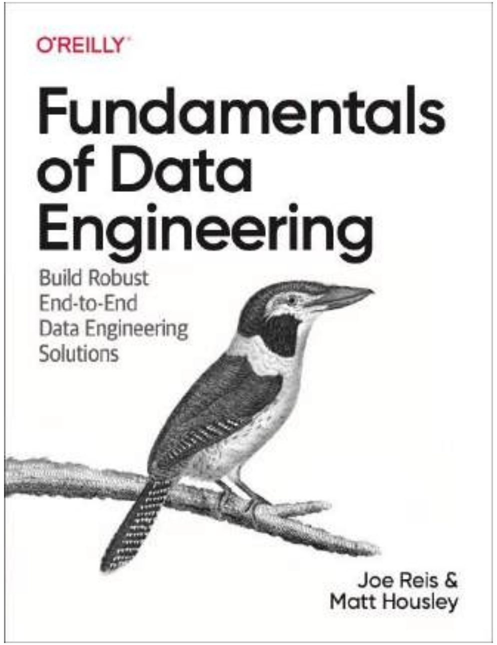
Software engineers occasionally dealt with data

Data has business value

Software engineers began doing data engineering work

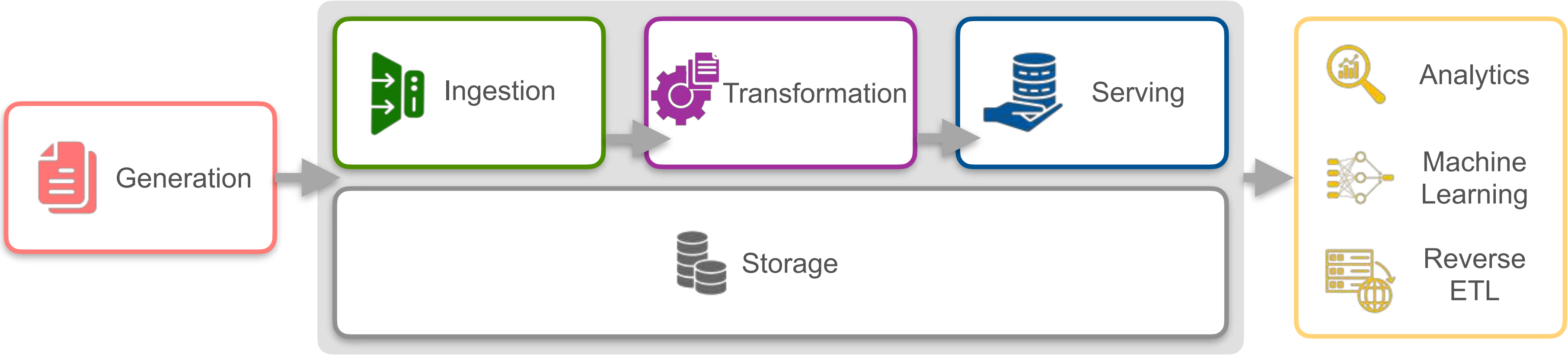
Data engineering emerged as a field

Data Engineering


O'REILLY
Fundamentals of Data Engineering
Build Robust End-to-End Data Engineering Solutions
Joe Reis & Matt Housley

"Data engineering is the development, implementation, and maintenance of systems and processes that take in raw data and produce high-quality, consistent information that supports downstream use cases, such as analysis and machine learning. Data engineering is the intersection of security, data management, DataOps, data architecture, orchestration, and software engineering."

Data Engineering Lifecycle


Generation

Ingestion

Transformation

Serving

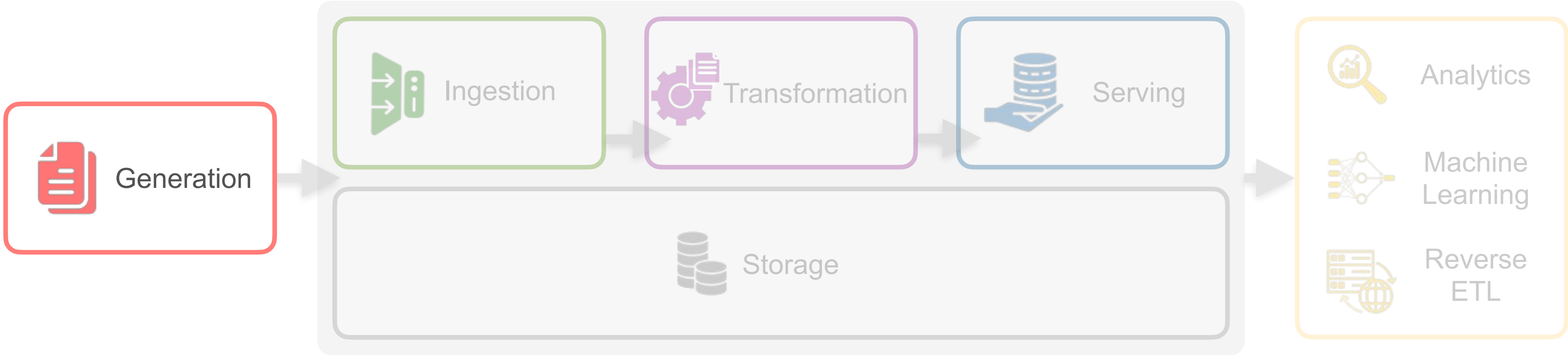
Storage

Analytics

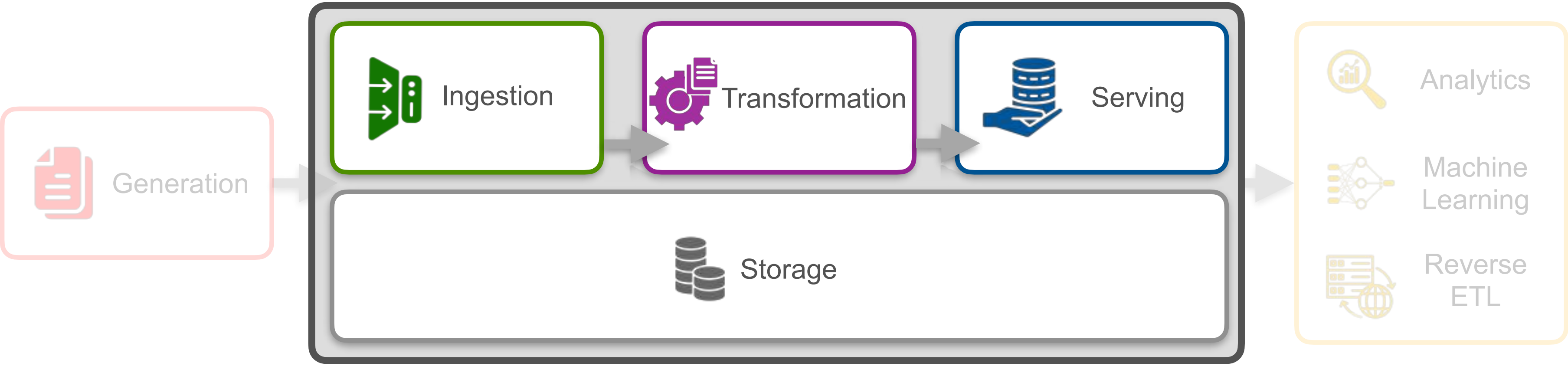
Machine Learning

Reverse ETL

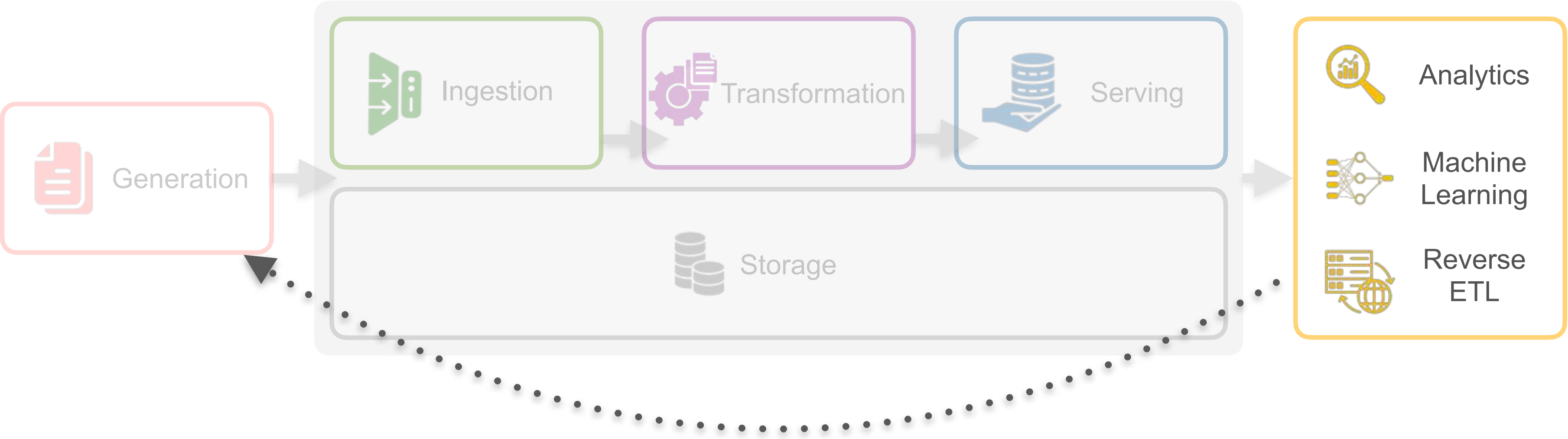
Data Engineering Lifecycle



Data Engineering Lifecycle

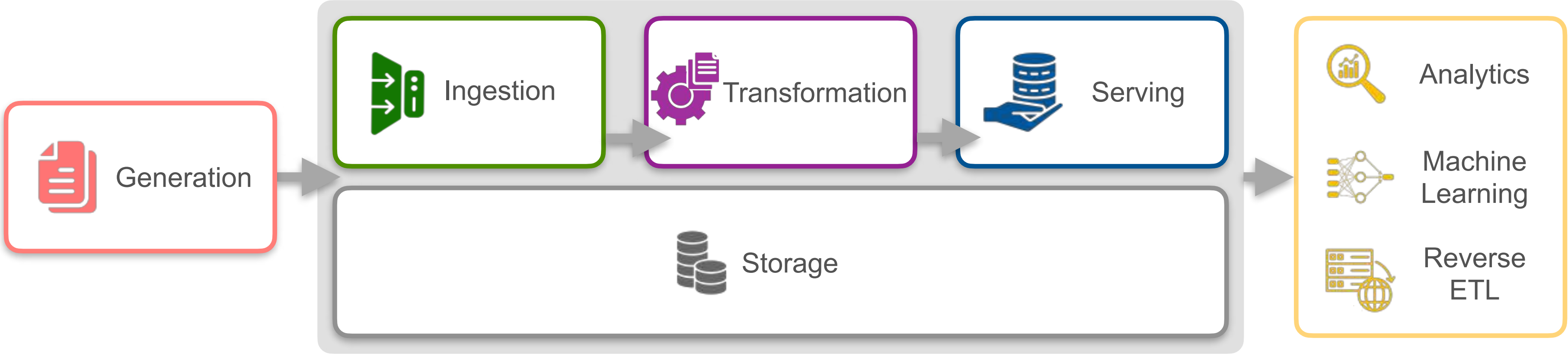


Data Engineering Lifecycle



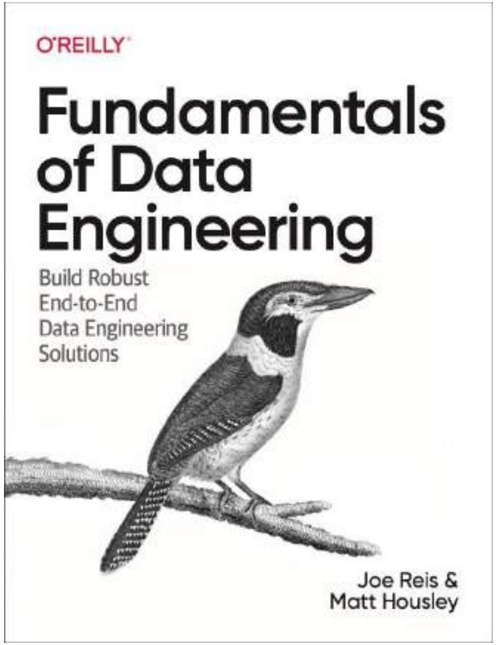
send processed data back to source systems

Data Pipeline



Data Pipeline The combination of architecture, systems, and processes that move data through the stages of the data engineering lifecycle.

Data Engineering



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Fundamentals of Data Engineering

Build Robust End-to-End Data Engineering Solutions

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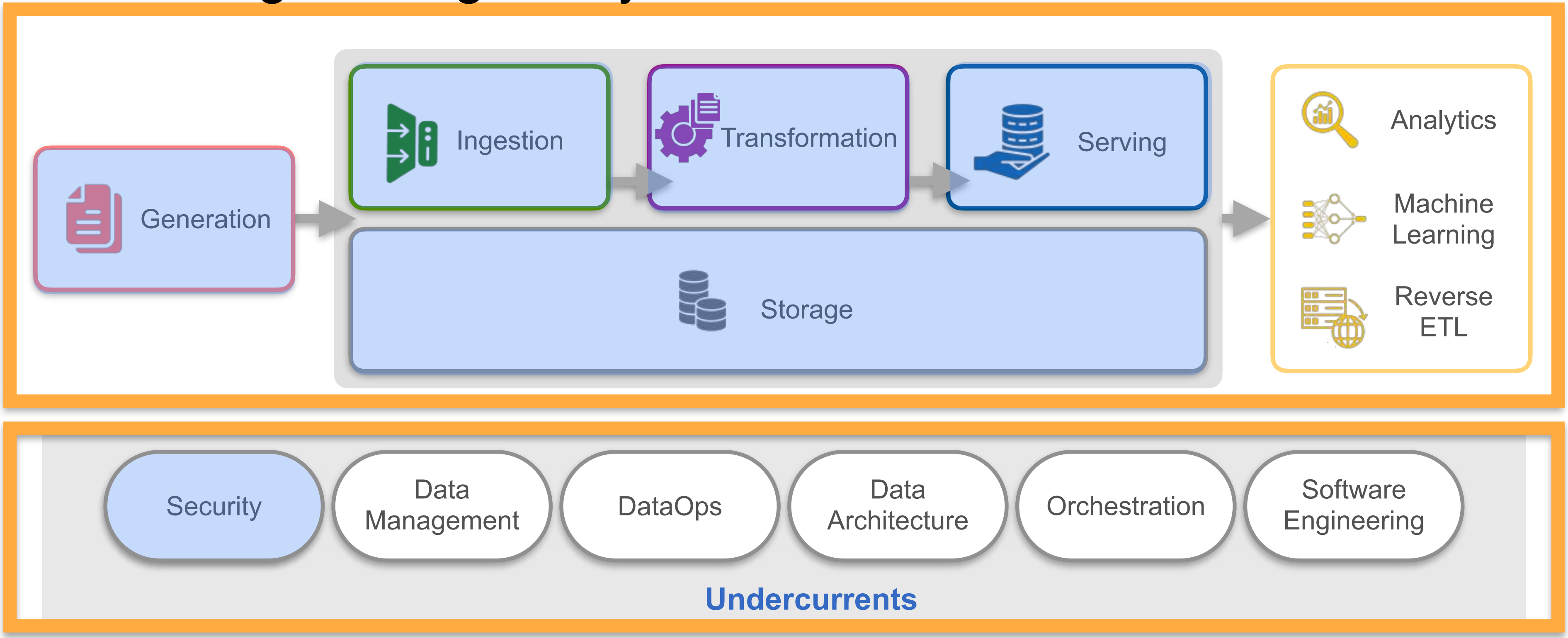
“Data engineering is the development, implementation, and maintenance of systems and processes that take in raw data and produce high-quality, consistent information that supports downstream use cases, such as analysis and machine learning. Data engineering is the intersection of Security, Data Management, DataOps, Data Architecture, Orchestration, and Software Engineering.”

