

(Big) Data Engineering In Depth

From Beginner to Professional

Mostafa Alaa Mohamed

Senior Big Data Engineer

 MoustafaAlaa  Moustafa Alaa  @Moustafa_alaa22

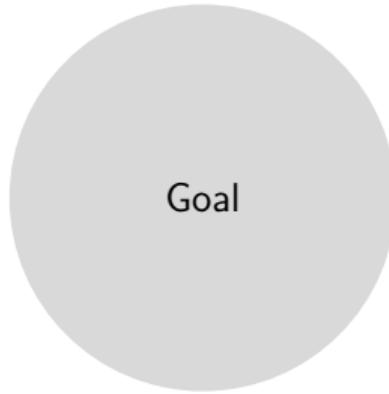
 mustafa.alaa.mohamed@gmail.com

¹Big Data & Analytics Department, Epam Systems

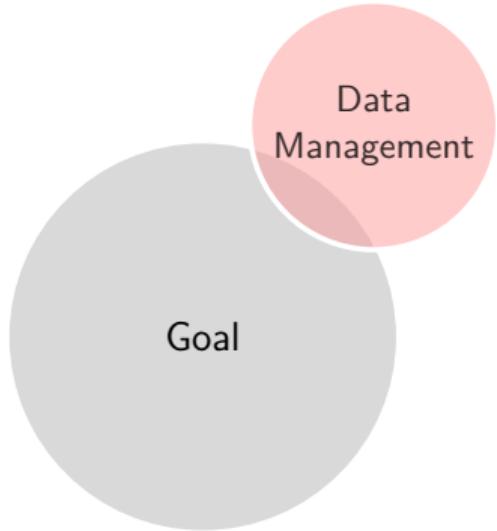
The Definitive Guide to Big Data Engineering Tasks

