

# (Big) Data Engineering In Depth

From Beginner to Professional

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Senior Big Data Engineer

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<sup>1</sup>Big Data & Analytics Department, Epam Systems

The Definitive Guide to Big Data Engineering Tasks

# Course Introduction

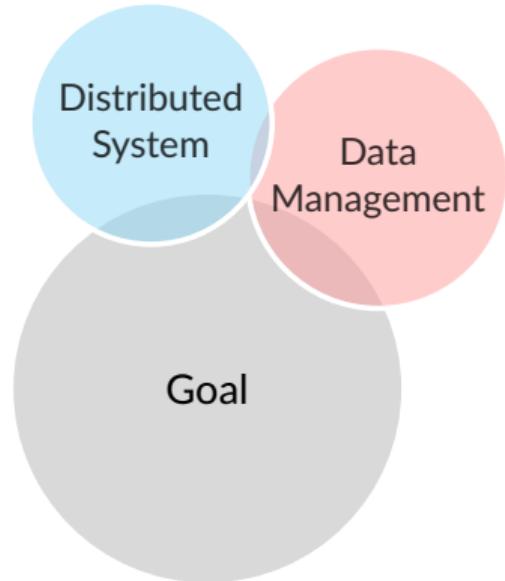
# Course Target



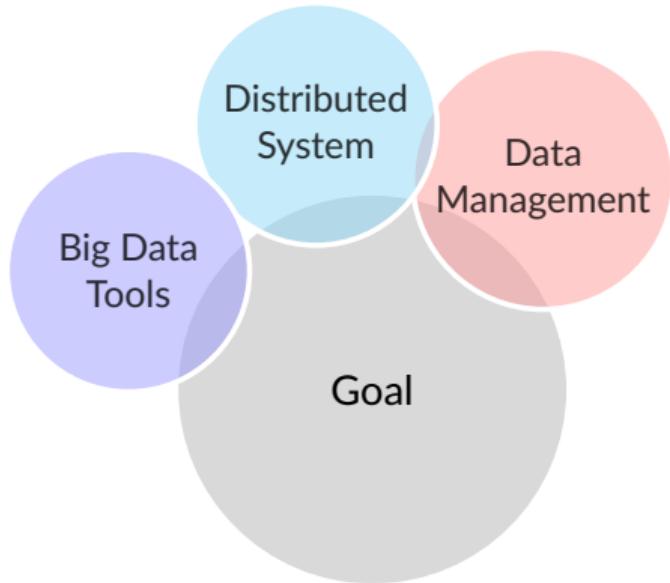
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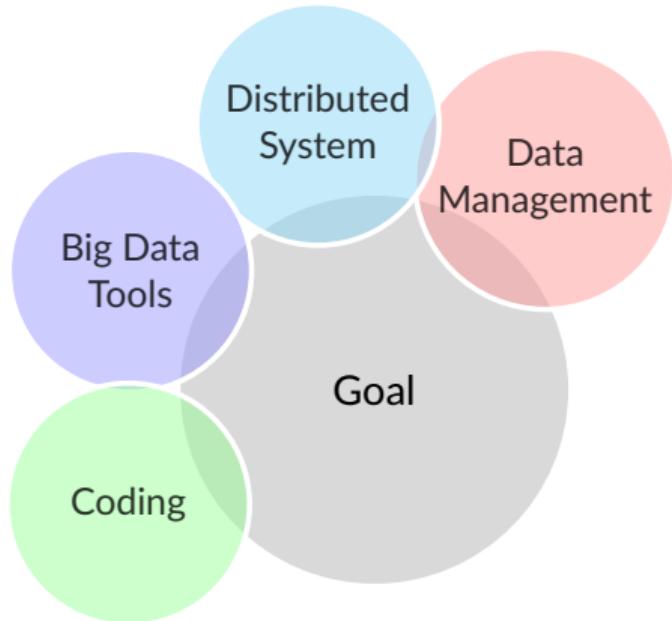
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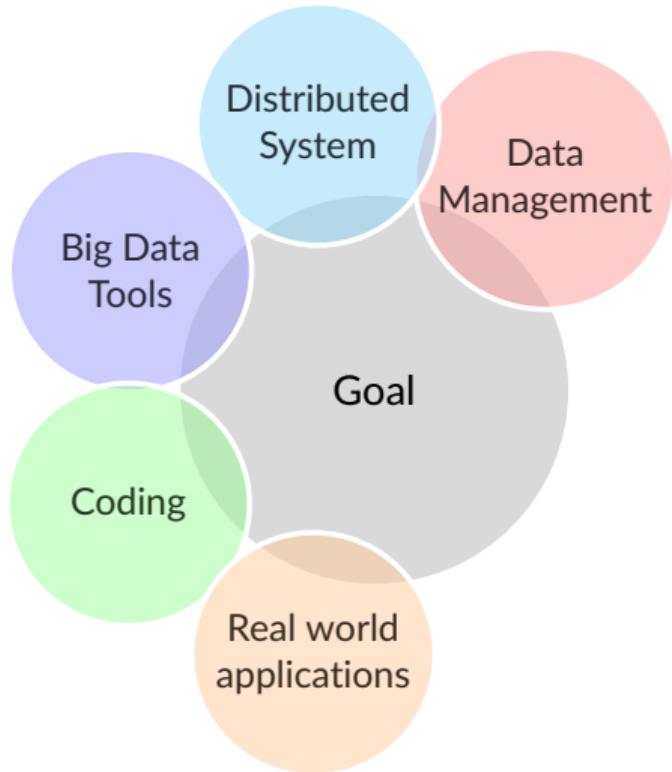
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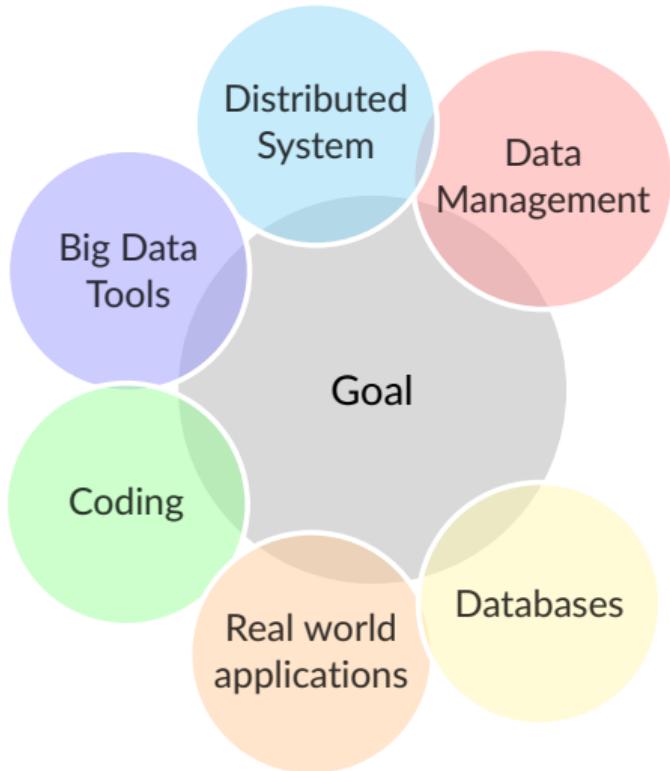
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## Learning Objectives and Audience

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- Understanding of the DevOps tools and functions in data life-cycle ([Appx. H](#)).

# Videos classification

Watching Method / Audience	Computer	Mobile/Tablet	Just listening
Developer	●		
DevOps			●
Business		●	

Figure: Video classification

The green circle ● means short video.

The blue circle ● means medium video.

The red circle ● means long video

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- DevOps engineer who needs to understand the concepts of big data.
- Business or entrepreneur who needs to get more information about how to build or manage a data product.

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- Do the assignments.
- Ask your questions.
- Join online meetings or discussions.

# Chapter Dependencies

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⚠ You MUST finish the red chapters first

Ch.01 Introduction

🔔 Finish colored groups  
before moving to the next group.

Ch.02 Data Management

Ch.03 Distributed Systems

Ch.04 Hadoop and MR

Ch.05 FN and Scala

Ch.06 Spark

Ch.07 Big Data Application

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## Assignments, Labs, and Text Books



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- Full project code.