Data Engineering Lifecycle & Undercurrents



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Introduction to Data Engineering

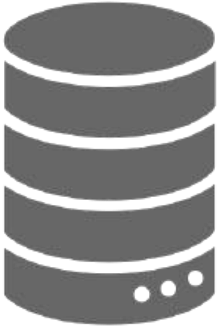
A Brief History of Data Engineering

History of Data Engineering

1960s

Computers

Computerized Database

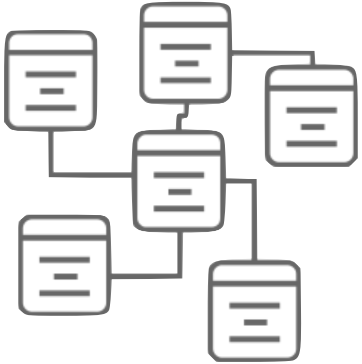


History of Data Engineering

1960s

1970s

Relational Databases



Structured Query Language

History of Data Engineering

1960s

1970s

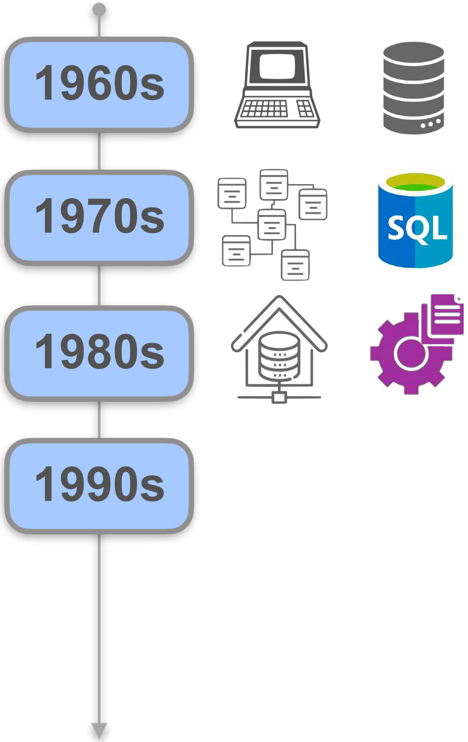
1980s

Bill Inmon

Data Warehouse

Transforming Data

History of Data Engineering



1960s

1970s

1980s

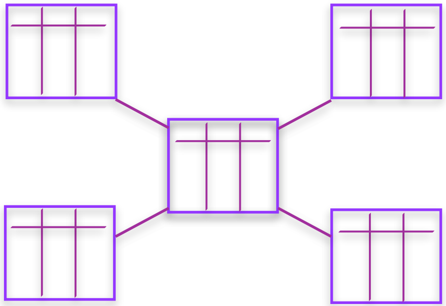
1990s

Business Intelligence

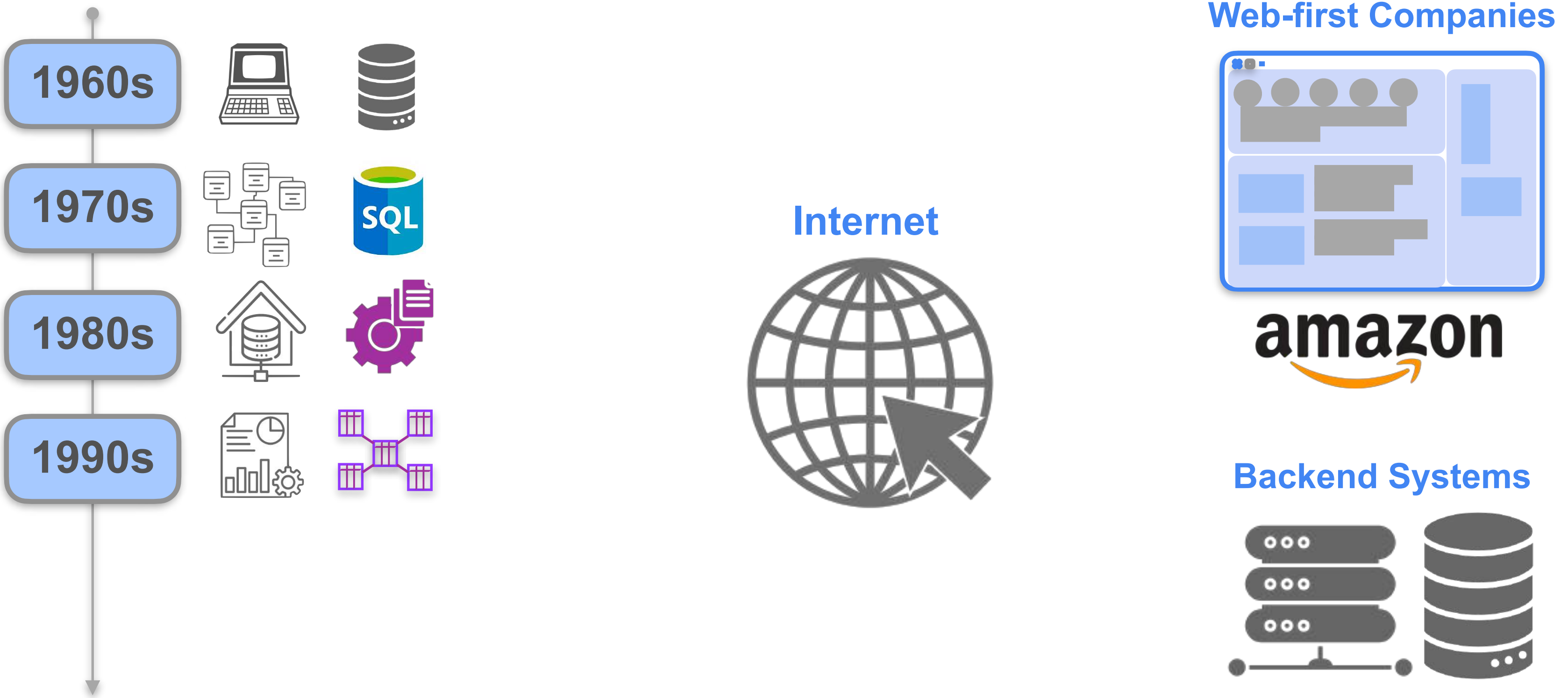
Bill Inmon

Ralph Kimball

Data Modeling



History of Data Engineering



1960s

1970s

1980s

1990s

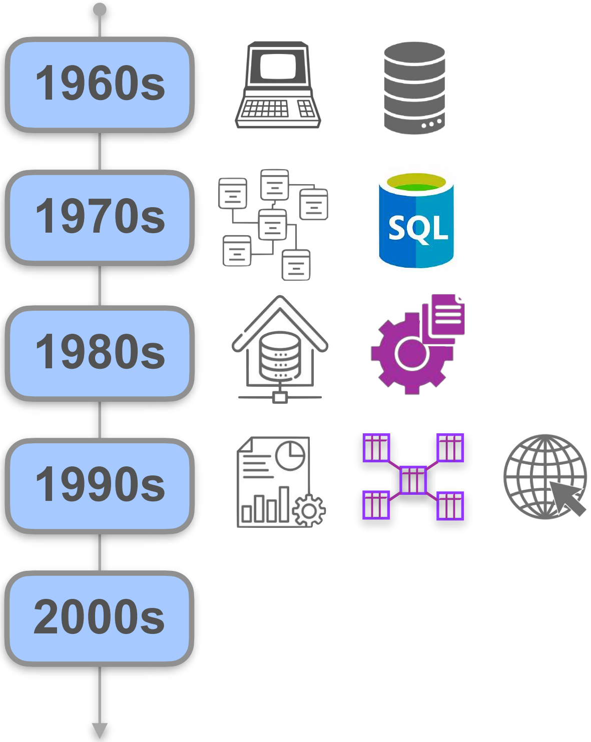
Internet

Web-first Companies

amazon

Backend Systems

History of Data Engineering



1960s

1970s

1980s

1990s

2000s

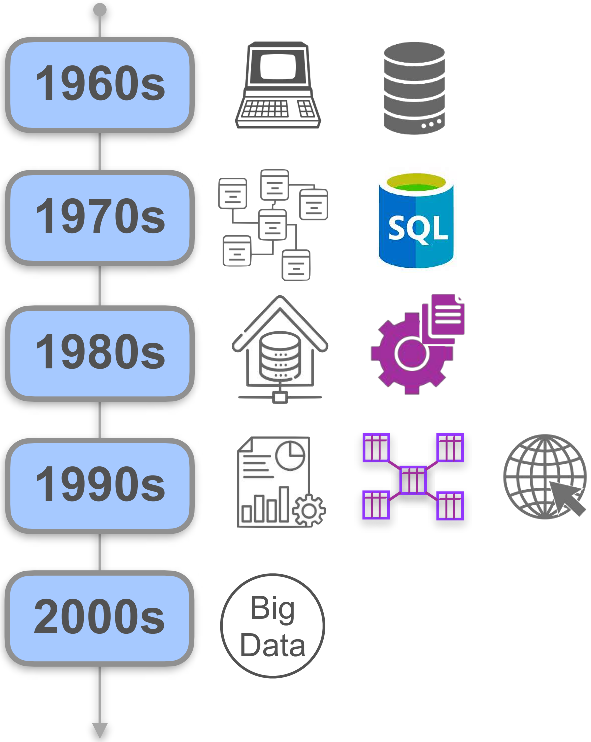
yahoo!

Google

amazon

Big Data

History of Data Engineering



1960s

1970s

1980s

1990s

2000s

Big Data

The “Big Data” Era

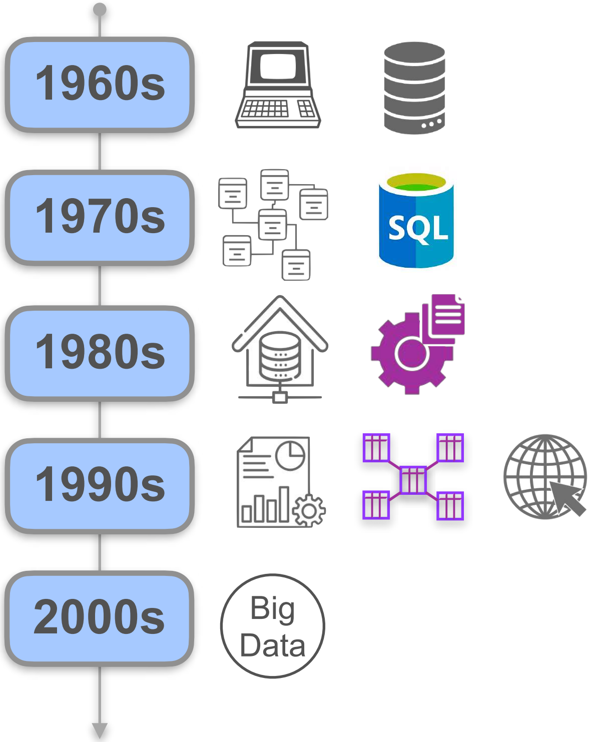
“extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations, especially relating to human behavior and interactions.”

Velocity

Variety

Volume

History of Data Engineering



1960s

1970s

1980s

1990s

2000s

2004

Google

MapReduce: Simplified Data Processing on Large Clusters

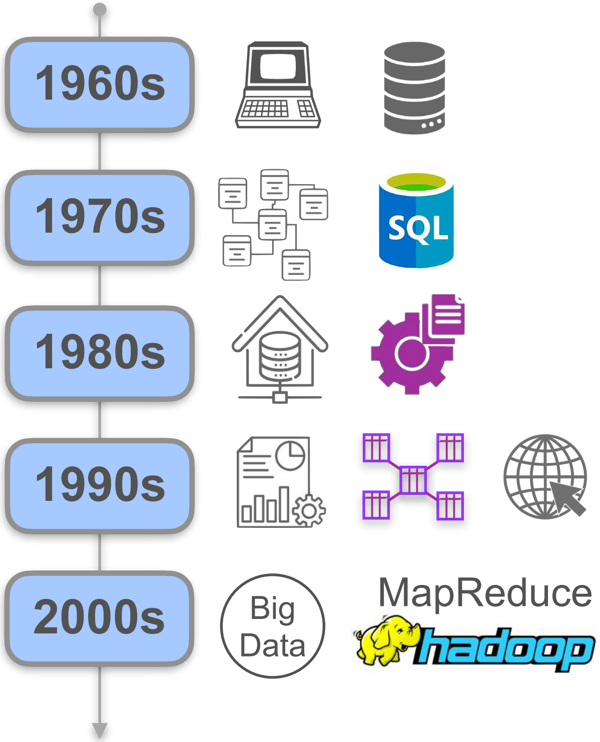
2006

yahoo!

hadoop

The “Big Data Engineer” Era

History of Data Engineering



Pay-as-you-go resource marketplace

Amazon EC2

Amazon S3

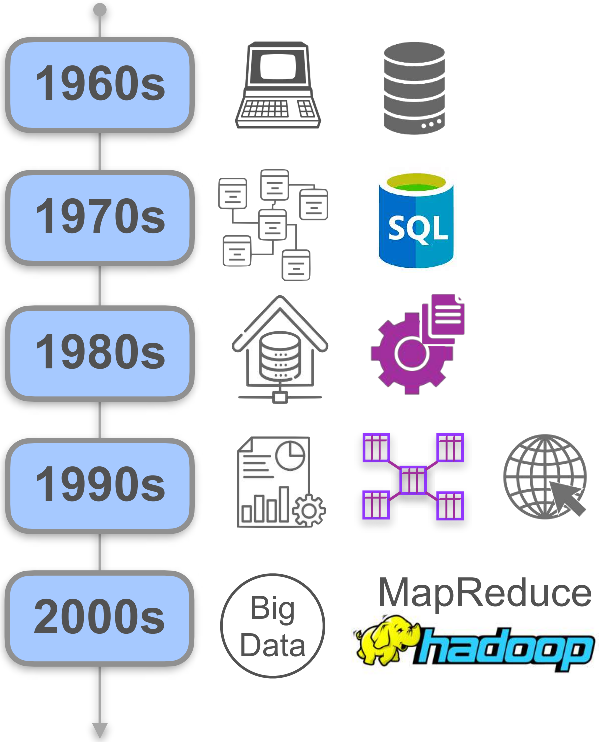
Amazon DynamoDB

aws

Amazon Web Services

The first popular public cloud

History of Data Engineering



1960s

1970s

SQL

1980s

1990s

2000s

Big Data

MapReduce

hadoop

Public Cloud

aws

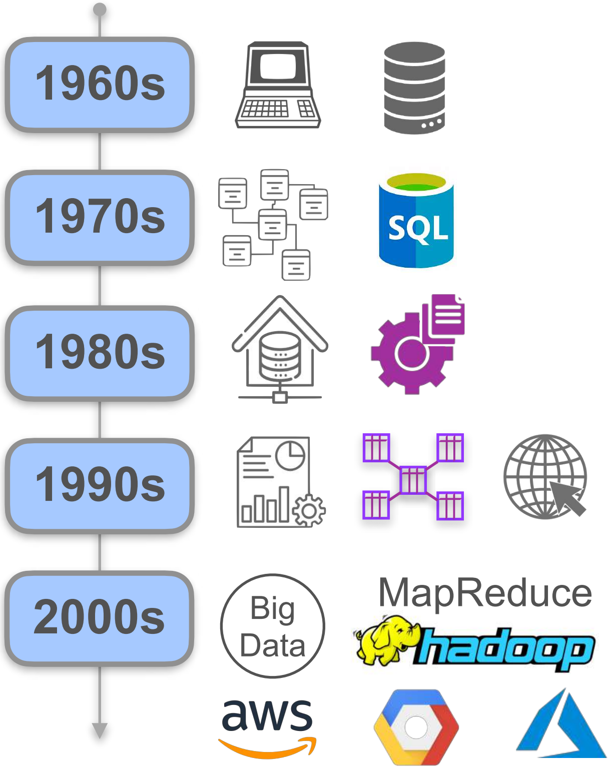
Google Cloud Platform

Azure

Public Cloud & Early big data tools :