Course Introduction

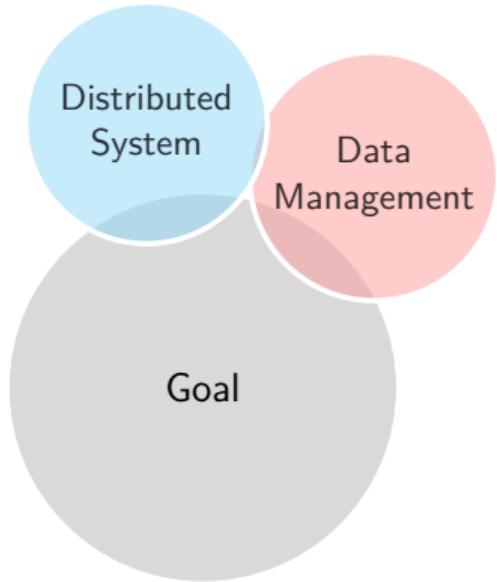
Course Target



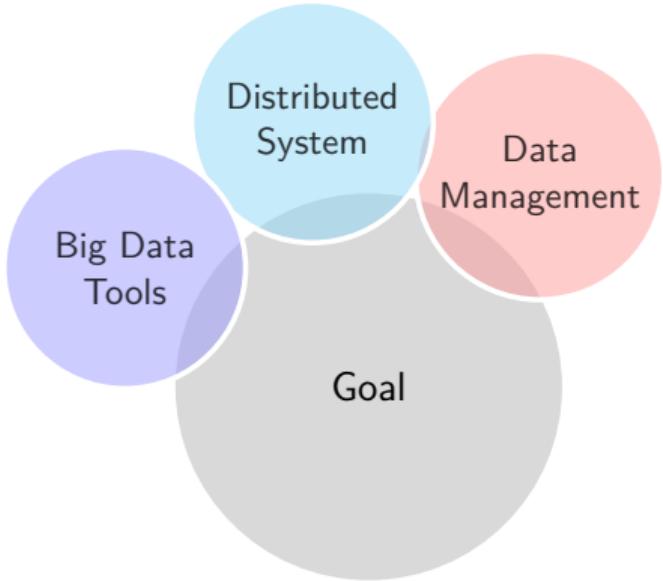
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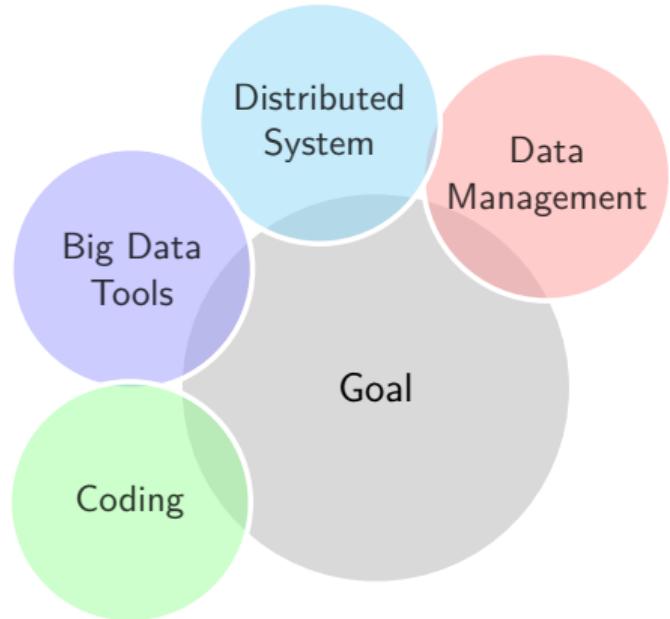
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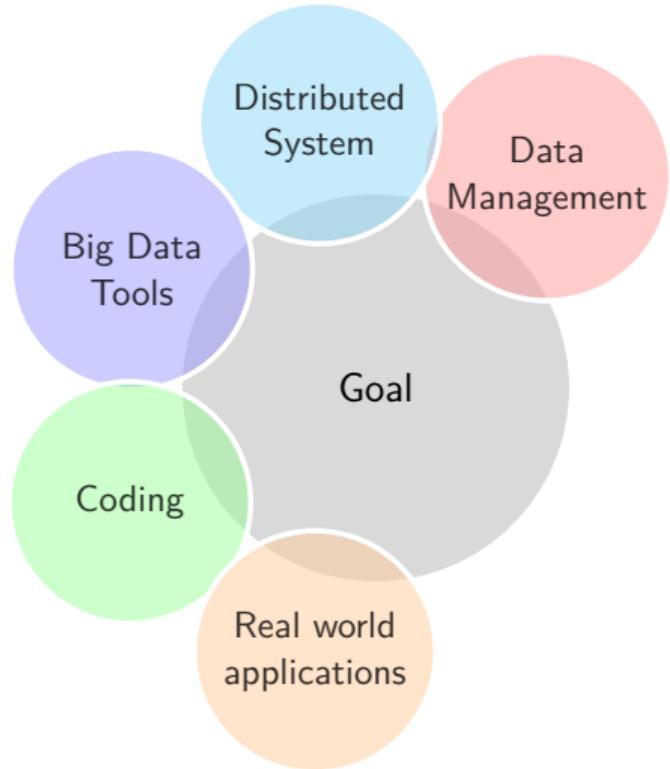
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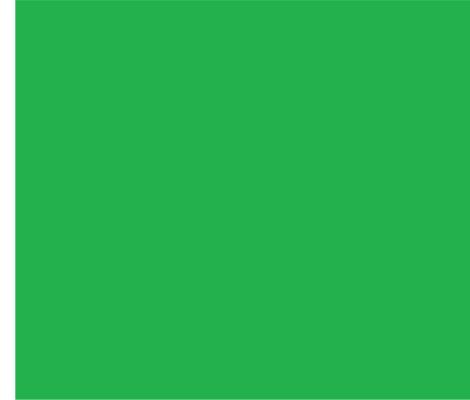
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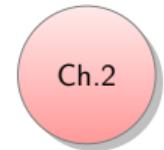


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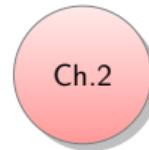


Learning Objectives and Audience

Learning Objectives



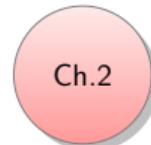
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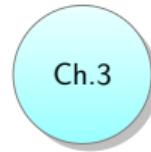
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Understand the data management life-cycle



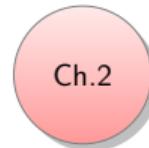
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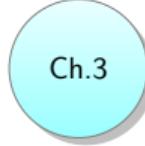


Learning Objectives



Ch.2

Simplify the concepts in data management.
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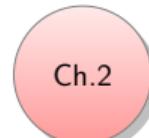


Ch.3

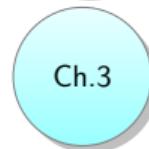
Illustrate the basics of distributed systems concepts.



Learning Objectives



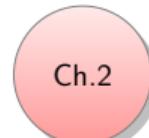
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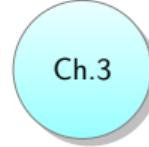
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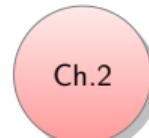
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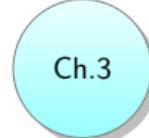
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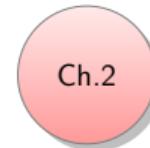
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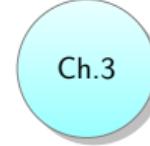
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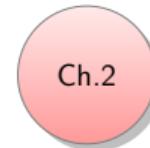
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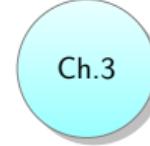
Apply QA and testing the data.



Learning Objectives



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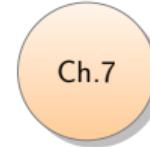
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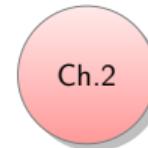
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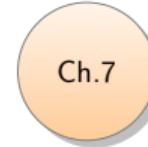
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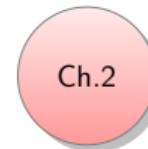
Apply QA and testing the data.



Building real-life examples.



Learning Objectives



Ch.2

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Ch.3

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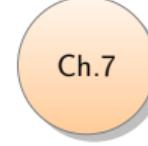
Ch.4/6

Be familiar with ETL for (batch/streaming) data
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Ch.6/7

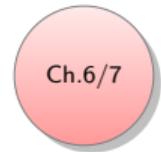
Apply QA and testing the data.