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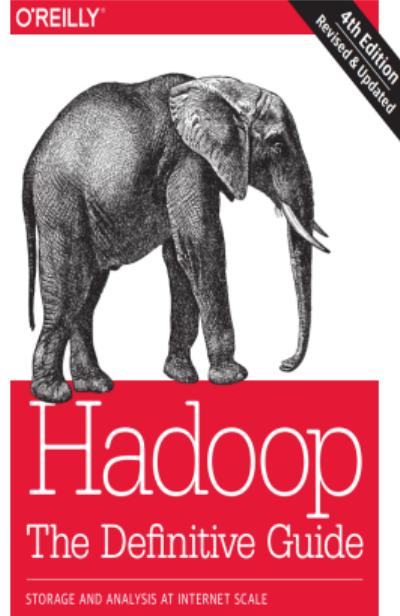
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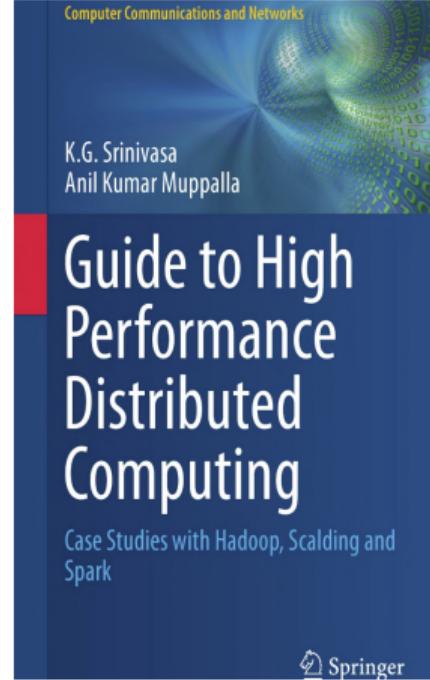
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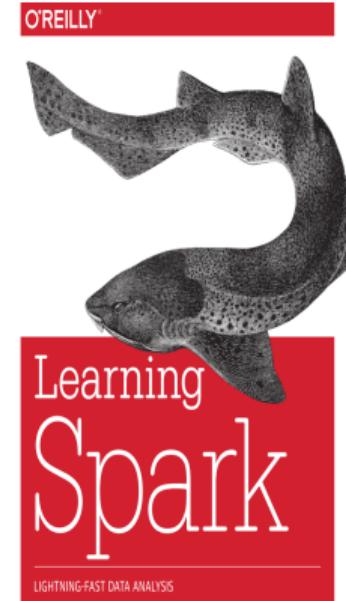
# Textbooks-1



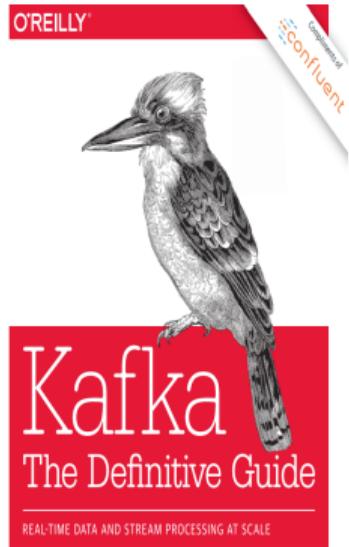
Tom White



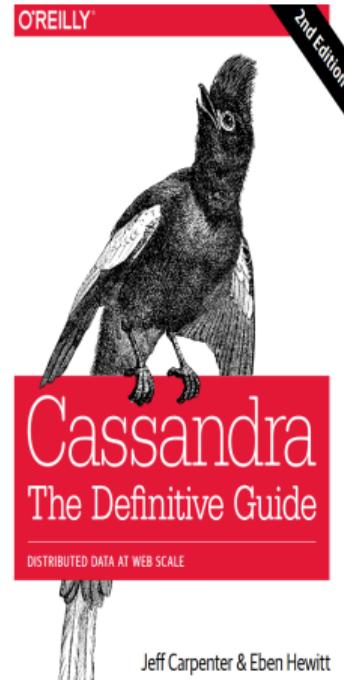
# Textbooks-2



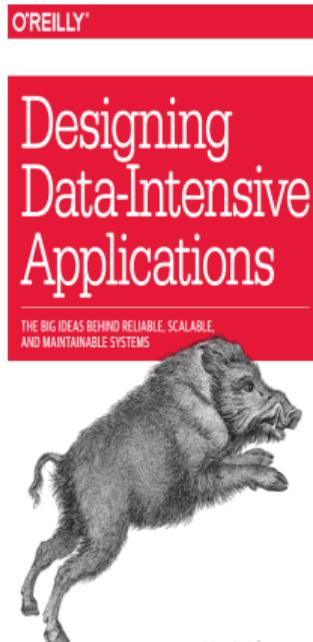
# Textbooks-3



Neha Narkhede,  
Gwen Shapira & Todd Palino



Jeff Carpenter & Eben Hewitt



Martin Kleppmann



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- User stories or technical discussions are not related to any of my current work or my previous companies.