Foundation for today's data ecosystem

History of Data Engineering



1960s

1970s

SQL

1980s

1990s

2000s

Big Data

MapReduce

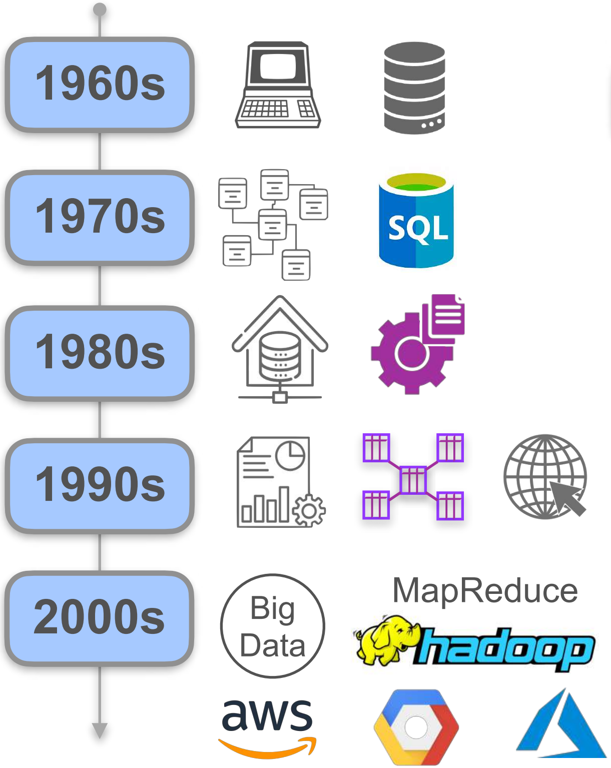
hadoop

aws

Late 2000s and 2010s (big data tools)

- Access to bleeding-edge data tools
- Transition from batch computing to event streaming

History of Data Engineering



1960s

1970s

1980s

1990s

2000s

2010s - present

Abstract Simplified Tools

Data Sources

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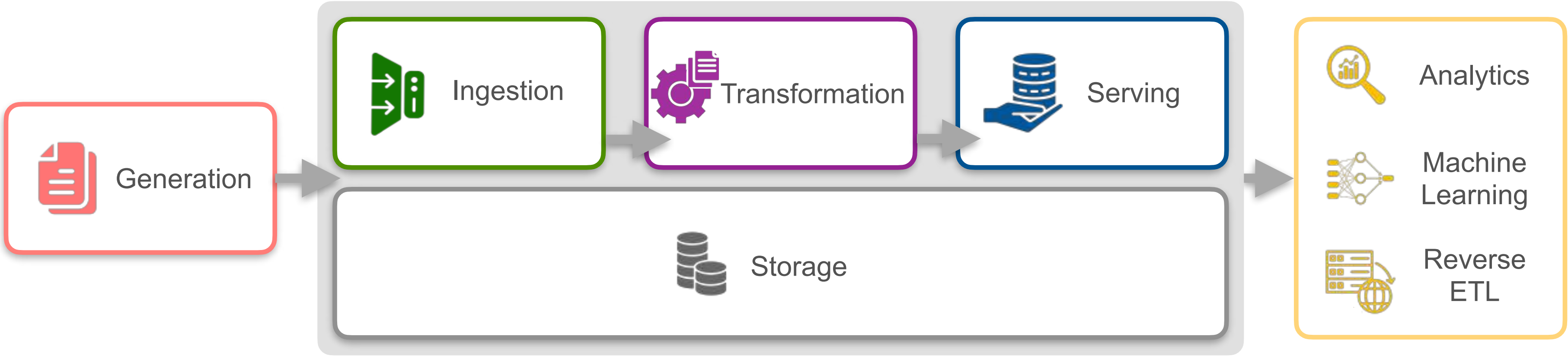
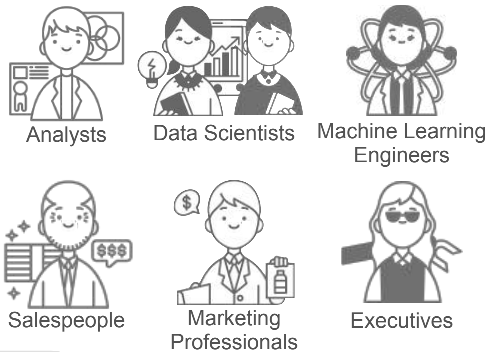
Introduction to Data Engineering

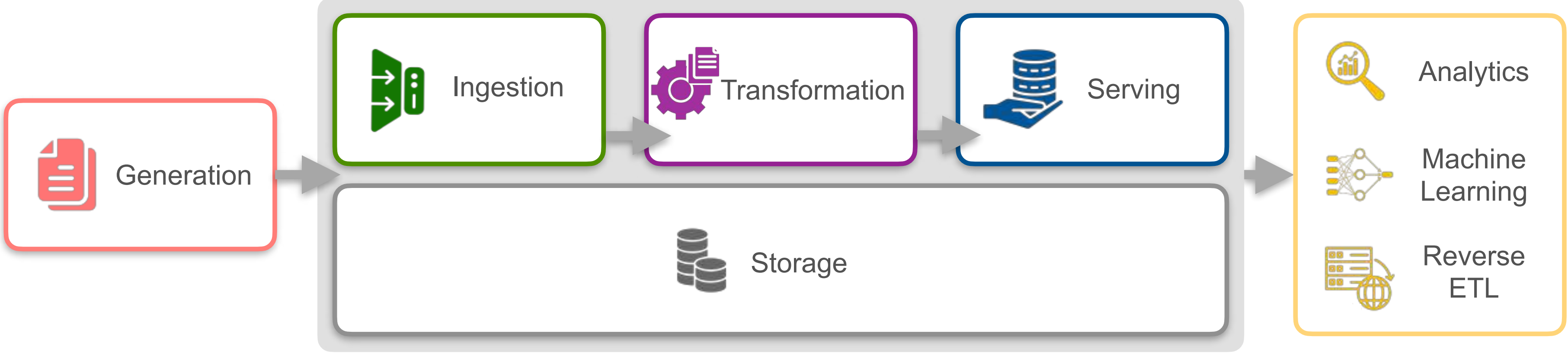
The Data Engineer Among Other Stakeholders

Downstream Use Cases

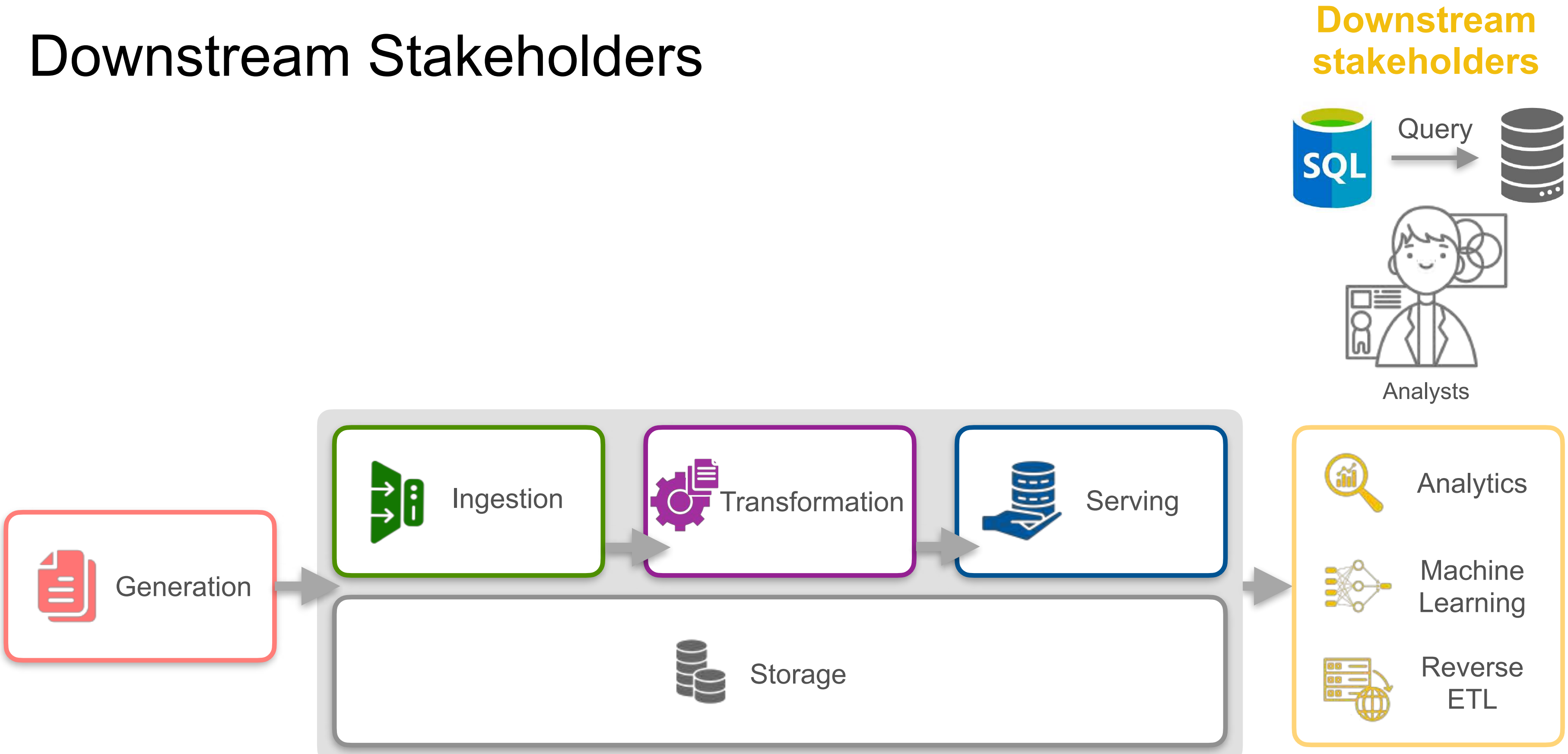


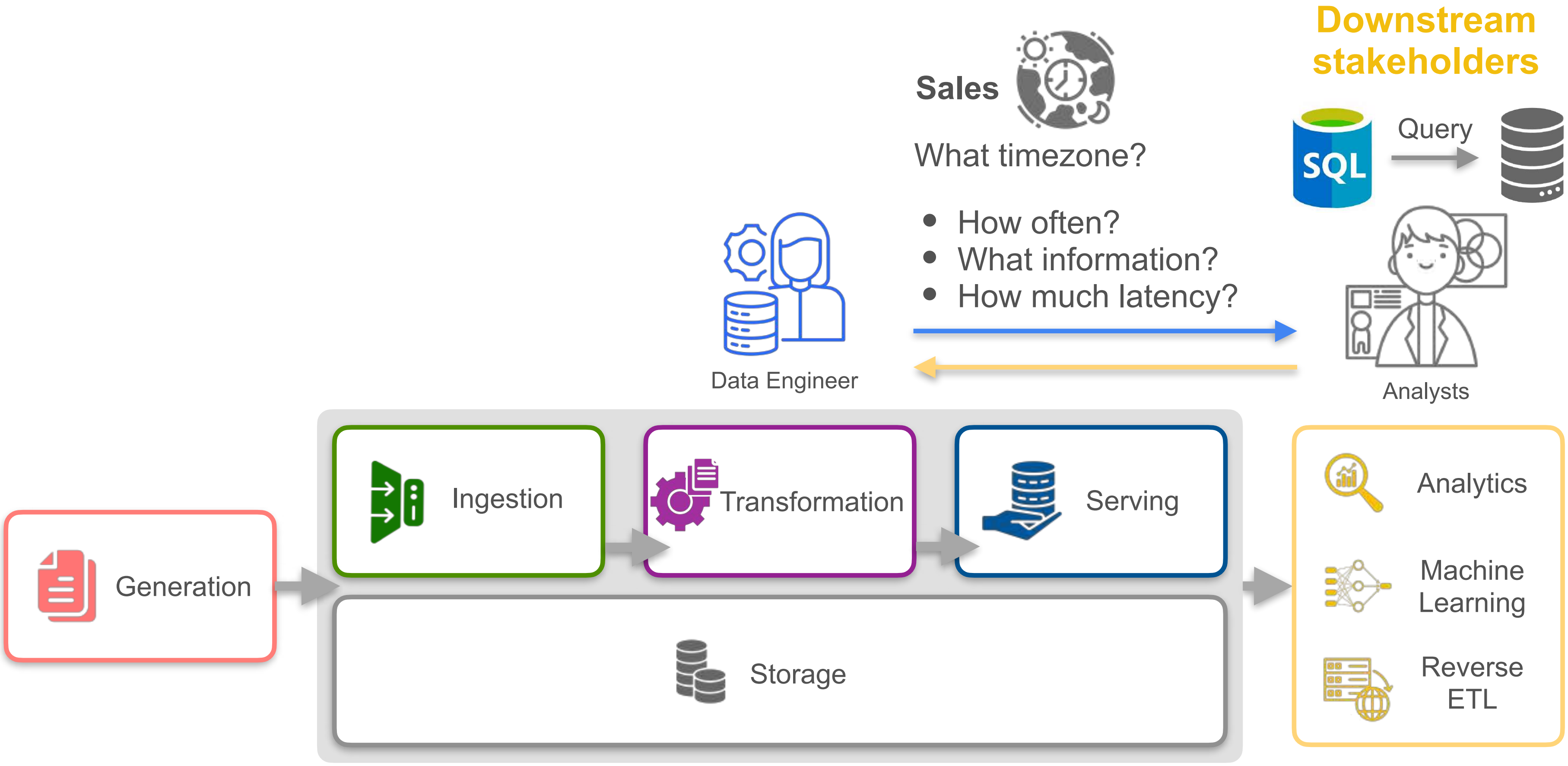
Downstream stakeholders





Downstream Stakeholders





Downstream stakeholders

Sales

What timezone?

- How often?
- What information?
- How much latency?