Ch.7

Building real-life examples.

Learning Objectives



Learning Objectives

Ch.6/7

Applying machine learning over big data.



Learning Objectives



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Learning Objectives



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Build and scale your data product.



Learning Objectives



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Learning Objectives



Applying machine learning over big data.



Build and scale your data product.



Understanding of the DevOps tools and its functions
in data life-cycle and development automation (e2e).



Learning Objectives



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Videos classification

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

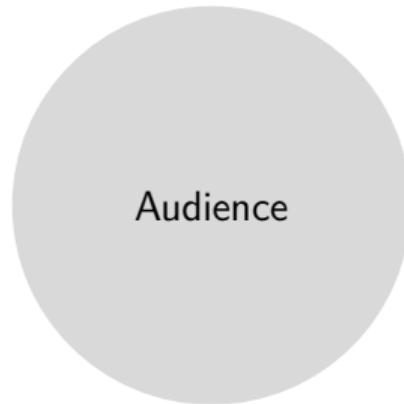
Table: Video classification

The green circle ● means short video.

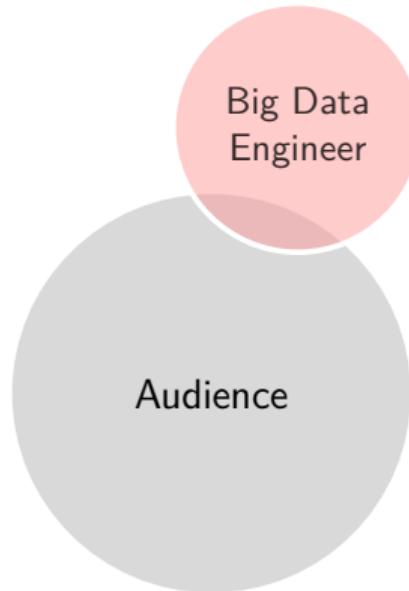
The blue circle ● means medium video.

The red circle ● means long video

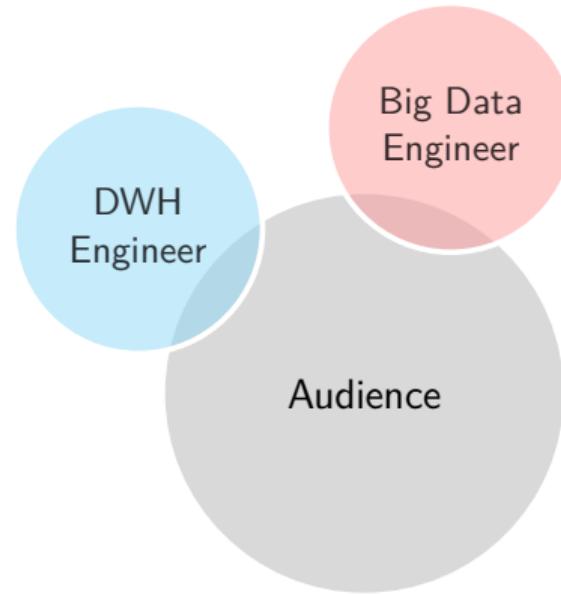
Audience: Who Should Take This Course?



