(Big) Data Engineering In Depth

From Beginner to Professional

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Senior Big Data Engineer
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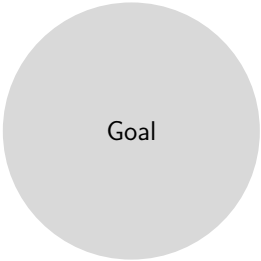
[1]Big Data & Analytics Department, Epam Systems

The Definitive Guide to Big Data Engineering Tasks

Course Introduction

Course Target



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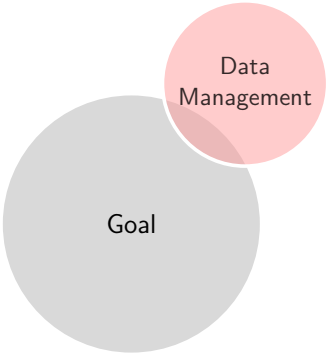

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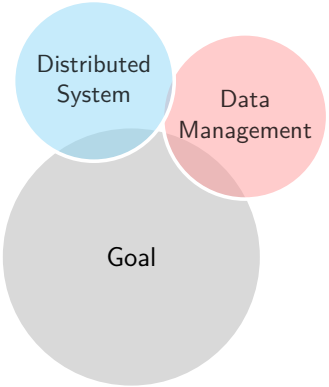

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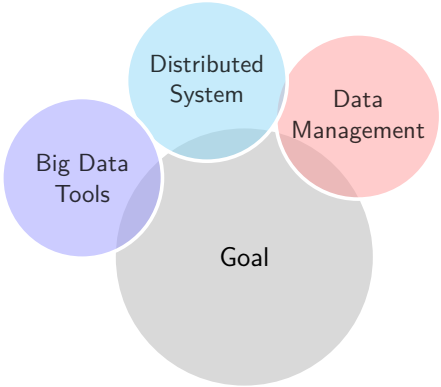

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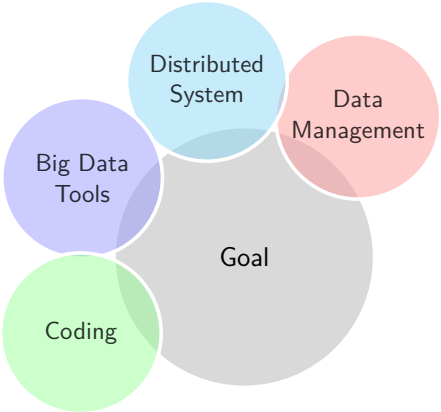

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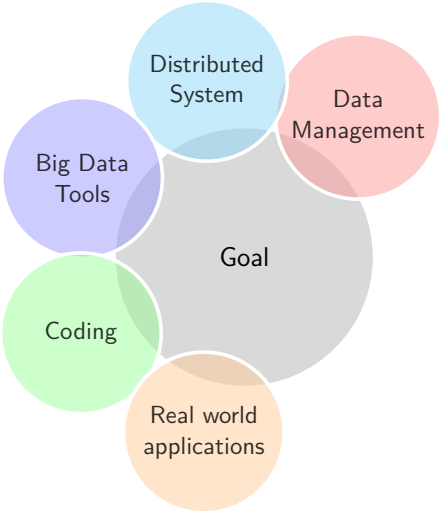

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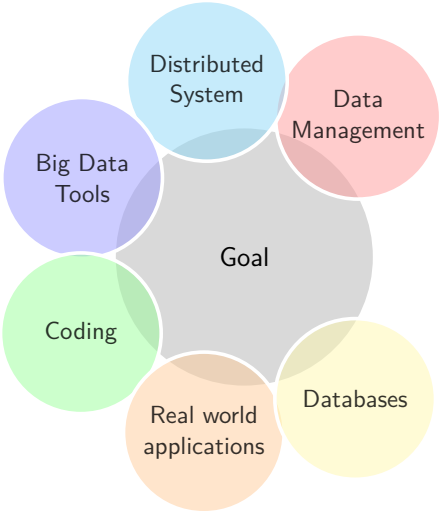

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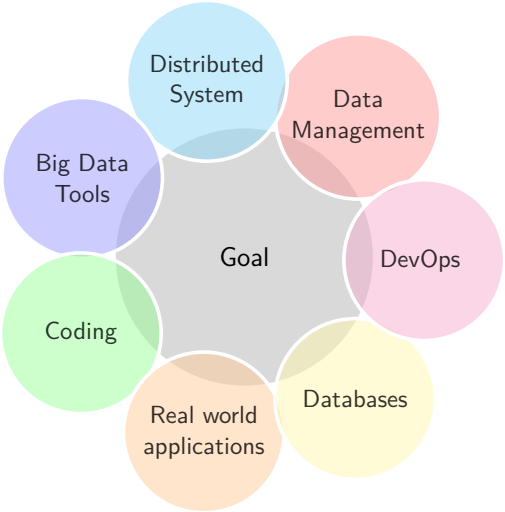

Learning Objectives and Audience

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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		●	

Table: Video classification
The green circle ● means short video.
The blue circle ● means medium video.
The red circle ● means long video

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- Business or entrepreneur who needs to get more information about how to build or manage a data product.