SQL

Query

Data Engineer

Analysts

Generation

Ingestion

Transformation

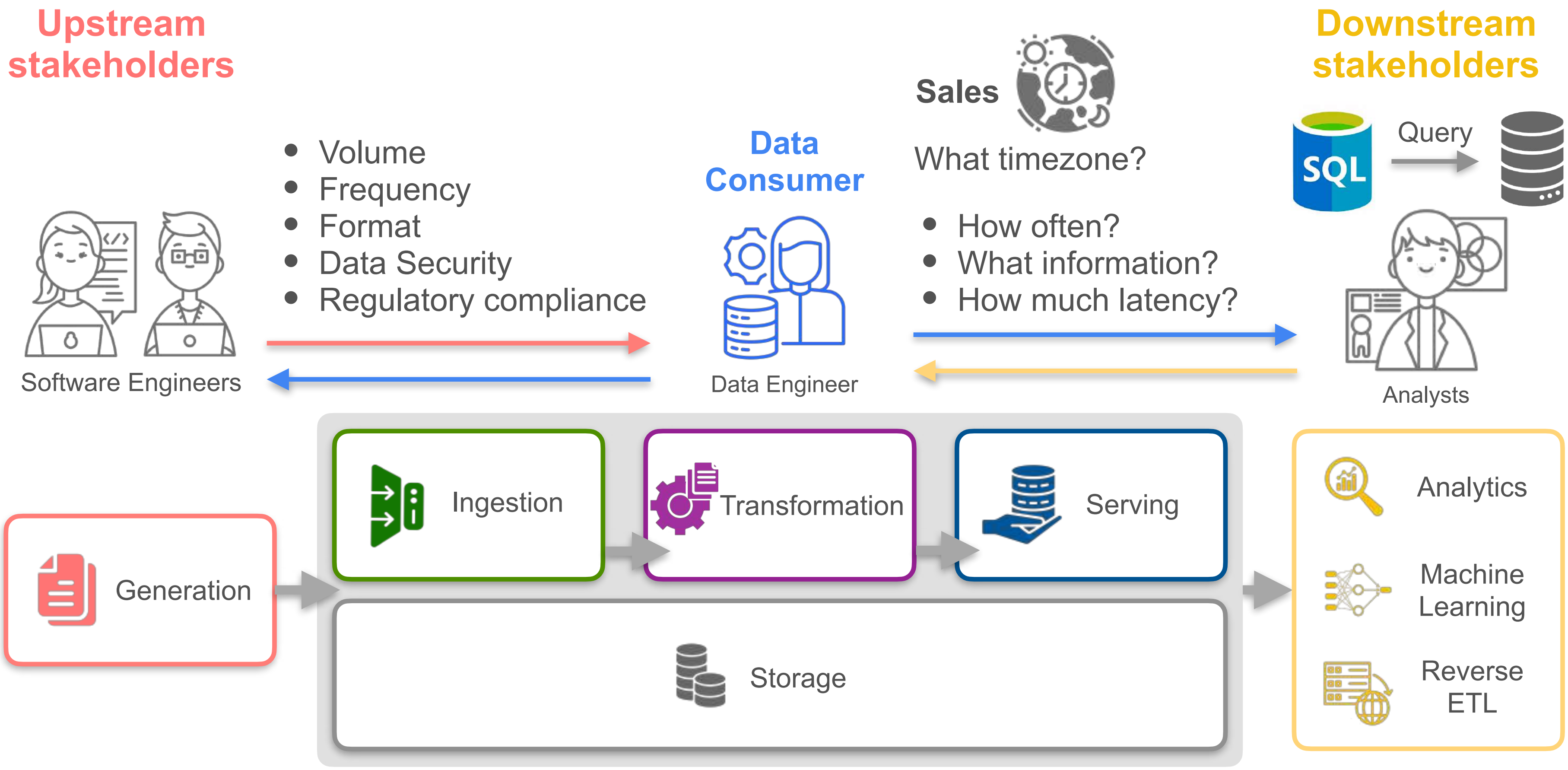
Serving

Storage

Analytics

Machine Learning

Reverse ETL



Upstream stakeholders

Software Engineers

- Volume
- Frequency
- Format
- Data Security
- Regulatory compliance

Data Consumer

Data Engineer

Sales

What timezone?

- How often?
- What information?
- How much latency?

Downstream stakeholders

SQL

Query

Analysts

Generation

Ingestion

Transformation

Serving

Storage

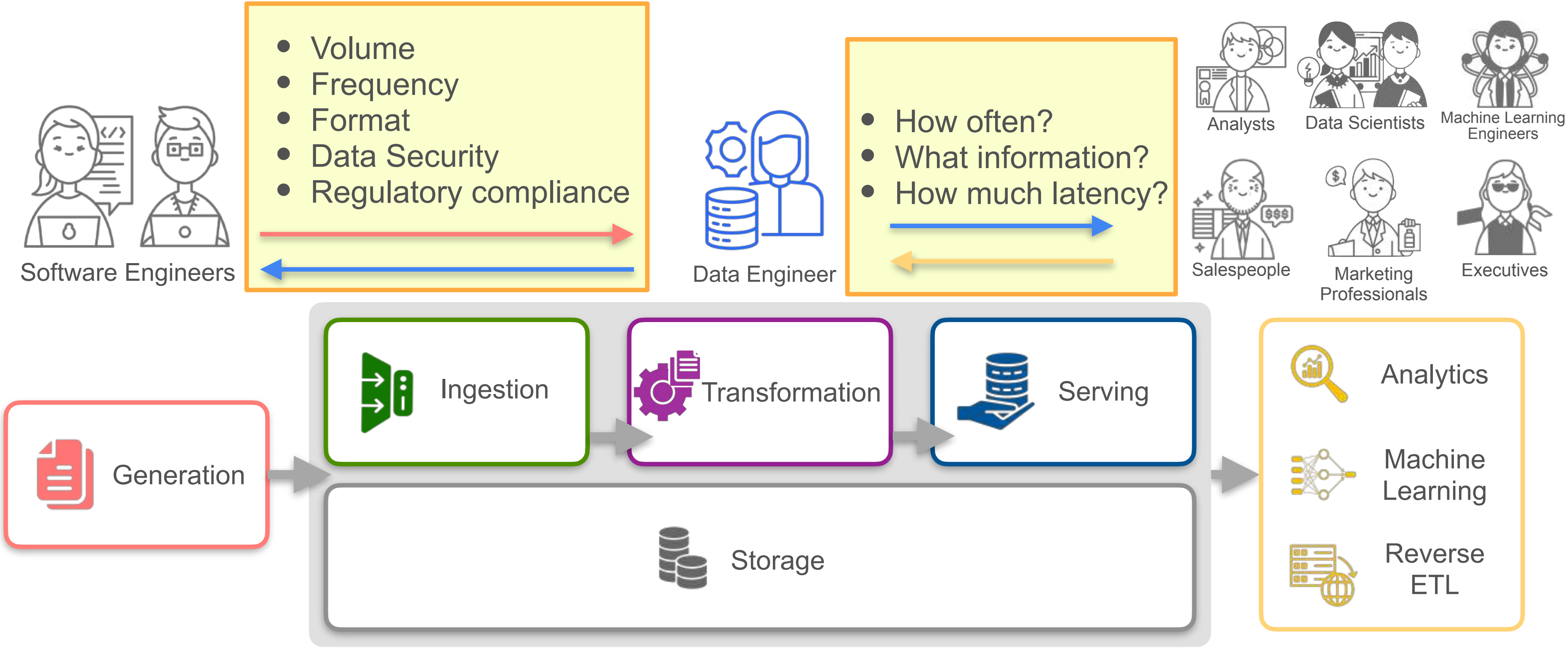
Analytics

Machine Learning

Reverse ETL

Upstream stakeholders

Downstream stakeholders



Software Engineers

- Volume
- Frequency
- Format
- Data Security
- Regulatory compliance

Data Engineer

- How often?
- What information?
- How much latency?

Analysts

Data Scientists

Machine Learning Engineers

Salespeople

Marketing Professionals

Executives

Generation

Ingestion

Transformation

Serving

Storage

Analytics

Machine Learning

Reverse ETL

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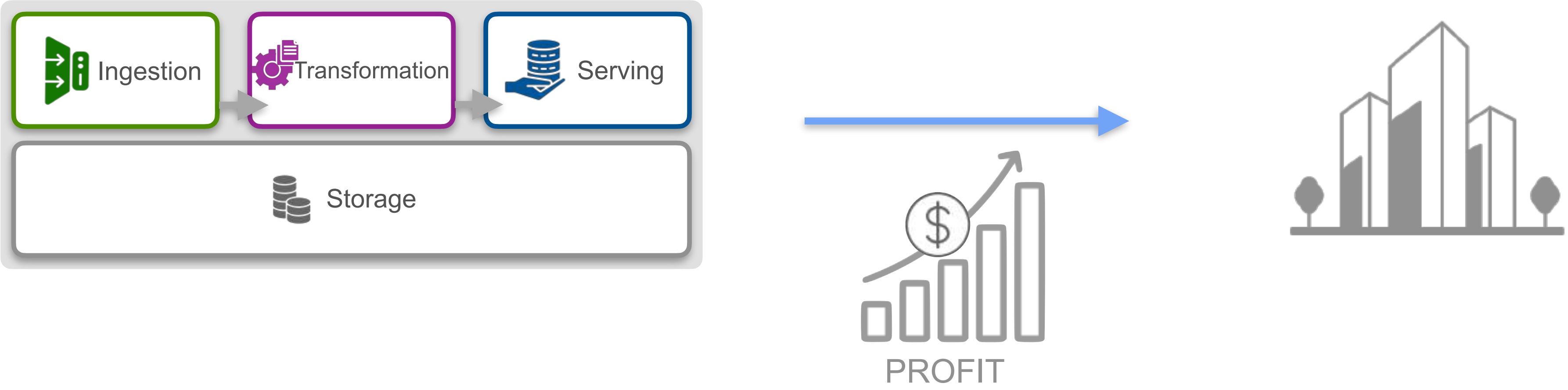
Introduction to Data Engineering

Business Value

Business Value

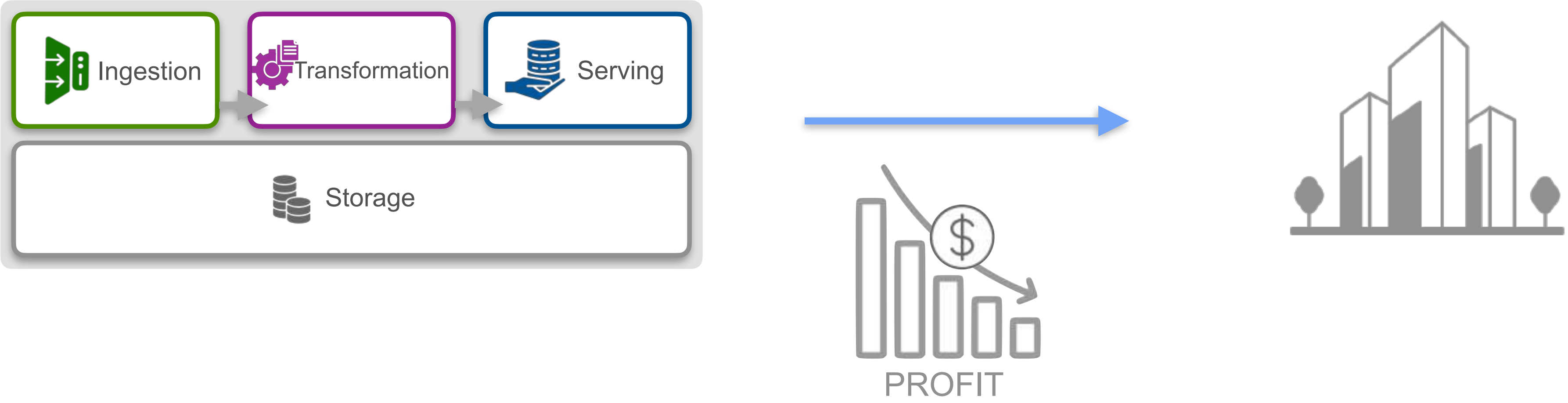
Goal: Revenue Growth

Value Created!



Business Value

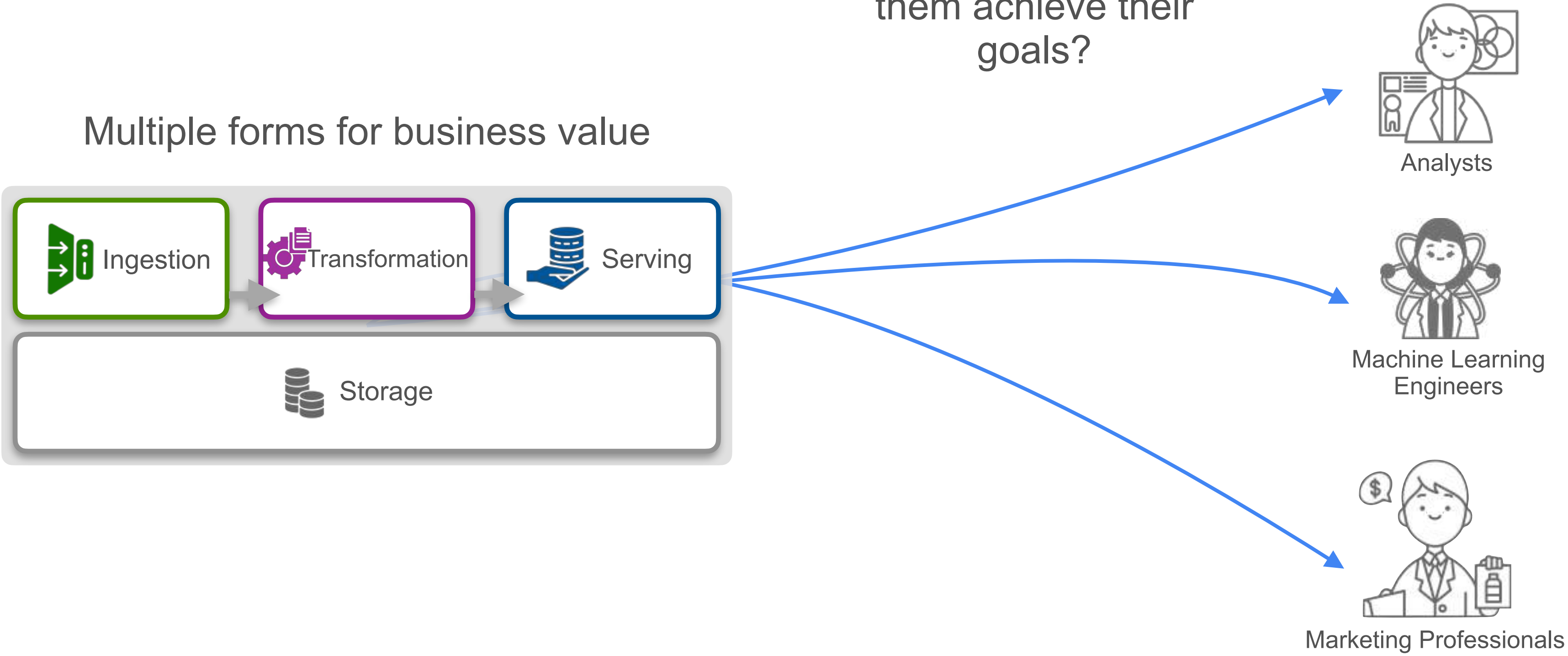
Goal: Revenue Growth



Business Value

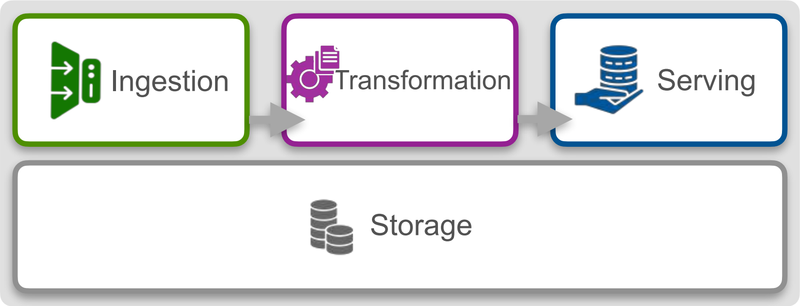
Is your work helping them achieve their goals?