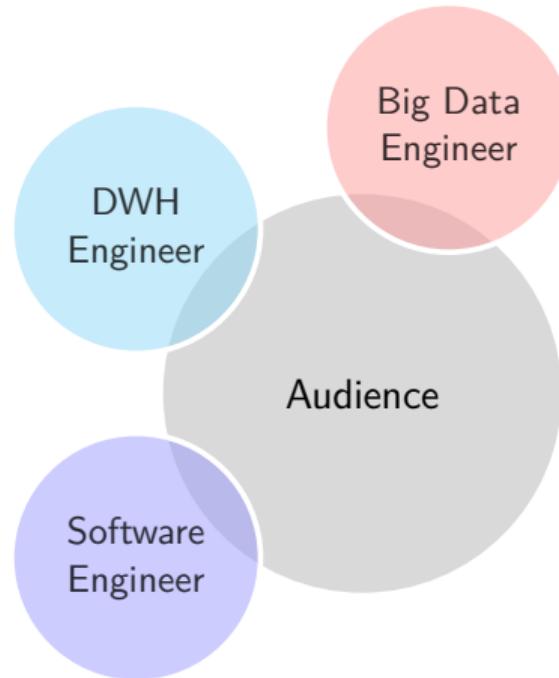
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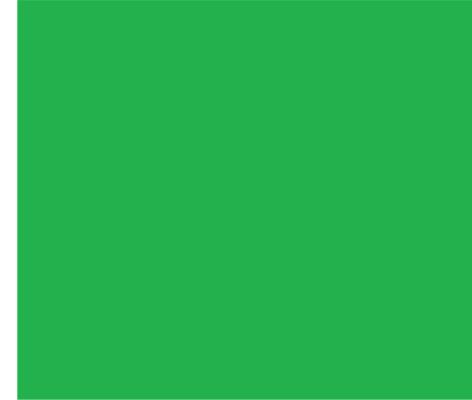
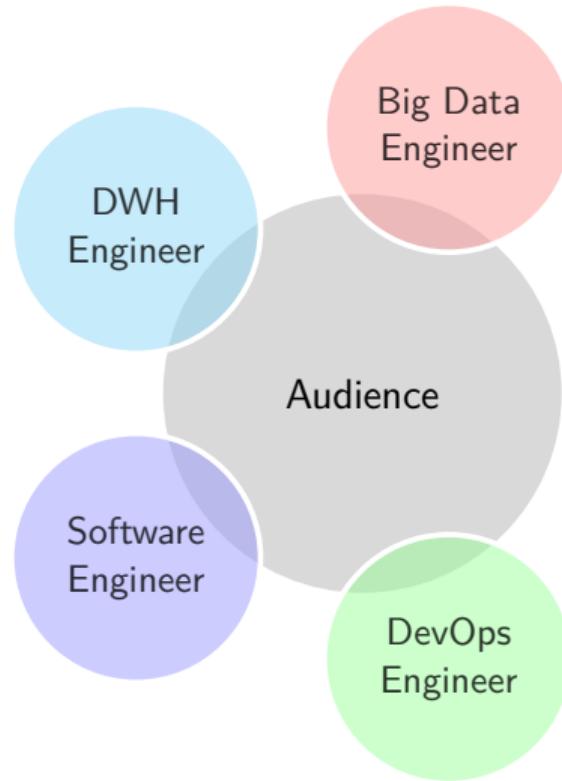
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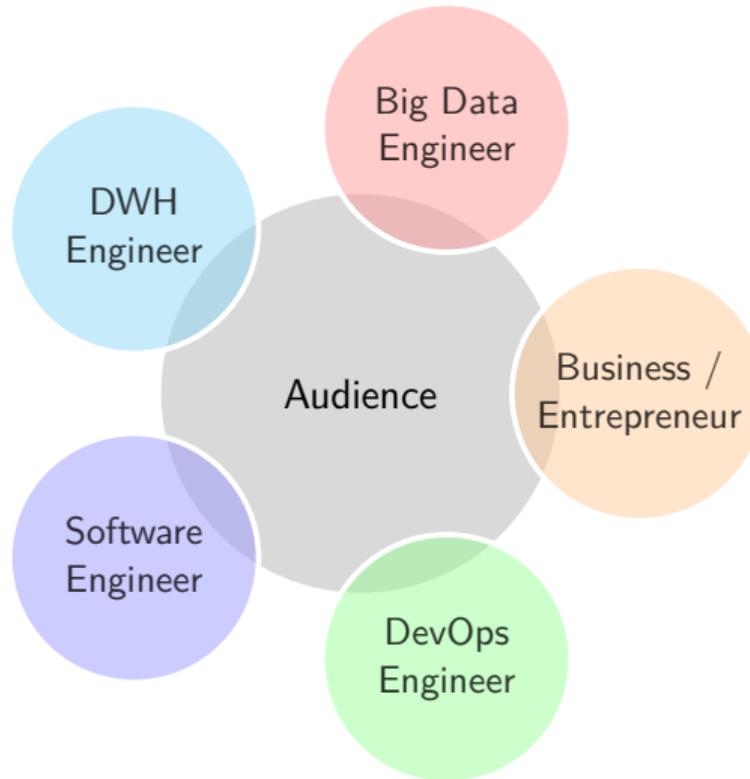
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Getting max benefit from this course

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Take the course advantage

- Follow the order of the videos as described.

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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

Ch.08 Massging Systems

Ch.09 Data Orchestration

Ch.10 NoSql

Ch.11 Elastic

Ch.12 Data Architecture Design

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Assignments, Labs, and Text Books

Assignments and Labs

Remark

- Full project code.

Assignments and Labs

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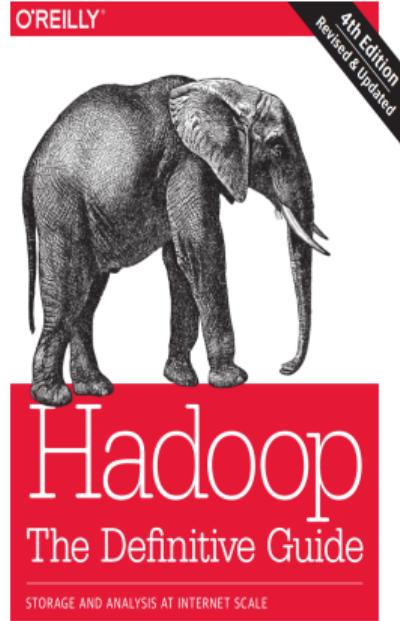
- Full project code.
- Notebooks (Jupyter or Zeppelin).