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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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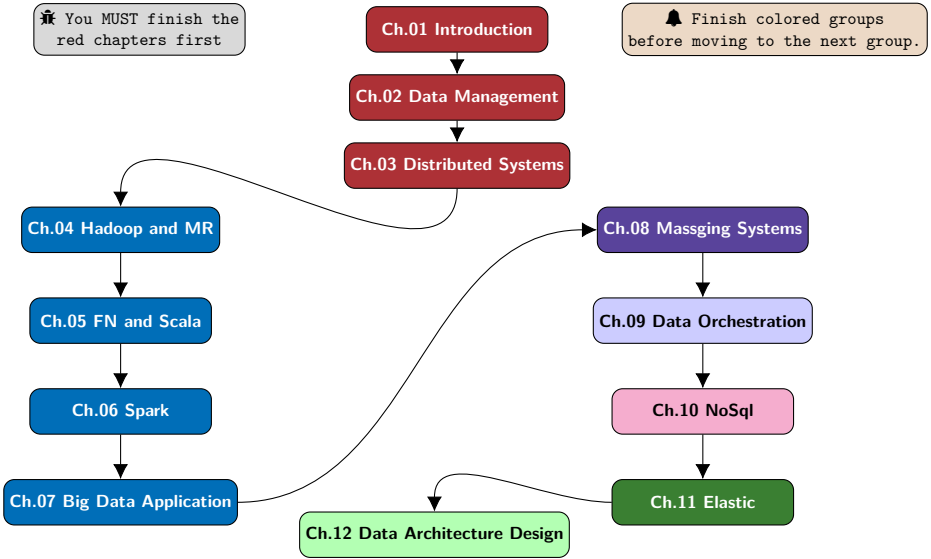
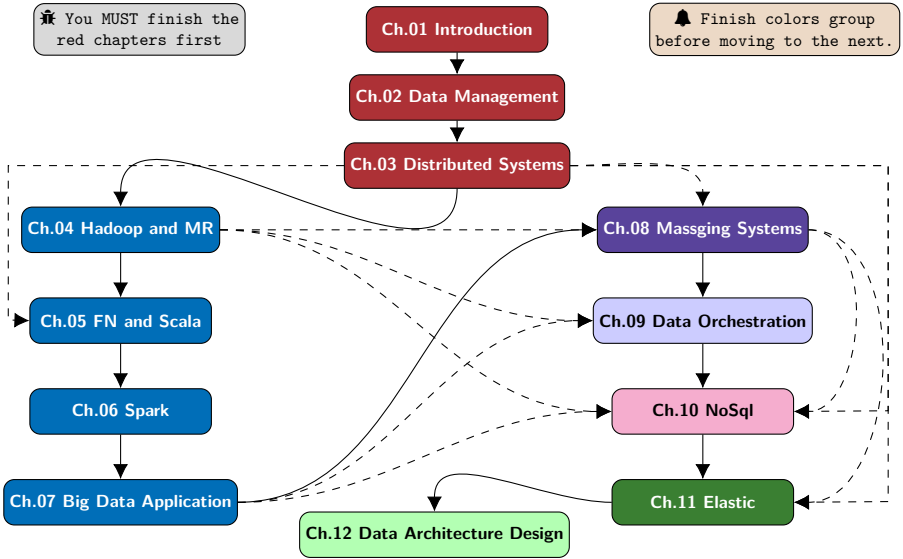


Chapter Dependencies (Jump Out Path)



Assignments, Labs, and Text Books

Assignments and Labs

Remark

- Full project code.