Multiple forms for business value



Business Value

Multiple forms for business value



- Increased Revenue
- Cost Savings
- Improved efficiency
- Launch a product

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Introduction to Data Engineering

System Requirements

Requirements

Business Requirements

High level goals of the business

For example: grow revenue, increase user base

Requirements

Business Requirements

High level goals of the business

For example: grow revenue, increase user base

Stakeholder Requirements

Needs of individuals within the organization

Things they need to get their job done well

Requirements

Business Requirements

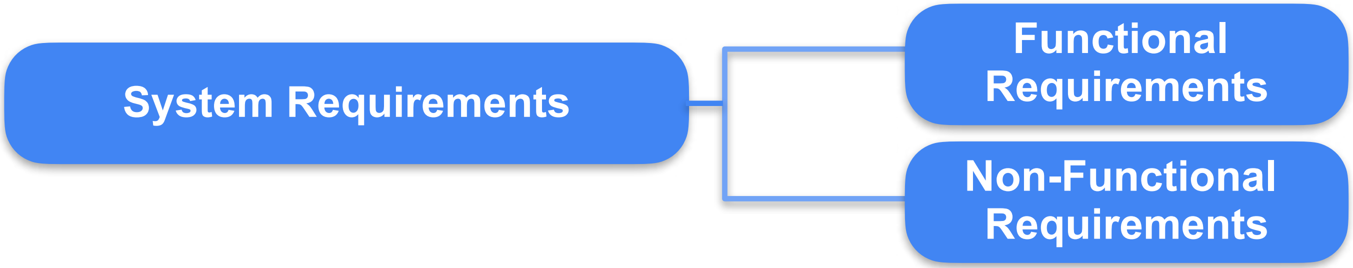
High level goals of the business

For example: grow revenue, increase user base

Stakeholder Requirements

Needs of individuals within the organization

Things they need to get their job done well



System Requirements

Functional Requirements

Non-Functional Requirements

The “WHAT”

The “HOW”

Requirements

Functional Requirements

What the system needs to be able to do

- Provide regular updates to a database
- Alert a user about an anomaly in the data

Non-Functional Requirements

How the system accomplishes what it needs to do

- Technical specifications of an ingestion or orchestration or storage approach
- How you'll meet the end user's needs

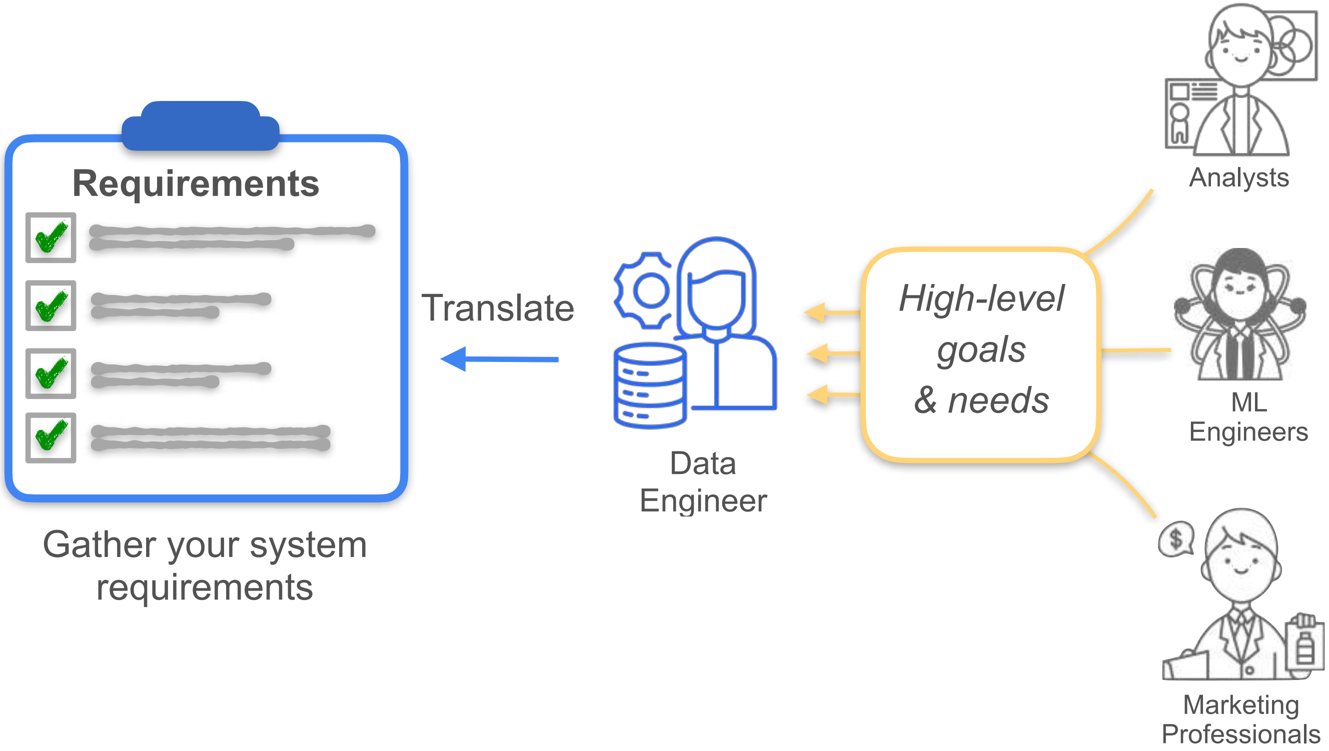
Requirements Gathering

Business & Stakeholder Requirements

Features & Attributes

Memory & Storage Capacity

Cost & Security Constraints



Gather your system requirements

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Introduction to Data Engineering

Translate Stakeholder Needs into Specific Requirements

Key Elements of Requirements Gathering

Learn what existing data systems or solutions are in place

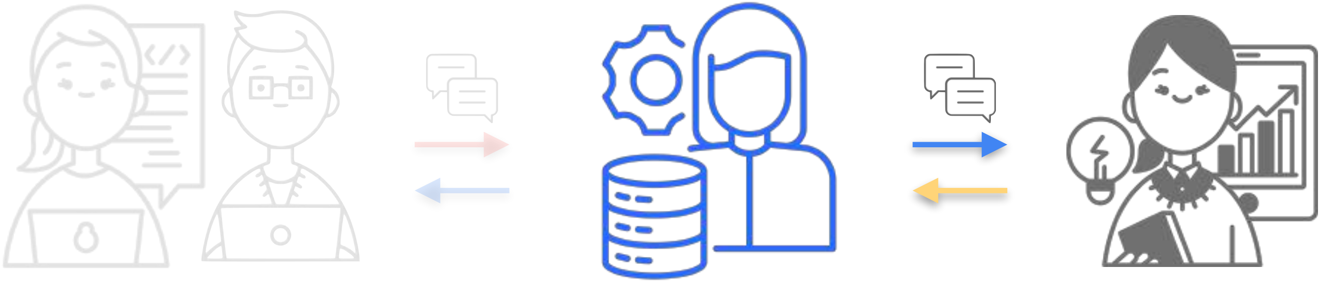
Learn what pain points or problems there are with the existing solutions

Learn what actions stakeholders plan to take with the data

Tip: Repeat what you learned back to your stakeholders.

Identify any other stakeholders you'll need to talk to if you're still missing information

Conversation with Data Scientist



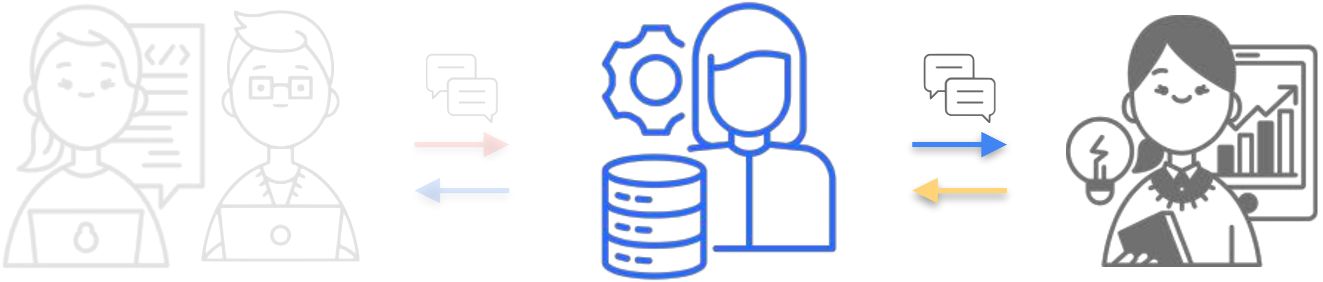
Marketing needs **real-time** analysis of product sales,

but I’m only getting a daily data dump from the software team.

Conversation with Data Scientist

- Build in automatic checks on the ingested data
- Know about changes or disruptions before they happen

Problems with schema changes & other anomalies in the data



Software Engineers

Data Engineer

Data Scientist

Conversation with Source Owners

What’s a better ingestion solution?

What kind of disruptions or changes can I expect?

How can I anticipate these changes?

Software Engineers

Data Engineer

Data Scientist

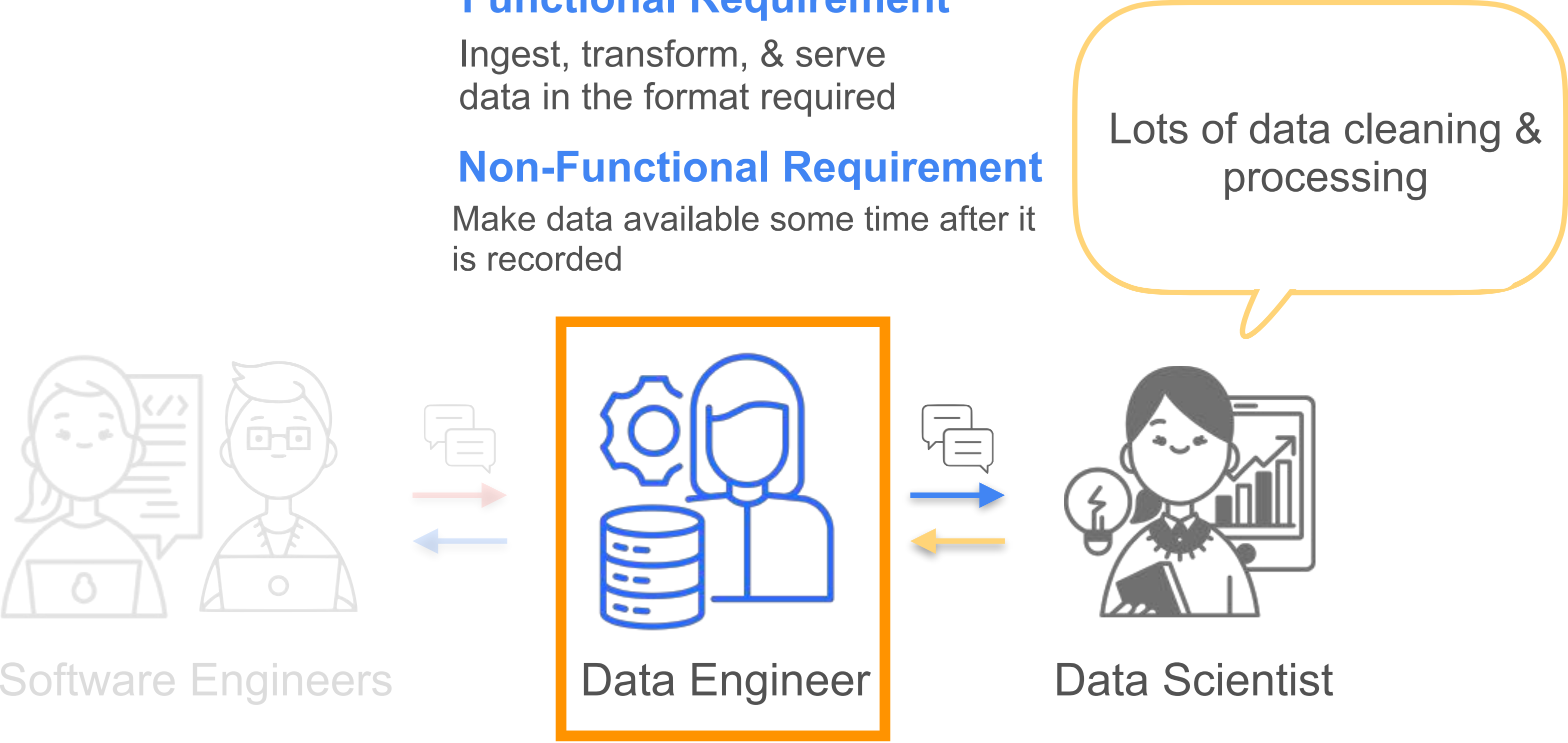
Conversation with Data Scientist

Functional Requirement

Ingest, transform, & serve data in the format required

Non-Functional Requirement

Make data available some time after it is recorded



Lots of data cleaning & processing

Software Engineers

Data Engineer

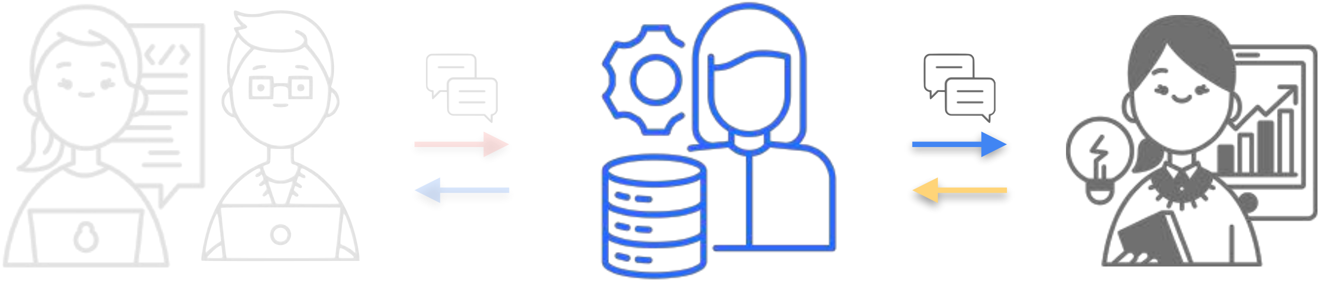
Data Scientist

Conversation with Data Scientist

What is "real-time"?

- monthly basis
- daily, hourly, minutes, seconds, ….