Assignments and Labs

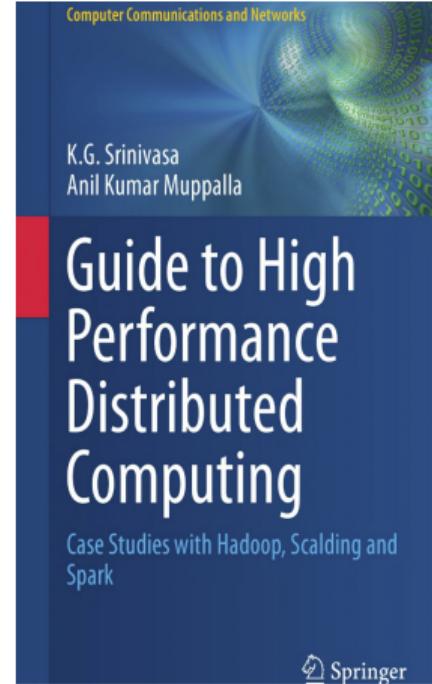
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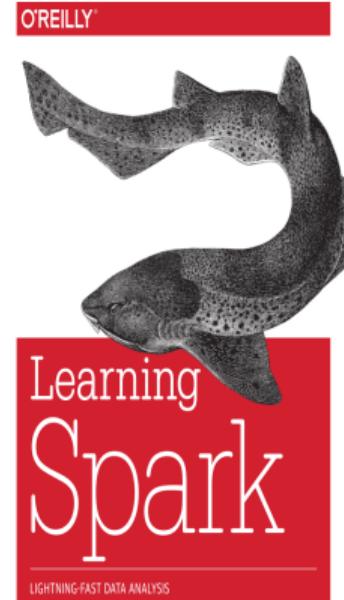
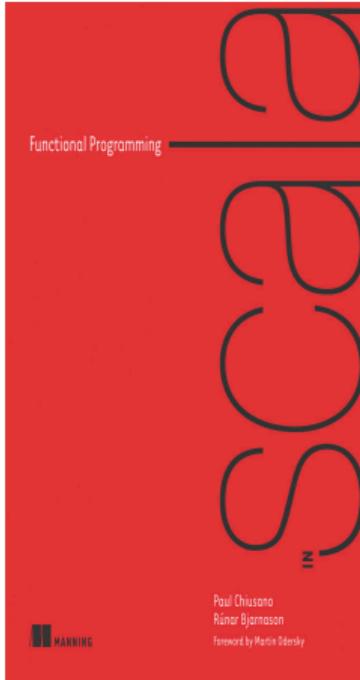
Textbooks-1



Tom White



Textbooks-2



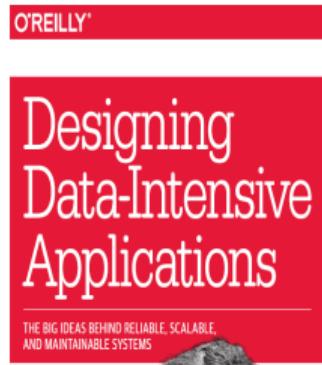
Textbooks-3



Neha Narkhede,
Gwen Shapira & Todd Palino



Jeff Carpenter & Eben Hewitt



Martin Kleppmann



Ugly but important

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



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- 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

- Be familiar with data management life-cycle.

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- Understand the data abstraction and the data layer.



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- Explain the data Encoding and Formats.

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- Use cases for DWH and how it differ from the operational db.
- Explain the data Encoding and Formats.
- Show what is the challenges to build a DWH?
- What is the data modeling and its design?



Data Management

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- Data are a product.



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- Data product has a life-cycle as following (simplified):



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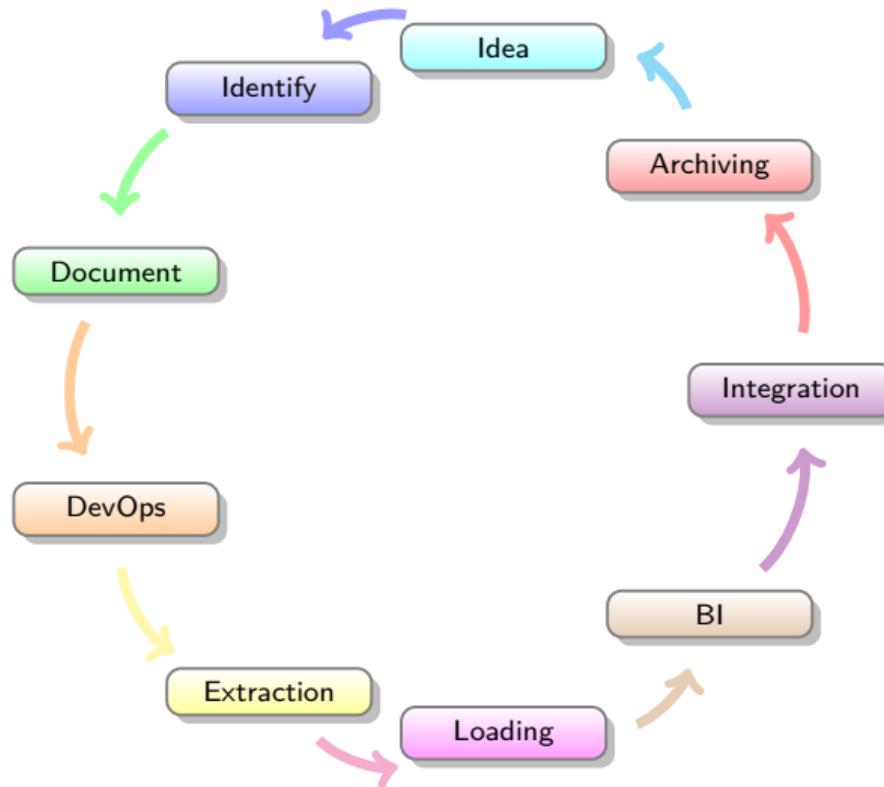
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 - Data retention or **archiving** process ex: (Hot or Cold storage).