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- User stories or technical discussions are not related to any of my current work or my previous companies.
- I am working at EPAM Systems. My company approved me for doing this online course public but the materials are not reviewed or assessed by my company. It is on my responsibilities.

# Introduction To Data Management and Data Warehouse

# Chapter Objectives

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- What is the data modeling and its design?

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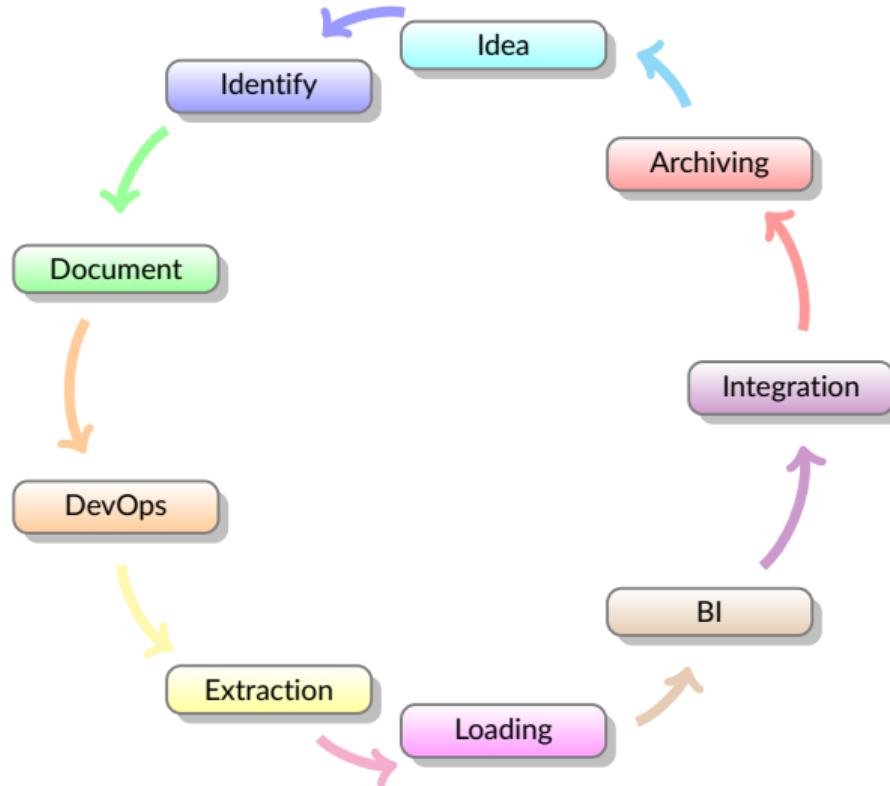
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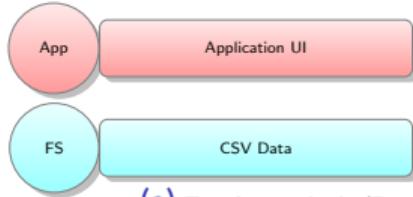
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# Data Management Life-Cycle

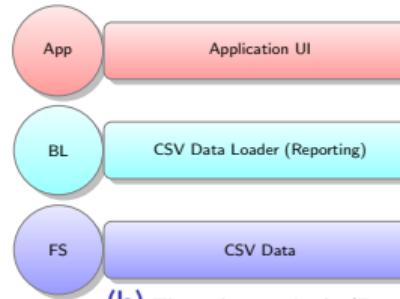


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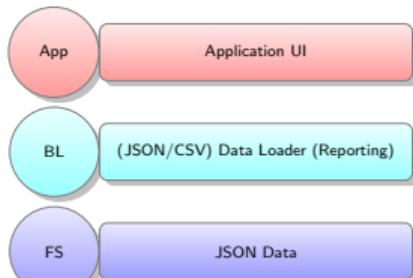
# Motivation to Data Layers (Use Case)