The marketing team needs the data in real-time



Software Engineers

Data Engineer

Data Scientist

Conversation with Data Scientist

Key Tactic:

Ask stakeholder what action they plan to take with the data

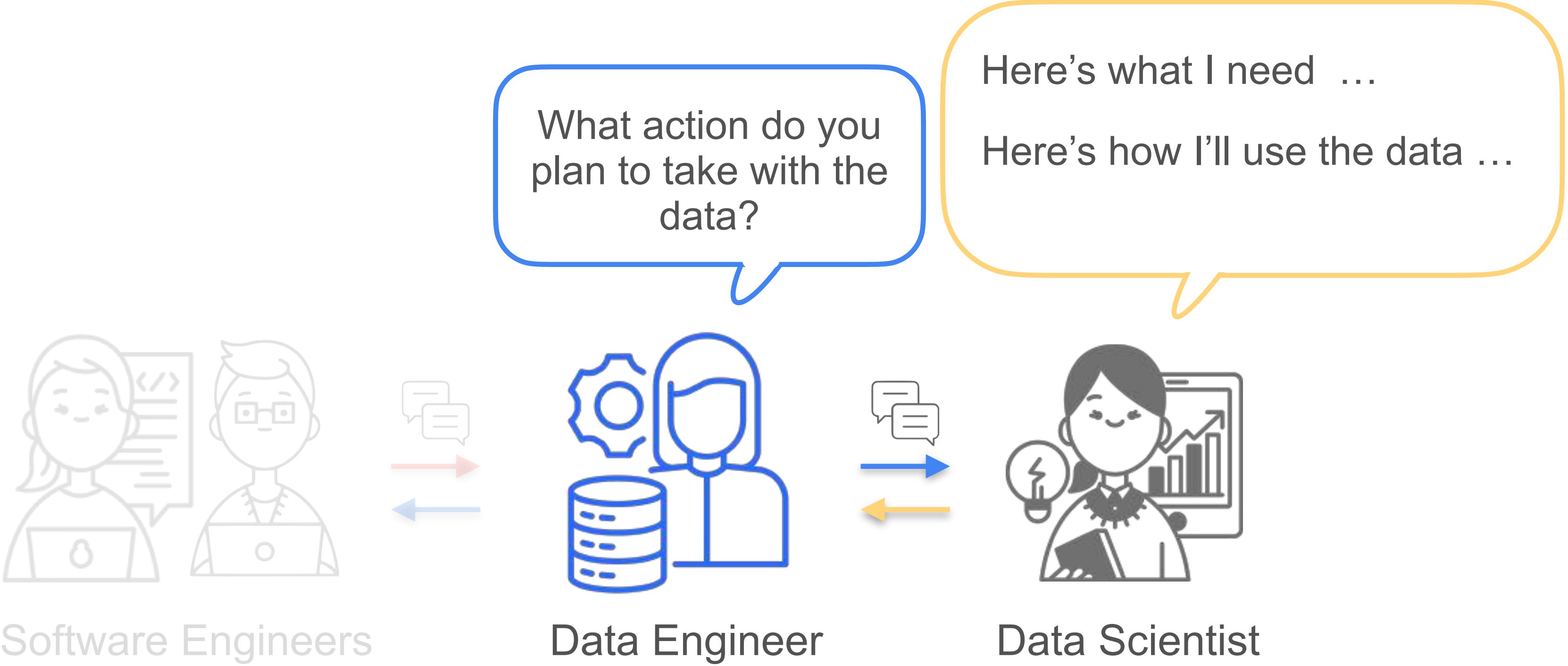
Not the same as asking what they need!

Software Engineers

Data Engineer

Data Scientist

Conversation with Data Scientist


What action do you plan to take with the data?
Here's what I need …
Here's how I'll use the data …
Software Engineers
Data Engineer
Data Scientist

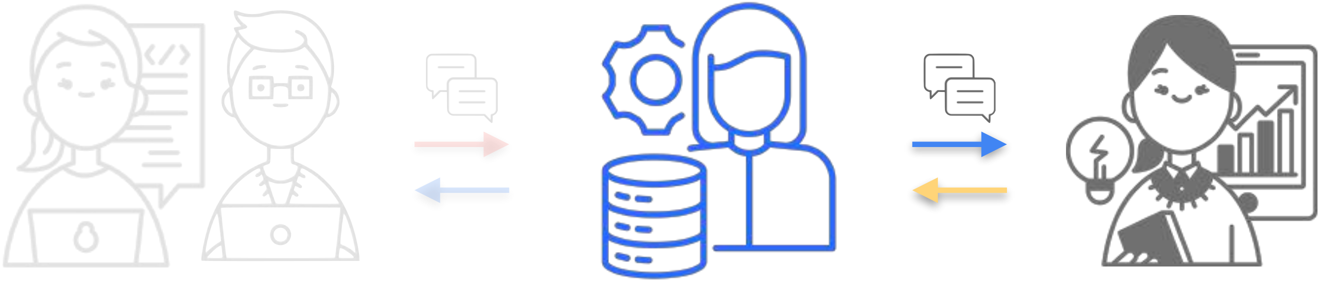
Conversation with Data Scientist

A recommender system

Provide product recommendations
in near real-time

An analytics dashboard

?



Software Engineers

Data Engineer

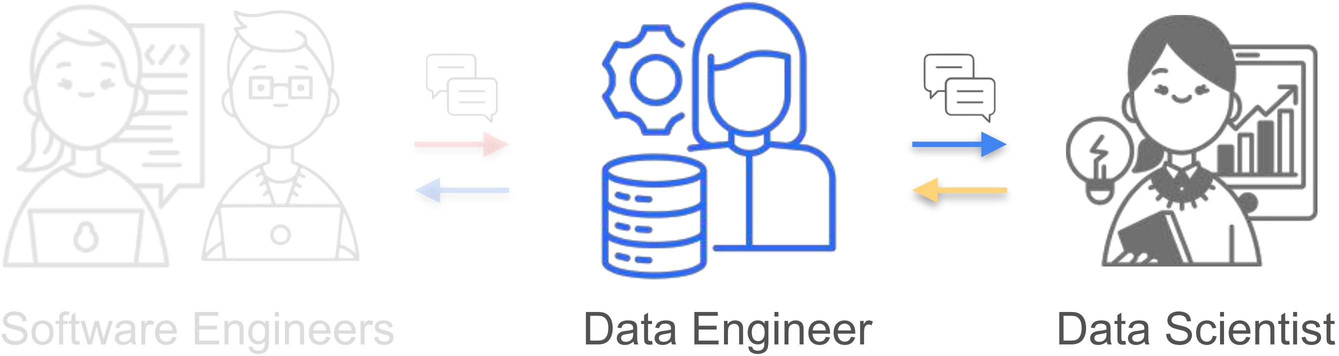
Data Scientist

Conversation with Data Scientist

1. Learned about existing solutions and pain points

2. Started to identify some of your system requirements

3. Identified stakeholders to talk to:
   - Marketing team
   - Software engineering team



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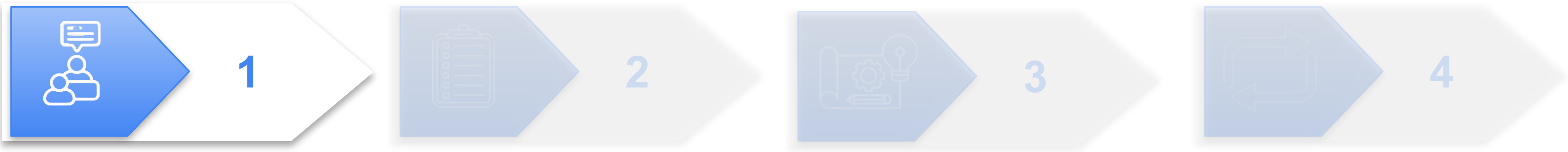
Introduction to Data Engineering

Thinking Like a Data Engineer

Thinking Like a Data Engineer



Identify business goals & stakeholder needs

Define system requirements

Choose tools & technologies

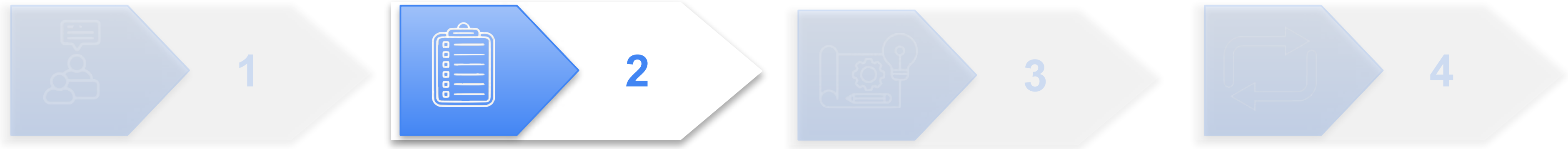
Build, evaluate, iterate & evolve

1. Identify business goals & stakeholders you will serve
2. Explore existing systems and stakeholder needs
3. Ask stakeholders what actions they will take with the data product

Business Goals

Stakeholders' Needs

Thinking Like a Data Engineer



Identify business goals & stakeholder needs

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2. Explore existing systems and stakeholder needs
3. Ask stakeholders what actions they will take with the data product

Define system requirements

1. Translate stakeholder needs to functional requirements
2. Define non-functional requirements
3. Document and confirm requirements with stakeholders

Choose tools & technologies

Build, evaluate, iterate & evolve

Confirm with Stakeholders

Thinking Like a Data Engineer

1

Identify business goals & stakeholder needs

1. Identify business goals & stakeholders you will serve
2. Explore existing systems and stakeholder needs
3. Ask stakeholders what actions they will take with the data product

2

Define system requirements

1. Translate stakeholder needs to functional requirements
2. Define non-functional requirements
3. Document and confirm requirements with stakeholders

3

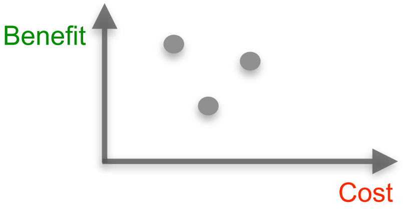
Choose tools & technologies

1. Identify tools & tech to meet non-functional requirements
2. Perform cost / benefit analysis and choose between comparable tools & tech
3. Prototype and test your system, align with stakeholder needs

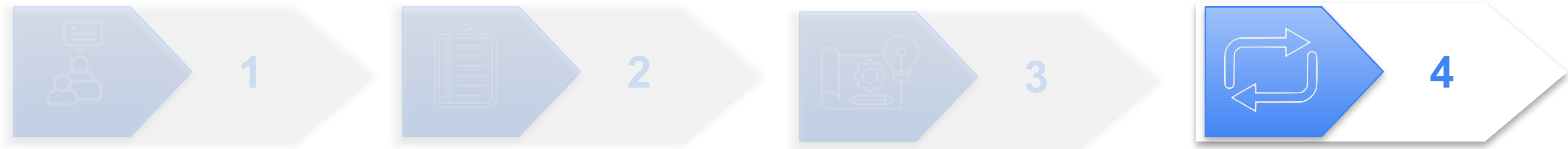
4

Build, evaluate, iterate & evolve

Cost-Benefit Analysis



Thinking Like a Data Engineer



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1. Identify tools & tech to meet non-functional requirements
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Build, evaluate, iterate & evolve

1. Build & deploy your production data system
2. Monitor, evaluate, and iterate on your system to improve it
3. Evolve your system based on stakeholder needs

Thinking Like a Data Engineer

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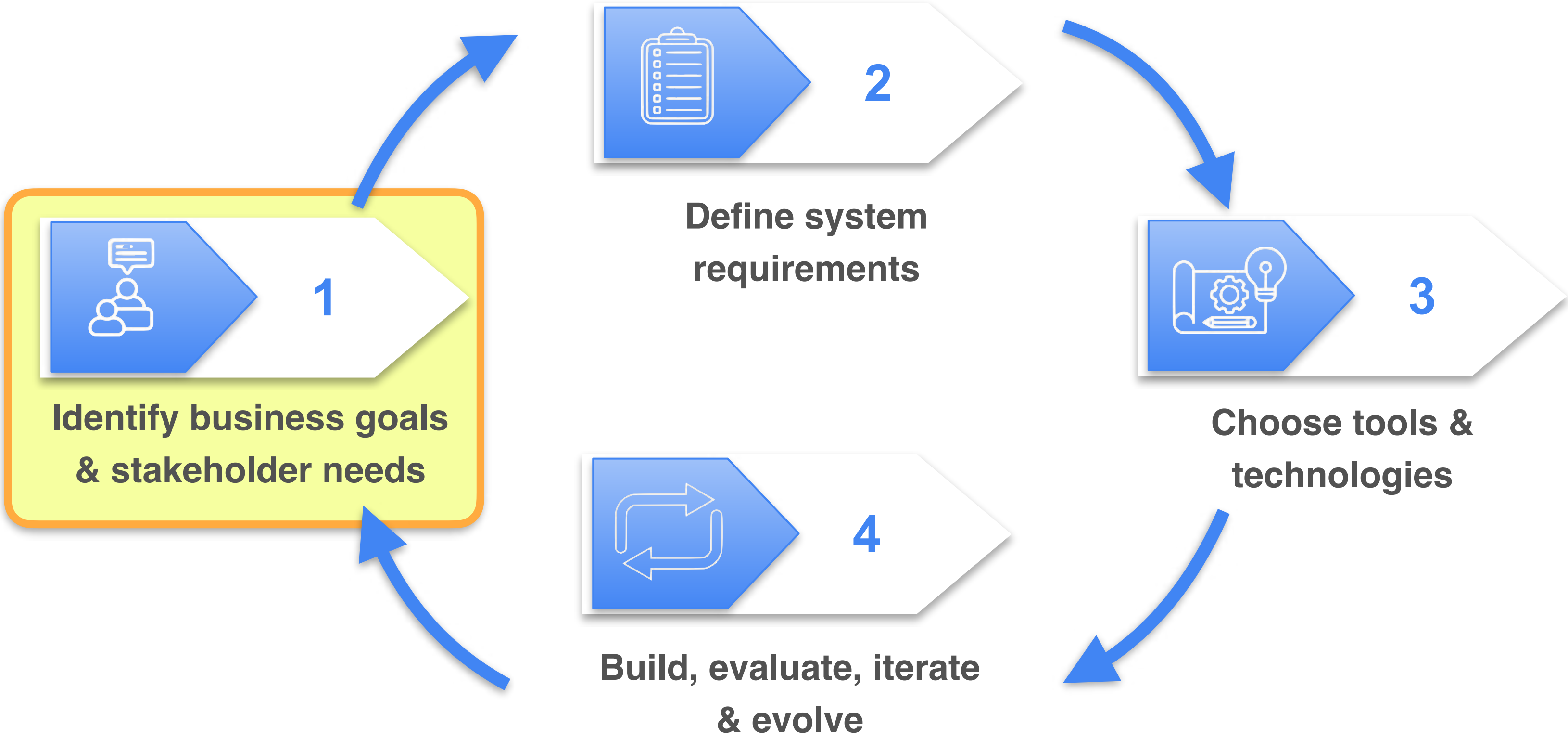

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Identify business goals & stakeholder needs
2
Define system requirements
3
Choose tools & technologies
4
Build, evaluate, iterate & evolve

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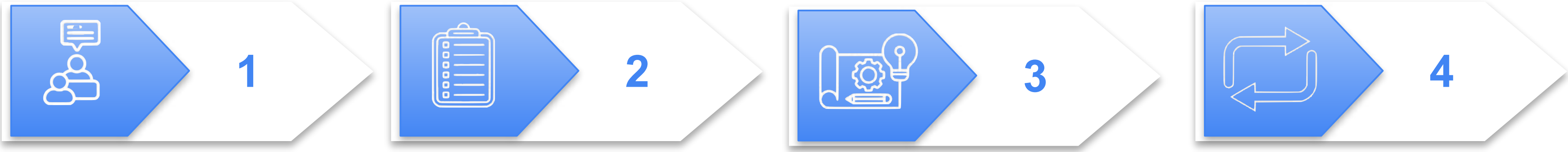