Data Management Life-Cycle

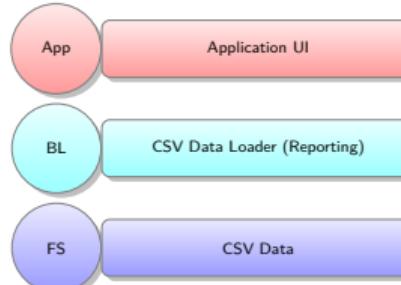


Data Abstraction

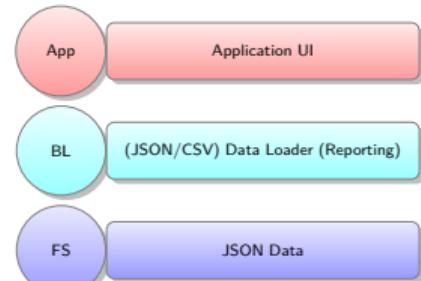
Motivation to Data Layers (Use Case)



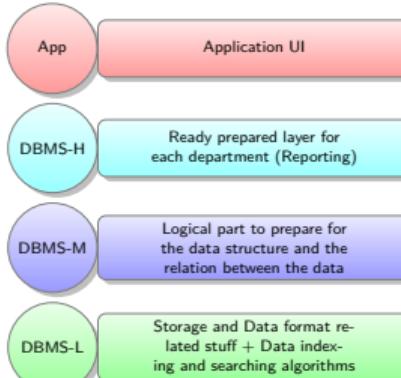
(a) Two layers Arch. (Data & UI)



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



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

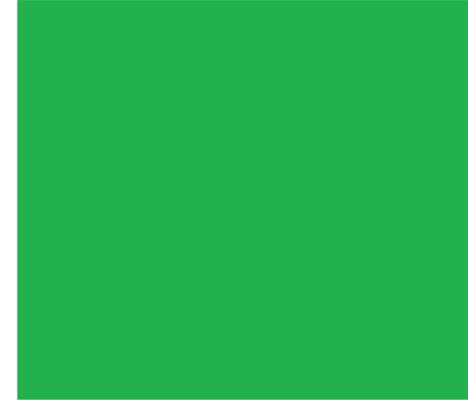


(d) Four layers Arch. (DB (L, M, H) & UI)

Figure: Data Abstraction Journey

Motivation to Data Layers (Solution Thinking)

- How can we think about a data solution or challenges in the data products?



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- How can we think about a data solution or challenges in the data products?
 - Requirements analysis.



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 - Think about how to overcome the challenges.

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 - What if we enhance/change the data structure or modeling?

Motivation to Data Layers (Solution Thinking)

- How can we think about a data solution or challenges in the data products?
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 - Identify the problem (challenges).
 - Think about how to overcome the challenges.
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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**.

Data Layers (Abstraction)

Definition

Data Abstraction and Data Independence: DBMS comprise of complex data-structures. In order to make the system efficient in terms of retrieval of data, and reduce complexity in terms of usability of users, developers use abstraction i.e. hide irrelevant details from the users. This approach simplifies database design.

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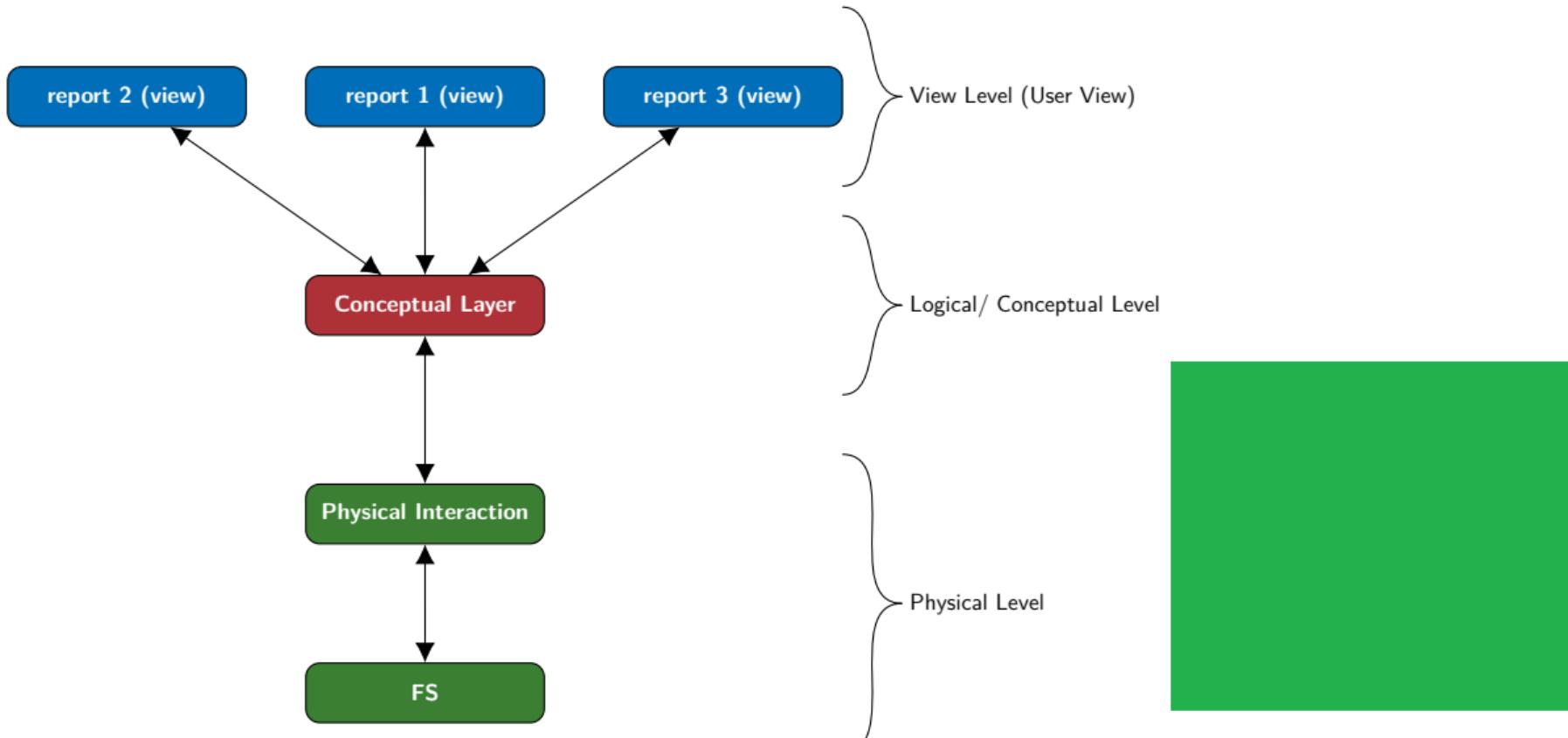
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 - View Level.