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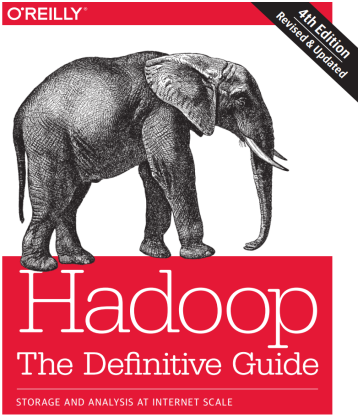
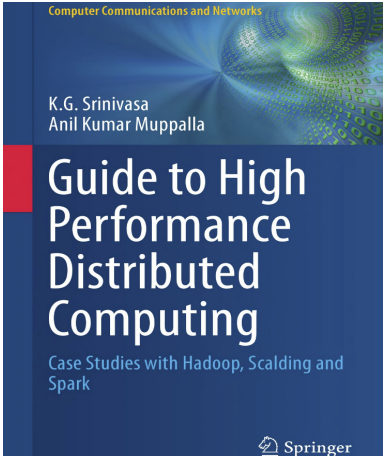
Textbooks-1

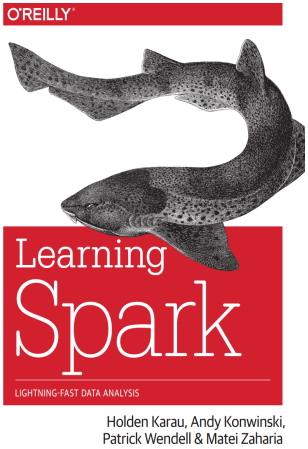

O'REILLY
4th Edition
Revised & Updated
Hadoop
The Definitive Guide
STORAGE AND ANALYSIS AT INTERNET SCALE
Tom White


Computer Communications and Networks
K.G. Srinivasa
Anil Kumar Muppalla
Guide to High Performance Distributed Computing
Case Studies with Hadoop, Scalding and Spark
Springer

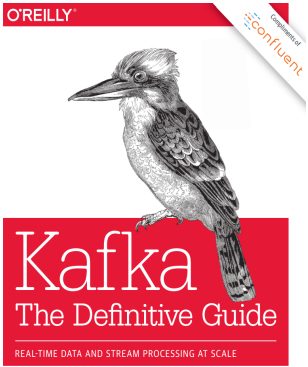
Textbooks-2

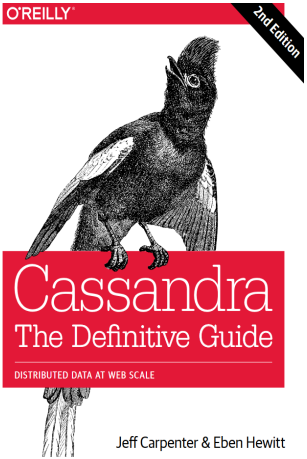

Functional Programming
scala
in
Paul Chiusano
Rúnar Bjarnason
Foreword by Martin Odersky
MANNING

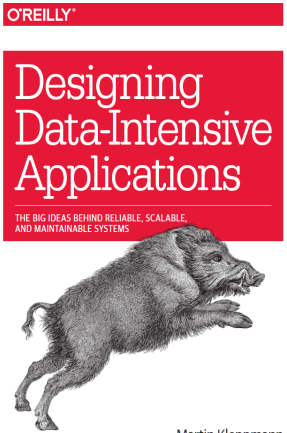

O'REILLY
High Performance
Spark
BEST PRACTICES FOR SCALING
& OPTIMIZING APACHE SPARK
Holden Karau &
Rachel Warren


O'REILLY
Learning
Spark
LIGHTNING-FAST DATA ANALYSIS
Holden Karau, Andy Konwinski,
Patrick Wendell & Matei Zaharia

Textbooks-3


O'REILLY
Compliments of
confluent
Kafka
The Definitive Guide
REAL-TIME DATA AND STREAM PROCESSING AT SCALE
Neha Narkhede,
Gwen Shapira & Todd Palino


O'REILLY
2nd Edition
Cassandra
The Definitive Guide
DISTRIBUTED DATA AT WEB SCALE
Jeff Carpenter & Eben Hewitt


O'REILLY
Designing
Data-Intensive
Applications
THE BIG IDEAS BEHIND RELIABLE, SCALABLE,
AND MAINTAINABLE SYSTEMS
Martin Kleppmann

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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

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- What is the data modeling and its design?