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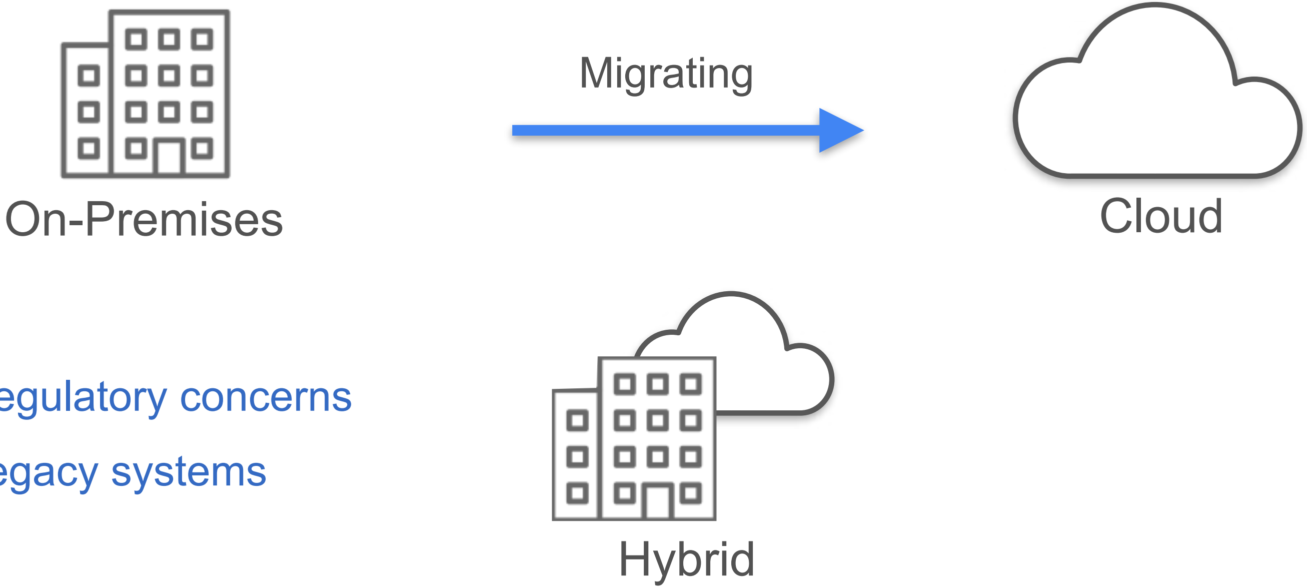
Data Engineering in Practice

Data Engineering on the Cloud

Location

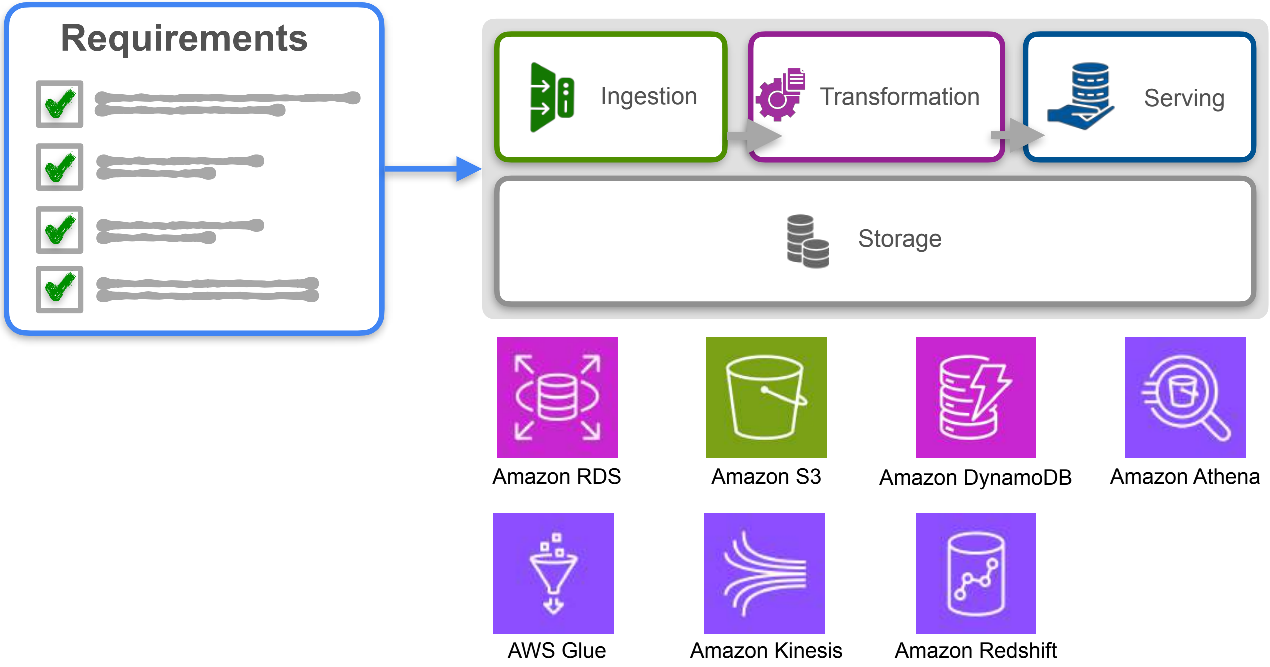


- Regulatory concerns
- Legacy systems

Public Cloud

Specialization Approach

Cloud-first approach



Just in time approach

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Data Engineering in Practice

Intro to the AWS Cloud

IT Resources

Compute

Places to run code

Virtual Machine

Container hosting services

Serverless functions

Storage

Places to store data

Amazon Simple Storage Service (S3)

Amazon Elastic Block Store (EBS)

Database Services

Networking

Connect other resources to each other

Amazon Virtual Private Cloud (VPC)

Security

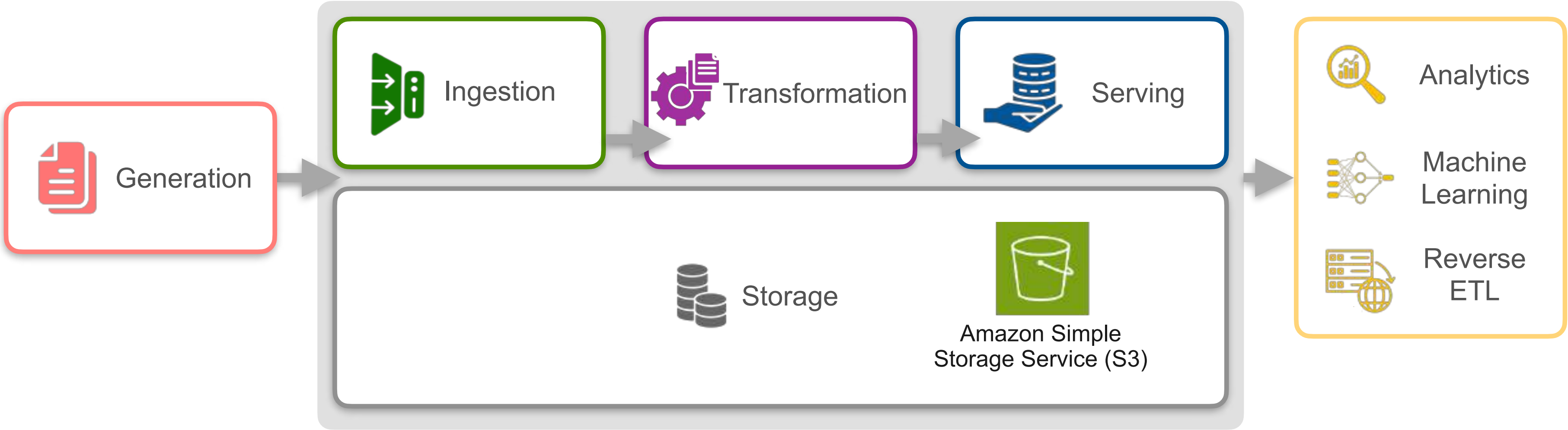
Data Streaming

Ingestion

Transformation

Advantage of Building on Cloud

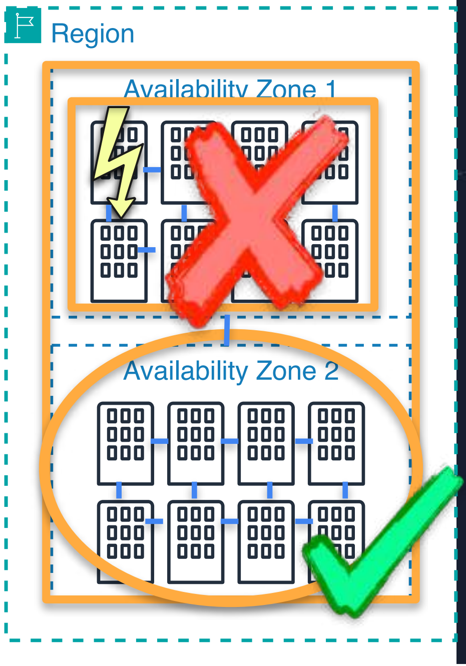
- Cloud resources are scalable and elastic.



- No need to worry about the exact storage capacity needed
- No need to manage the scaling operations

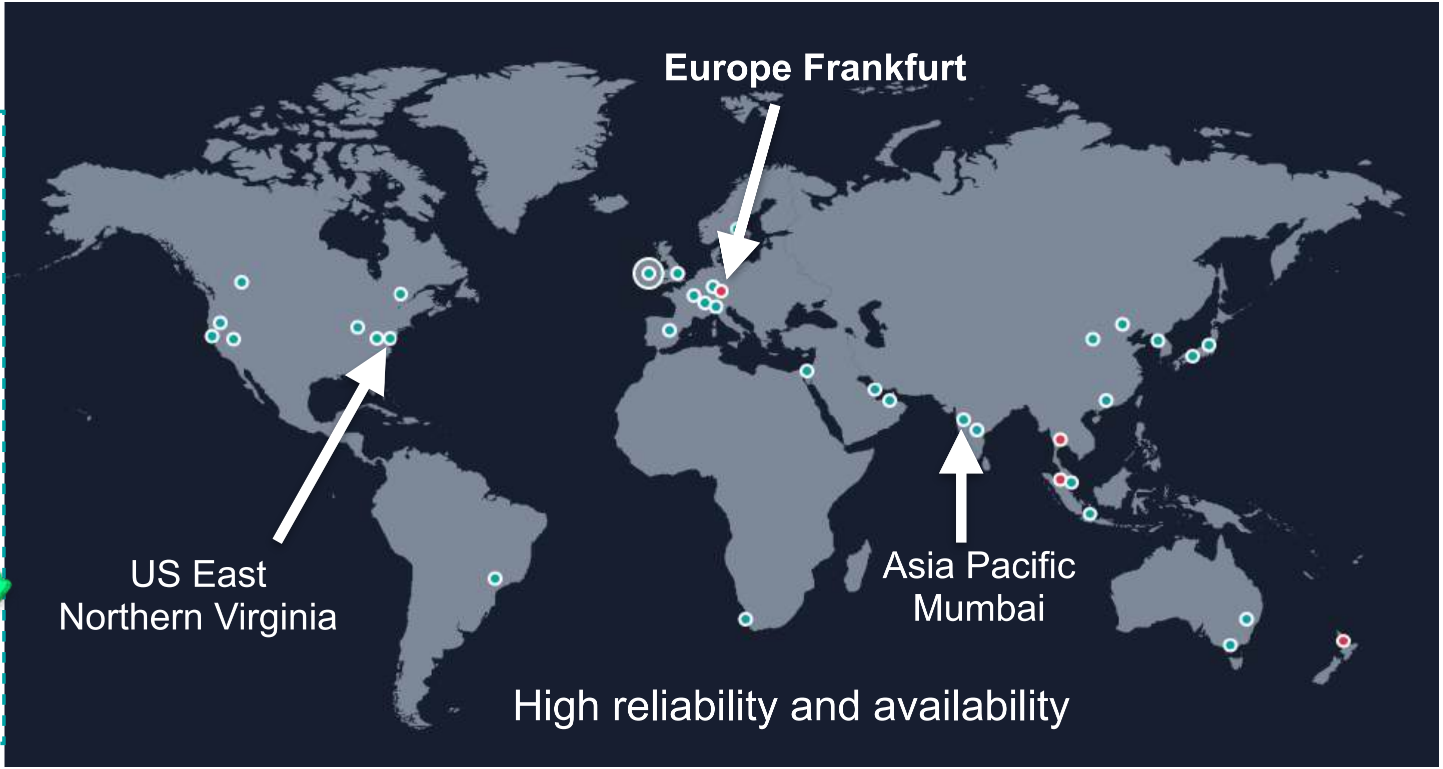
Data Center

Availability Zones



AWS Regions

Collections of data centers within geographical areas, where you can use AWS services



High reliability and availability

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Data Engineering in Practice

Intro to AWS Core Services

Compute

Amazon Elastic Compute Cloud (EC2)

The service that provides virtual machines, or VMs, on AWS

Virtual Machines

Virtual computers or servers, where you can run any operating system and applications.

EC2 Instance

EC2 Instance

EC2 Instance

- You have complete control over an EC2 instance
- EC2 is a very flexible option for your workloads:
  - Use as a development machine for programming
  - Use to run a web server, container, or machine learning workload

AWS Lambda

Amazon Elastic Container Service (ECS)

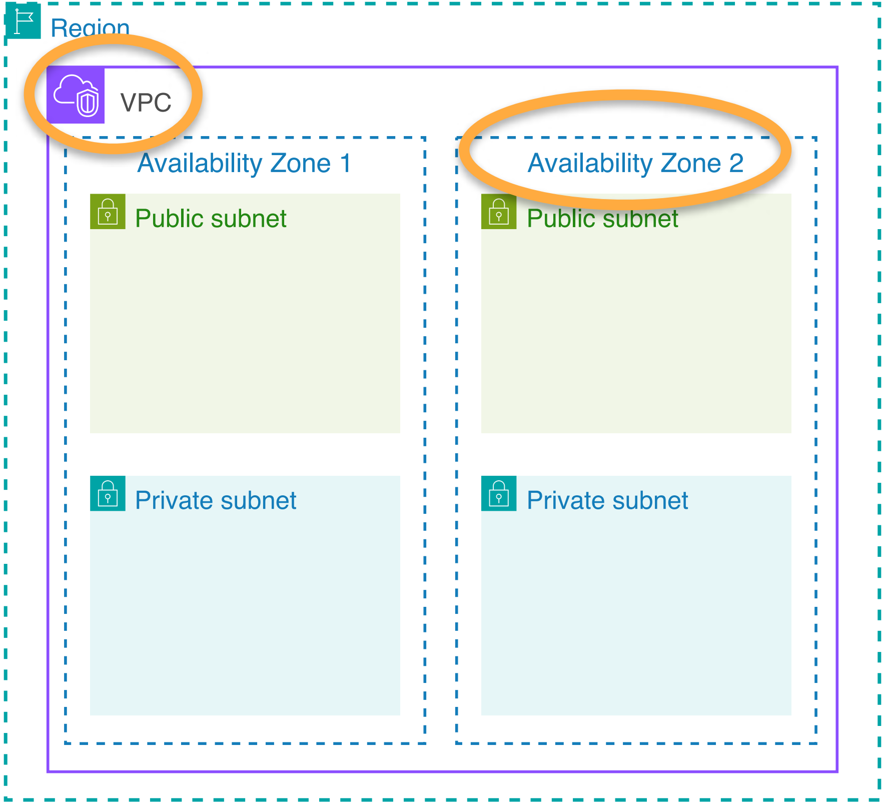
Amazon Elastic Kubernetes Service (EKS)

Networking

Amazon Virtual Private Network (VPC)

The private network you can create and place resources into.