Data Layers (Abstraction)



Physical level

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 - Describes how data is stored.



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 - Change the compression algorithm or hashing technique.

Physical level

Example

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Physical level

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- Physical layer describes

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 - Usually this layer abstracted from the programmers.

Logical level

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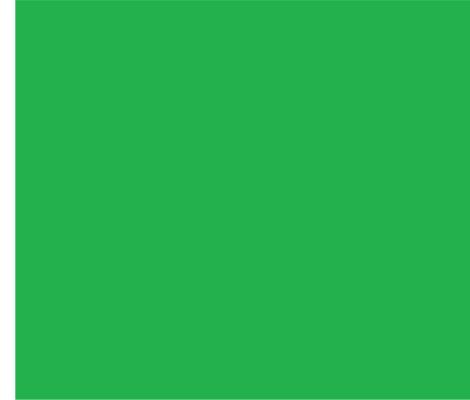
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Example

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- Logical Layer describes
 - 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

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- Not all the views is extended to all users and there is an authentication based on the category.



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- 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)

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 - When you have missing sources into your logical layer and you need to add this source and its structure.
 - There is a performance issue in the existing reports and you need to change in the model. For example, reduce the join by creating new join table (*materialized view*).
 - 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 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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- There are some challenges facing the people who work on data management backend:
 - 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>
Orientation	Product	Subject or multi products
Business Units	Product team	Multi organizational units
Normalization	Normalized	Not required (De-normalized in many use cases)
Data Model	Relational	Star Schema or Multi-dim
Intelligence	Reporting	Advanced reporting and Machine Learning
Use cases	Online transactions & operations	Centralized storage (360°)

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

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

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- 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 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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 - 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).

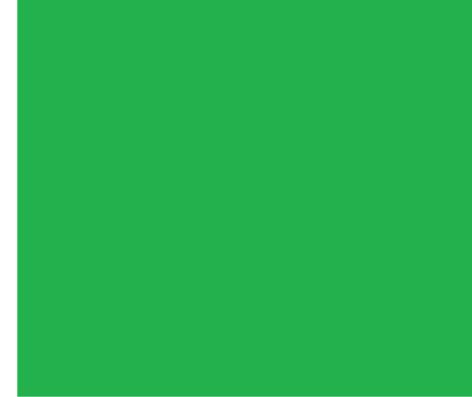
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- ODS uses the real-time aggregations to support the online systems from different source systems.

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).*

Hot vs Cold Storage

Hot vs Cold Storage

SOME DETAILS HERE



DWH Architecture

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- Metadata layer.
- System operations layer.