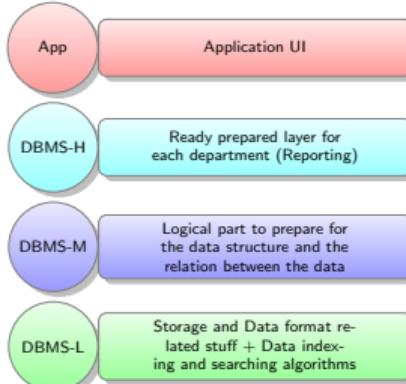
(a) Two layers Arch. (Data & UI)



(b) Three layers Arch. (Data & BL & UI)



(c) Three layers Arch. (Data (multi-sources) & BL & UI)



(d) Four layers Arch. (DB (L, M, H) & UI)

Figure: Data Abstraction Journey

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- To answer these questions you need to understand the **data layers**.

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- The process of **hiding** irrelevant details from developer (user) is called data **abstraction**.

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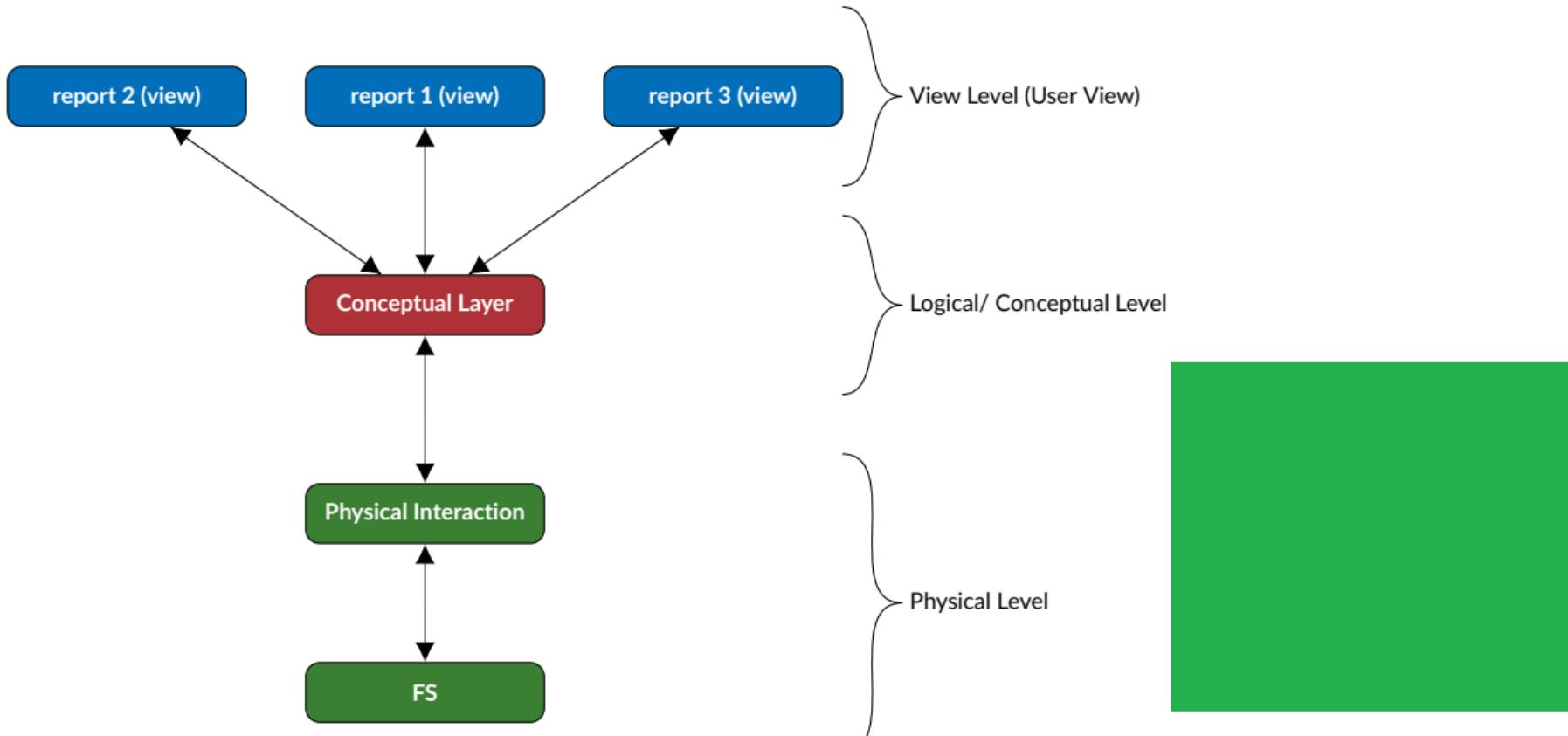
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  - Change the file type or use different storage structure.
  - Changing the access method.