- VPCs are isolated from other networks.
- You choose the size of the private IP space.
- Partition space into smaller networks called **subnetworks or subnets**.
- Your data and resources don't leave the region unless you specifically build your solutions to behave that way



Storage

Object Storage

Most often used for storing unstructured data

Amazon Simple Storage Service (S3)

Block Storage

Used for database storage, virtual machine file systems, and other low-latency environments

Amazon Elastic Block Store (EBS)

File Storage

Data is organized into files and directories in a hierarchical structure

Amazon Elastic File System (EFS)

Storage

Amazon Relational Database Service (RDS)

A cloud-based relational database service

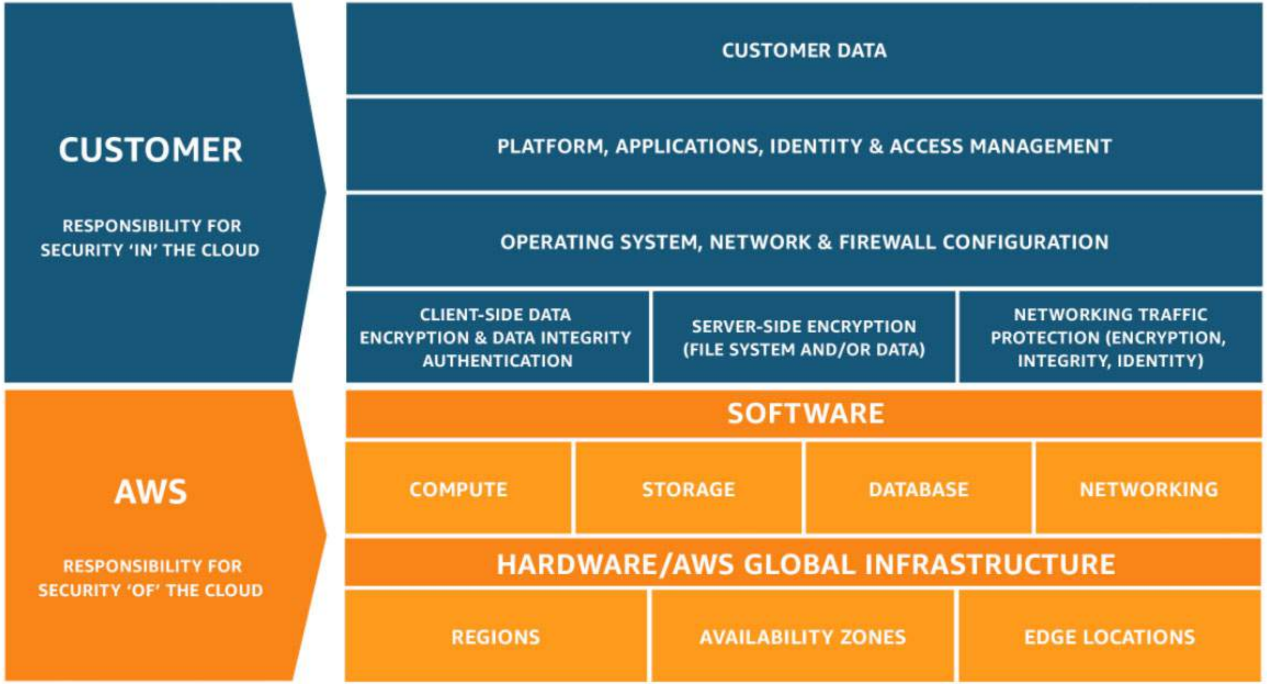
Amazon Redshift

A data warehouse service that allows you store, transform, and serve data for end use cases

Security

Shared Responsibility Model

AWS is responsible for security **OF** the cloud, and you are responsible for security **IN** the cloud



CUSTOMER

RESPONSIBILITY FOR SECURITY 'IN' THE CLOUD

CUSTOMER DATA

PLATFORM, APPLICATIONS, IDENTITY & ACCESS MANAGEMENT

OPERATING SYSTEM, NETWORK & FIREWALL CONFIGURATION

CLIENT-SIDE DATA ENCRYPTION & DATA INTEGRITY AUTHENTICATION	SERVER-SIDE ENCRYPTION (FILE SYSTEM AND/OR DATA)	NETWORKING TRAFFIC PROTECTION (ENCRYPTION, INTEGRITY, IDENTITY)

AWS

RESPONSIBILITY FOR SECURITY 'OF' THE CLOUD

SOFTWARE

COMPUTE	STORAGE	DATABASE	NETWORKING

HARDWARE/AWS GLOBAL INFRASTRUCTURE

REGIONS	AVAILABILITY ZONES	EDGE LOCATIONS

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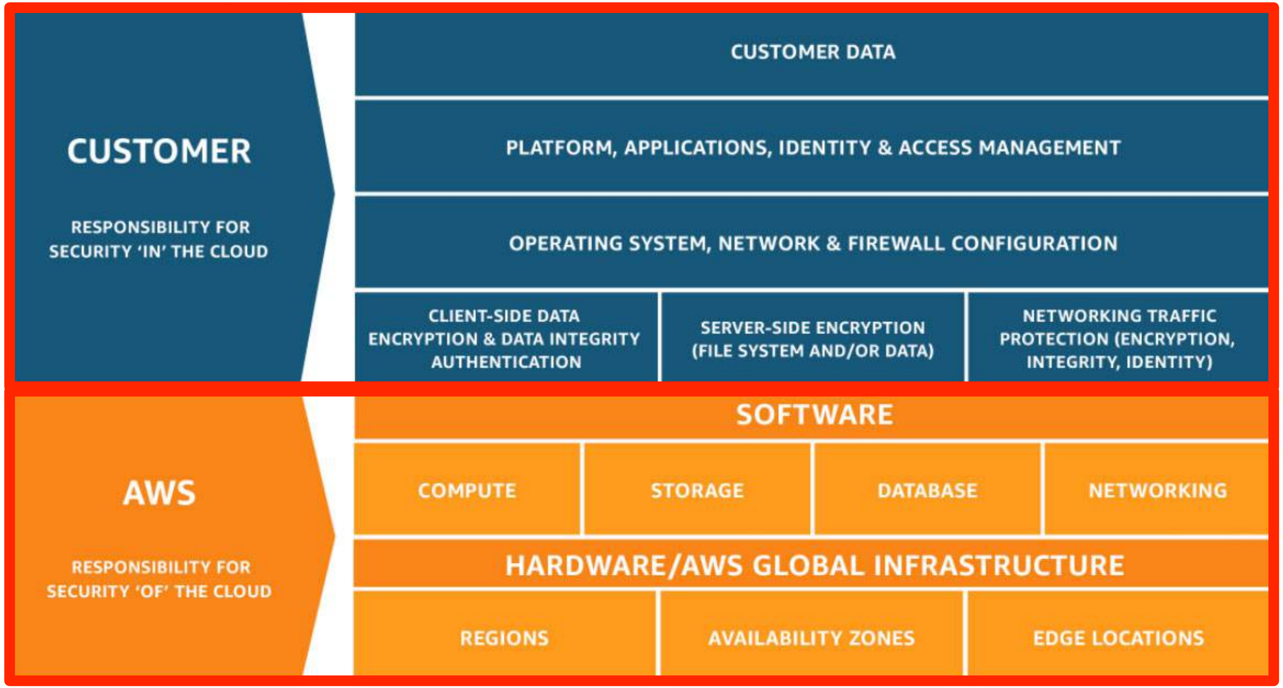

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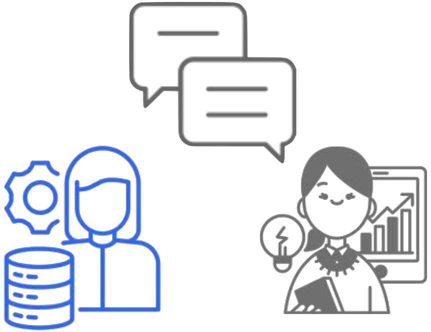
Introduction to Data Engineering

Week 1 Summary

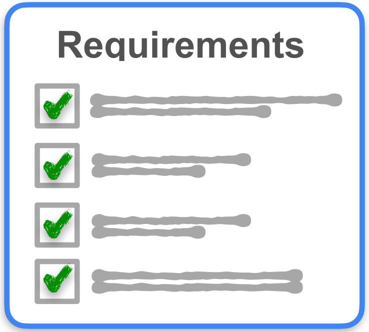
Week 1 Summary

1. Understand the needs of your stakeholders

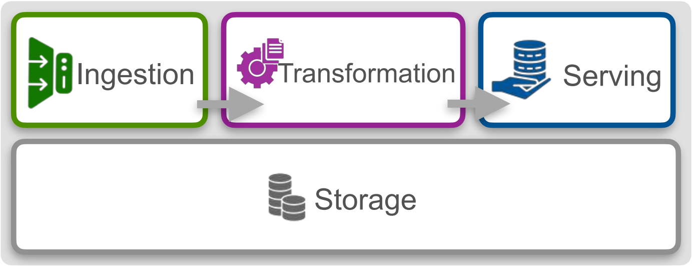


Data Engineer   Data Scientist

2. Translate needs into system requirements

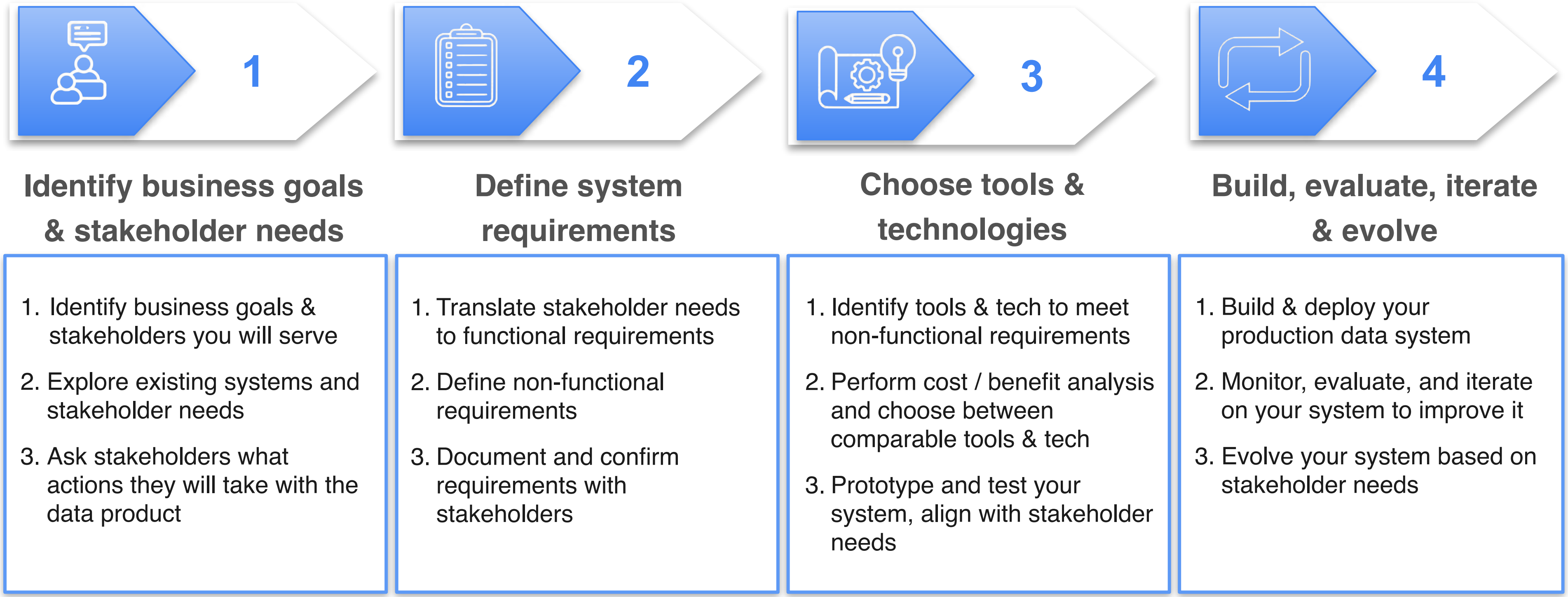


3. Choose appropriate tools & technologies



Value Created!

Thinking Like a Data Engineer



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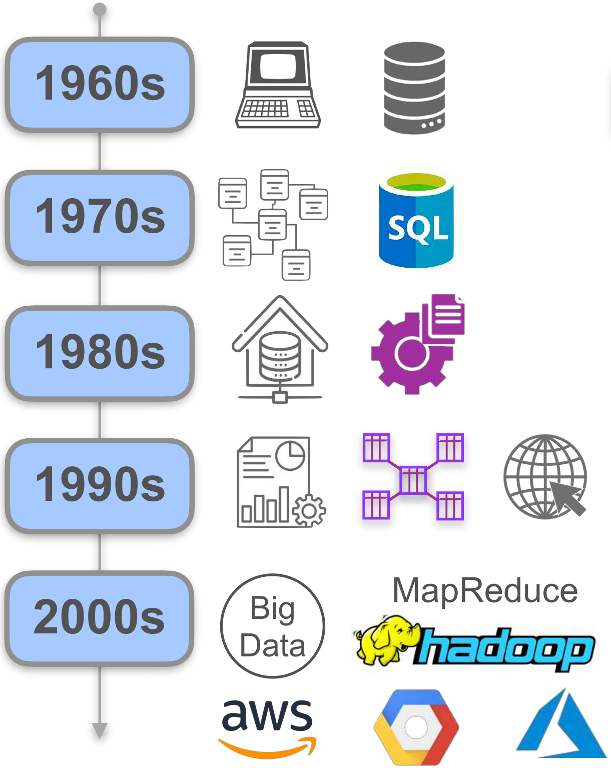
History of Data Engineering



1960s

1970s

1980s

1990s

2000s

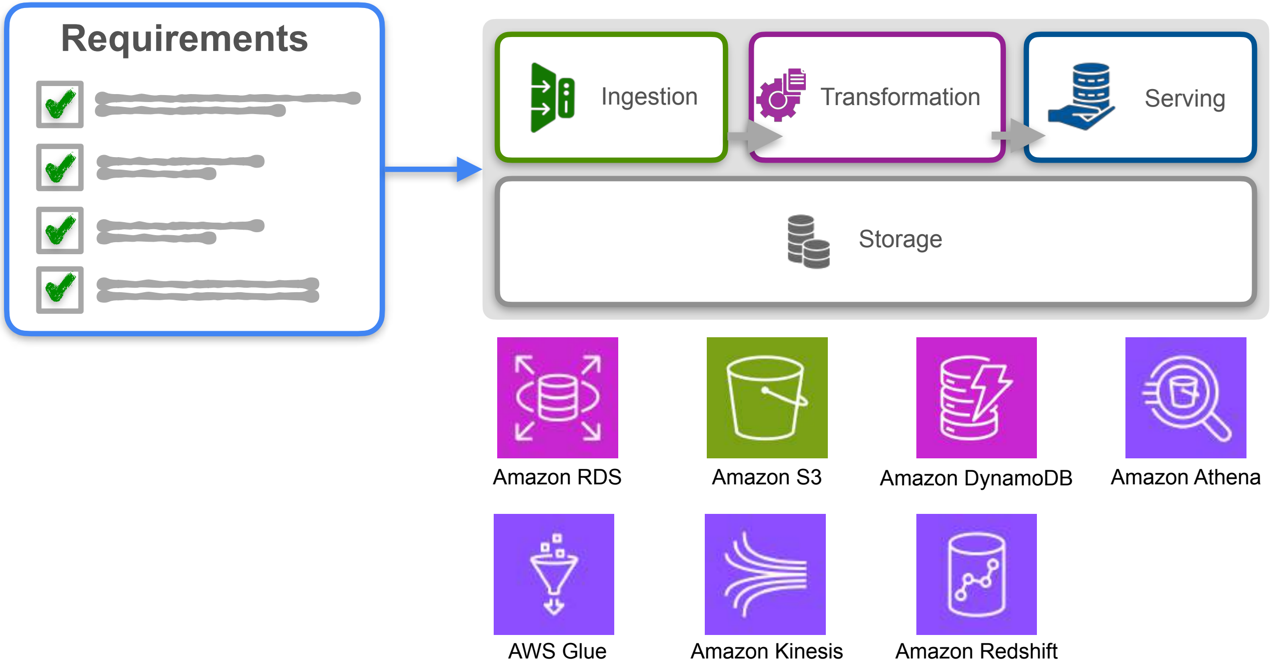
2010s - present

Abstract Simplified Tools

Specialization Approach

Cloud-first approach

A Data Pipeline



Requirements

Ingestion

Transformation

Serving

Storage

Amazon RDS

Amazon S3

Amazon DynamoDB

Amazon Athena

AWS Glue

Amazon Kinesis

Amazon Redshift

Just in time approach