DWH Architecture Overview

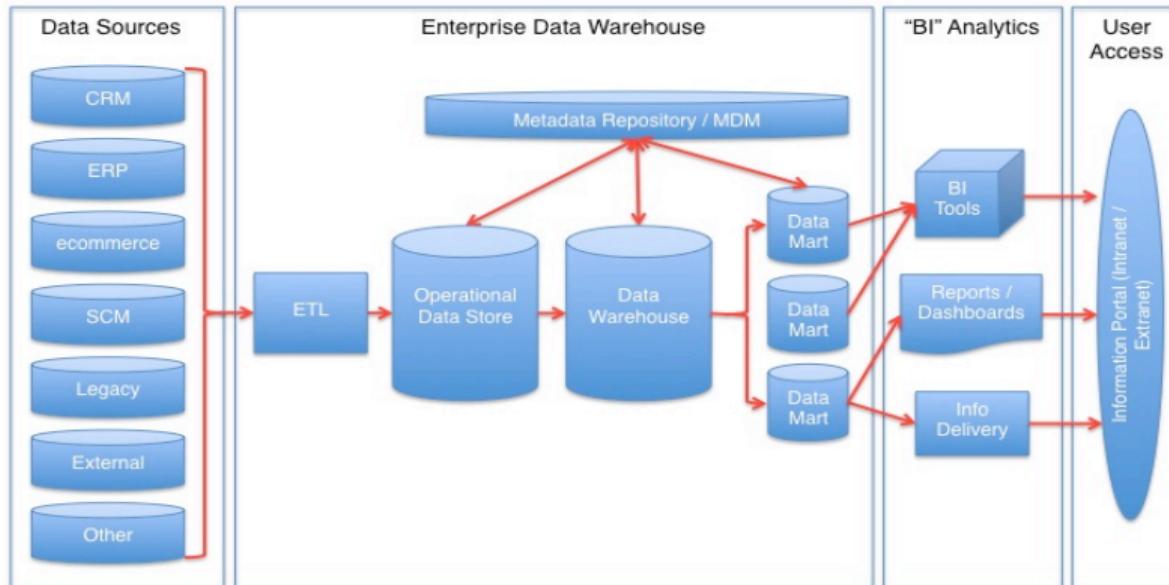


Figure: taken from

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 - Make the discussion online and put comments to make the history available always.

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- In some companies they hire or dedicate a team for this part (business analyst, system analyst, data analyst, or demand team).
- Before we start, ALL communications from start till the end should be documented into any format.
 - Confluence page, Word, or Excel sheet.
 - Make the discussion online and put comments to make the history available always.
 - All tasks should be clear what is the expected output for example (analysis means to document data structure, format, column names, etc..).

Source System Integration Process

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- This layer deliver a data analysis (Source system interface) document.

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- This layer output is a minimal data cleansing (no transformation) into the staging/landing layer.

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- The decision of the storage type is based on the use case and the data.



Data Modeling

Data Modeling Objective

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- Explore different types of data modeling.
- We will not go in details about how to design in this part (we will explain it later and in the appendix).

What is data model?

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- It refers to a set of concepts used in defining such as entities, attributes, relations, or tables.

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- It could engage with any source systems integration from early stages.
- This stage output is data model design document or mapping sheet.

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 vs Implementation

REVIEW THIS EXAMPLE

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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)

Data Model Design Principle

Decide what is the limitation of this part what is in and what is out to be part of the appendix

- facts, star schema, dimensional modeling techniques.
- Fact Tables and Dimension Tables.
- Multidimensional Model(Star, Snowflake, and Galaxy Schema).
- Support Roll Up, Drill Down, and Pivot Analysis
- Time Phased / Temporal Data
- Operational Logical and Physical Data Models
- Normalization and Denormalization
- Model Granularity : Level of Detail



ETL Process



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- This team takes the delivered output from the previous stage (data modeling) and start to implement the mapping.
- The implementation of the ETL preferred to be unified across the team members and the organization unless there is a special case of license or capacity.

ETL Characteristics

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 - Error Handling.
 - Managing Bad Data (Rejection Handling).

ETL Logging

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ETL vs ELT When? Why?

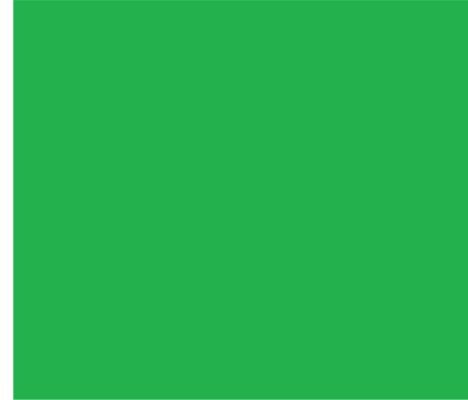
Storage layer

Storage layer



Logical layer

Logical layer



Reporting (UI) layer

Reporting (UI) layer



Metadata layer

Metadata layer



System operations layer

System operations layer

DWH Architecture Overview

There are mainly three types of Datawarehouse Architectures: -

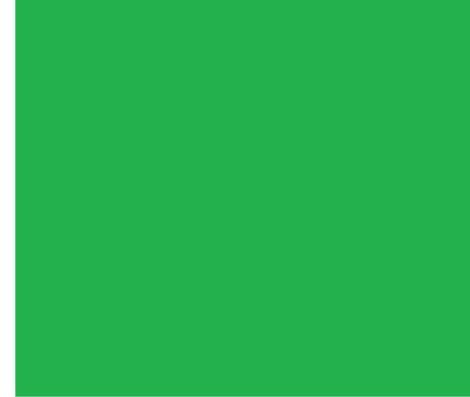
- Single-tier architecture.
- Two-tier architecture.
- Three-tier architecture.



File Formats

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- Any Big Data solution working based distributed systems.



File Formats

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- What is distributed systems in brief?



Data Encoding and Formats

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Data Archiving and Retention

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- some details about hot vs cold storage,



DWH On Cloud

Further Readings and Assignment