# Physical level

- **Physical level (Internal):**

- Lowest level.
- Describes how data is stored.
- Describes the data structure.
- It allows you to modify the lowest level (Physical part) without any change in the logical schema. These changes could be
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  - Changing the access method.
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  - Changing the access method.
  - Modifying indexes.
  - Change the compression algorithm or hashing technique.

# Physical level

## Example

- Database contains product information.

# Physical level

## Example

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- Physical layer describes

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- Physical layer describes
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  - The amount of memory used.
  - Usually this layer abstracted from the programmers.

# Logical level

- Logical level (Conceptual):



# Logical level

- **Logical level (Conceptual):**
  - Intermediate level.



# Logical level

- **Logical level (Conceptual):**
  - Intermediate level.
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- Describes what is the relationship between the stored data.



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  - Change attribute (Add, delete) to existing table.

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  - The product fields and their data types.
  - How this product interact with other entities in the database.
  - The programmers design this level based on the business knowledge and the requirements.

# View level

- View level (External):



# View level

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  - Highest level.



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- View of the data stored?
- Designed for category of users needs.
- It is the final interface for the user.
- It could be extended or hidden based on user's role.
- Not all the views is extended to all users and there is an authentication based on the category.



## Example

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- It could be designed to show the sales of product in specific region.

## Example

- Database contains product information.
- It could be designed to show the sales of product in specific region.
- We might hide information about some products based on the teams or users.

# Data solution thinking (Summary)

Let's answer our previous the question, How can we solve data challenges?



# Data solution thinking (Summary)

- Let's split the problem based on the data layers.



# Data solution thinking (Summary)

- Let's split the problem based on the data layers.
  - View layer



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# Data solution thinking (Summary)

- Let's split the problem based on the data layers.
  - View layer
    - When we need to add/remove/create new reports it is usually view layer.
    - We don't need to change the logical or physical layer to support the view layer.

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    - Update the data type or the existing relation which could help to fix some data or performance issues.

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    - If we need to change your storage/compression/structure/access technique.
    - If we need to change the data orientation structure from row to column or key-value storage, It is time to change the physical layer.

# Introduction to DWH

## Motivation to Data Warehouse (DWH)

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  - Performance.
  - Integration.
  - Applying analytical functions.
- Vendors who are working to solve the above challenges creating their own product of DWH and their ultimate work is to optimize the above points.

# Motivation to Data Warehouse (DWH)

## Definition (What is Data Warehousing?)

A DWH is defined as a technique for collecting and managing data from varied sources to **provide meaningful business insights**. It is a blend of technologies and components which aids the strategic use of data.

The real concept was given by Inmon Bill. He was considered as a father of the DWH. He had written about a variety of topics for building, usage, and maintenance of the warehouse & the Corporate Information Factory

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- The DWH is the core of the BI system which is built for data analysis and reporting.

# Motivation to Data Warehouse

Data warehouse system is also known by the following names:

- Decision Support System (DSS).
- Business Intelligence Solution.
- Executive Information System.
- Management Information System.
- Analytic Application.
- Data Warehouse.