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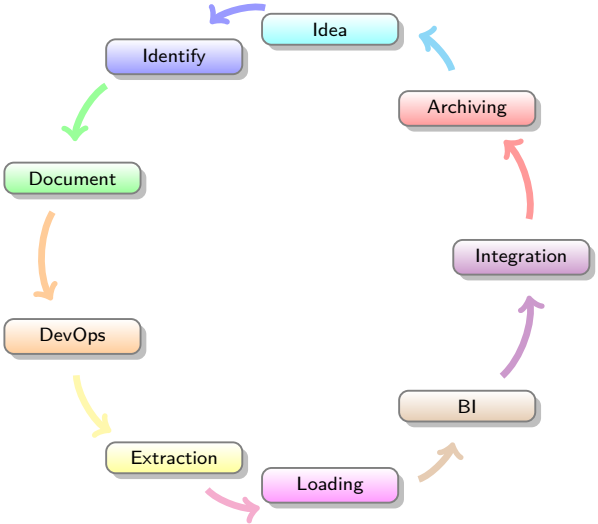
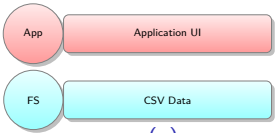
Data Management Life-Cycle

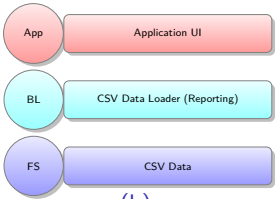


Data Abstraction

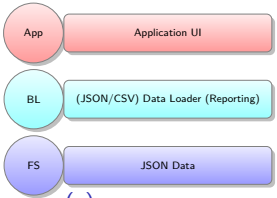
Motivation to Data Layers (Use Case)



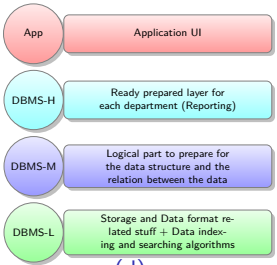
(a) Two layers Arch. (Data & UI)



(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

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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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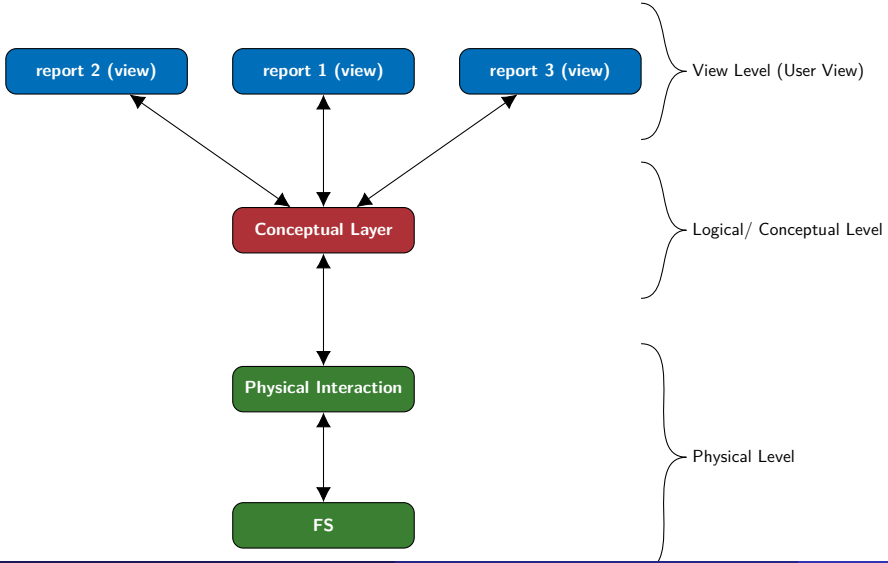

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    - Modifying indexes.
    - Change the compression algorithm or hashing technique.

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  - The programmers design this level based on the business knowledge and the requirements.

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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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View level

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- 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.

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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 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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  - 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	Short-term	Long-Term
rows	<1000M	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	Centeralized storage (360°)

Transnational DB Use cases

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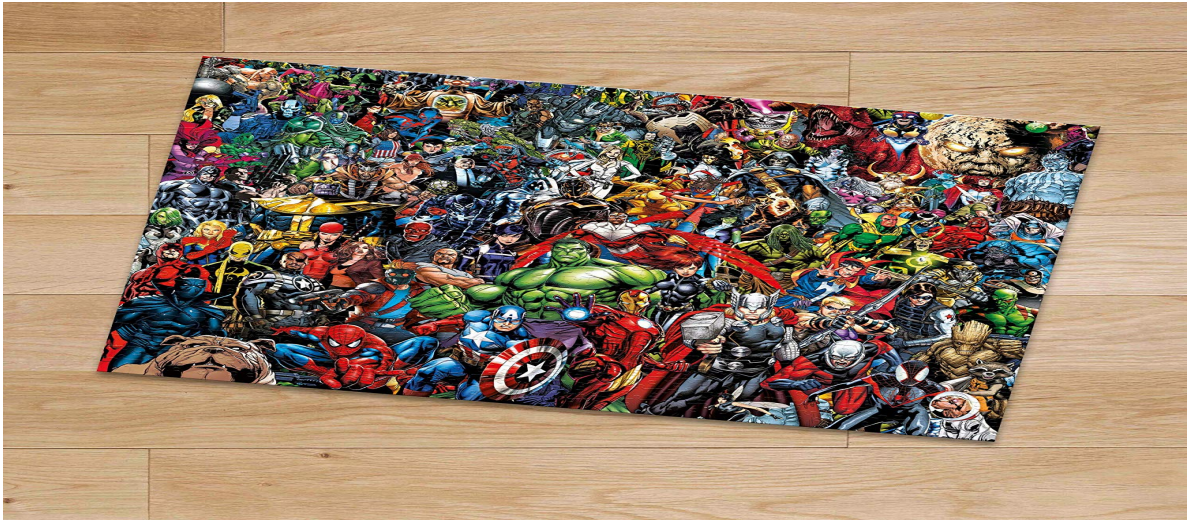
DWH Use cases