## Differences Between DWH and Operational DB

# DWH vs Operational databases

Metric	Transactions DB	DWH
Volume	GB/TB	TB/PB
Historical rows	Short-term ≤1000M	Long-Term 1000M+ Subject or multi products
Orientation	Product	Multi organizational units
Business Units	Product team	Not required (De-normalized in many use cases)
Normalization	Normalized	Star Schema or Multi-dim
Data Model	Relational	Advanced reporting and Machine Learning
Intelligence	Reporting	Centralized storage (360°)
Use cases	Online transactions & operations	

# Transnational DB Use cases



# Transnational DB Use cases



# DWH Use cases



# DWH Use cases



# DWH Use cases



## Types of DWH

# Motivation to Data Warehouse

## Types of Data Warehouse

**Enterprise Data Warehouse (EDWH)** It provides decision support service across the enterprise. It offers a unified approach for organizing and representing data (DWH Model). It offers data classifications according to the subject with privileges policy.

**Operational Data Store (ODS):** is a central database that provides an up-to-date (real-time) data from multiple transnational systems for operational reporting into a single DWH.

**Data Mart:** A data mart is a subset of the data warehouse. It specially designed for a particular line of business, such as sales, finance, sales or finance. In an independent data mart, data can collect directly from sources.

# DWH vs ODS vs Data Mart

Metric	DWH	ODS	Data Mart
Latency	Day -1	Real-time	Day -1
Data level	Transnational	Transnational	Summary
Historical	Long-term	Snapshot	Aggregated Long-Term
Size	TB/PB	GB	GB/TB
Orientation	Multi sources	Multi sources	Product
Business Units	Multi organizational units	Product team	Business team

## Use Cases of Operational DB vs DWH



# Use case (Operational DB)

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  - This system has a backend database (MySQL).
  - CRM team can report their sales and customer activities from their database.
  - Product owner can take a decision based on their system backend reports.

# Use case (DWH)

- What is the need for DWH?



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  - So, they need to ingest (transfer) the data from the source systems to one single database.
  - The decision from the DWH is a **global and strategical decision**.
  - If the company needs to build a machine learning model which needs data from different sources. They need to load the data from a centralized database rather than read each source alone.

## Use case (DWH)

The Full picture required a DWH. However, we still need the other operational databases for product development perspective.



# Use case (ODS)

- Why do we need the ODS?



# Use case (ODS)

- Why do we need the ODS?
- How does it fit in our system?



## Use case (ODS)

**XTec** has a call center system which handles the customer inquiries.

This system requires the some data related to usage, customer information, billing details to be calculated and accumulated in **real-time** to be able to give the customer the right answer for his inquiries.

# Use case (ODS)

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# Use case (ODS)

- So, What is the challenge for this system?
  - It needs specific information from different source systems.
  - It requires to track the source system database changes or update in real-time.
  - Its functionality is based on the aggregate data not the transactions for example (It needs the total outgoing calls till time or it needs the total charging amounts from prepaid or the available limits from billing if it is postpaid).

## Use case (ODS)

- ODS is based on change data capture (CDC). This approach used to determine the data change and apply action based on this change.



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- ODS is based on change data capture (CDC). This approach used to determine the data change and apply action based on this change.
- ODS uses the real-time aggregations to support the online systems from different source systems.

## DWH Characteristics

# DWH Characteristics

- The characteristics of DWH:
  - Integrated: *DWH is an integrated environment which allows us to integrate different source systems. Data are modeled (organized) into a unified manner.*
  - Time-Variant: *Data modeled (organized) based on time periods (hourly, daily, weekly, monthly, quarterly, yearly, etc.)*
  - Subject-oriented: *DWH main target is to support business needs for the whole organization including (decision makers, departments, and specific user requirements).*
  - Non-Volatile: *It refers to the data will not erased or deleted (It could be archived and retrieved when needed). Data can be accumulated daily the new snapshots (refreshed at based on the source system interval. For example, It could be updated daily, weekly, and monthly).*

# DWH Architecture

# DWH Architecture Layers

- DWH Architecture contains the following layers:
  - Source system layer.



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  - Storage layer.
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- Metadata layer.
- System operations layer.

# DWH Architecture Overview

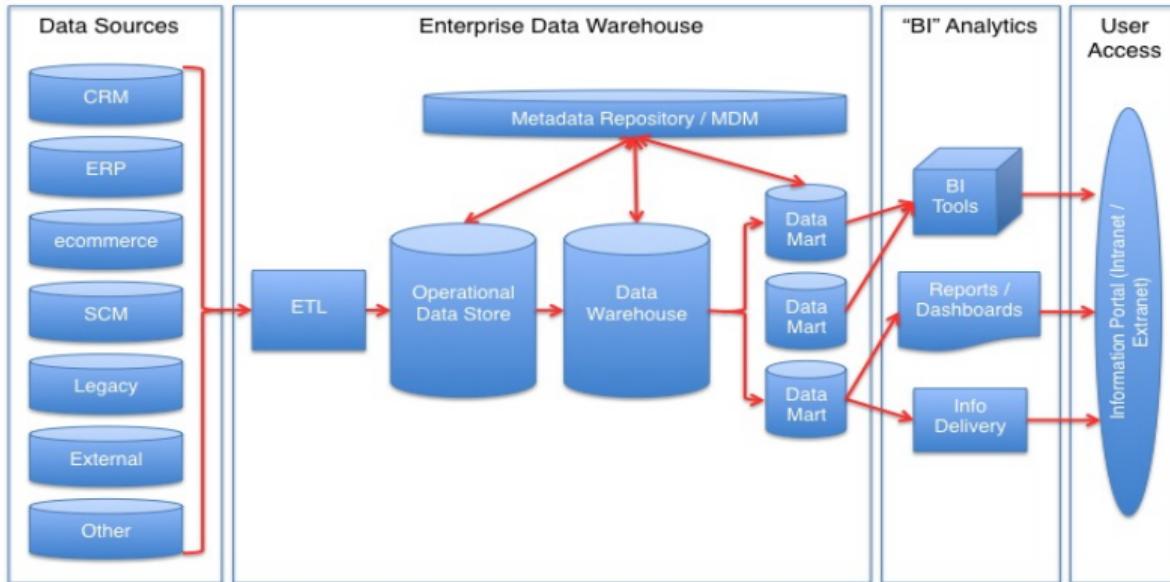


Figure: taken from

# Source System Integration Process

- We have requirements or business case (It could be DWH unification)
- Identify the stakeholders (Data owner(s))
- Before we start, ALL communications from start to the end should be documented into any format.
  - Confluence page, Word, Sheet.(The best option to be query format!!)
  - Make the discussion online and put comments to make the history available always (we need to stop the one man show).
  - All tasks should be clear what is the expected output for example (analysis means document what is the column names, structure format).
- Source System Data Analysis.
- Check The data structure
- Check for the data latency
- Check for connectivity and security analysis (assessment).
- Technical discussion about the best way to ingest the data (push/pull).



- Data Ingestion format (file, database, api, etc..)

- Sign or confirmation for every point from the stakeholders.

# ETL Process

## ETL vs ELT When? Why?



# Data Models

# What is data model?

Data model is

- An abstract model that organizes elements of data.



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- It describes how application (report) API data manipulation.
- It describes the conceptual design of a business or an application with its flow, logic, semantic information (rules), and how things are done.
- It refers to a set of concepts used in defining such as entities, attributes, relations, or tables.

# What is data model?

Data model is not

- a science.
- a static design for each organization.
- a type of database.
- a new invention which needs to be done for each project.

Data model is

- an engineering design practices.
- a general concepts which lead to build full architecture.
- different based on the use case and the database type.
- customizable and we can utilize some of ready built architecture.
- implementing using different ways.
- affecting the information reporting performance and ways.

# Why does data models are important?

- Data models are currently affecting software design.
- It decides how engineers will think about the problem they are solving.



# Data Model Design

# Data Model Design vs Implementation

- You need to build a home. So, how do we design this home?



# Data Model Design vs Implementation

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  - Determine if the home is one level or multi-level and decide man bedrooms and bathrooms for each floor. (User needs)



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- What do we do for the implementation?
  - Hire a contractor to build (implement the design) the home.
  - This phase will implement the design but it also include some detail related to the actual way to build the tools and the material. (Physical Design)

# DWH Architecture Overview

There are mainly three types of Datawarehouse Architectures: -

- Single-tier architecture.
- Two-tier architecture.
- Three-tier architecture.



# File Formats

# Data Models

- Any Big Data solution working based distributed systems.



# Data Models

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- What is distributed systems in brief?



# Data Encoding and Formats

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# Data Compression Technique

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# Data Archiving and Retention

# Data Models

- some details about hot vs cold storage,



## Different Types of Storage

# Cold storage vs Hot storage

some details about hot vs cold storage,



# DWH On Cloud



## Further Readings and Assignment