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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  - 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)

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  - The decision from the DHW 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 inquires.

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.
  - It's 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)

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

DWH Characteristics

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- 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

DWH Architecture Layers

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  - Reporting (UI) layer.
  - Metadata layer.
  - System operations layer.

DWH Architecture Overview

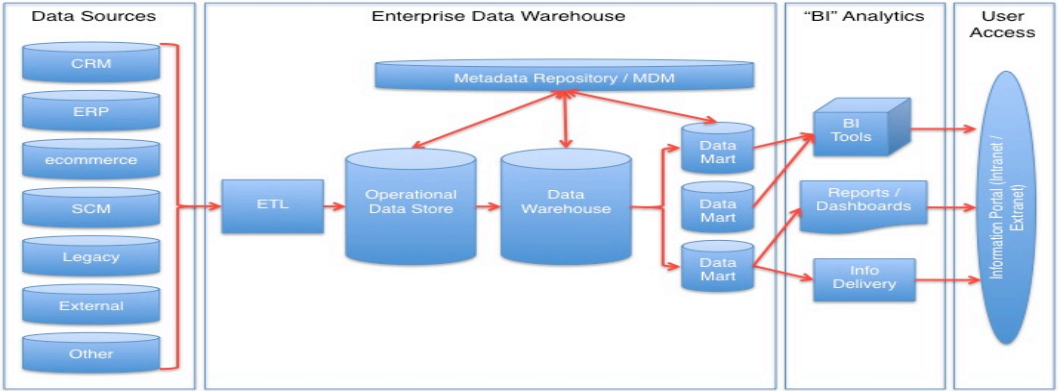

Figure: taken from https://commons.wikimedia.org/wiki/File:Datawarehouse_reference_architecture.jpg

Source System Integration Process

Source System Integration Process

- In some companies they hire or dedicate 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.
  - Conflounce page, Word, 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

- Requirements.
- Identify the stakeholders (Data owner(s)).
- Data Analysis.
- Analyze data latency.
- Connectivity analysis and security (assessment).
- Technical discussion about the best way to ingest the data.
- Data Ingestion method and format.
- Sign or confirmation for every point between the stakeholders.
- This layer deliver a data analysis (Source system interface) document.

Extraction Layer

Extraction Layer

- In some companies they hire or dedicate team for this part (extraction or ingestion team) but in other companies it is part of the data engineering team.
- This layer take the output analysis and decisions from the previous layer (source system analysis) and do the implementation (output quality from the previous team highly affect this team).
- There are many consideration this team need to take care about or deal with but we can summarize it in the following:
  - Data latency will affect the tool and the methodology (stream or batch).
  - Data extraction method (push or pull).
  - Data size and format compared with the available resources for this project.
- This layer output is a minimal data cleansing (no transformation) into the staging/landing layer.

Staging Layer

Staging Layer

- This layer handled by the same team who own the storage part in most of the organizations.
- Segregation of this layer if it uses different storage type or multi-teams access this layer for different purpose (ex: Kafka as landing layer) NEED TO CLARIFY THIS EXAMPLE AS KAFKA IS NOT STORAGE BUT COULD BE LANDING LAYER.
- All the ETL layers are working on top of this layer.
- The decision of the storage type is based on the use case and the data.

Data Modeling

Data Modeling Objective

- Understanding the data modeling and its roles.
- Be aware about its importance.
- 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 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

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

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- 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

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

Data Model Design vs Implementation

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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

ETL Process

What is ETL?

ETL vs ELT When? Why?

Storage layer

What is ETL?

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

File Formats

- Any Big Data solution working based distributed systems.

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- Any Big Data solution working based distributed systems.
- 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

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- some details about hot vs cold storage,

DWH On Cloud

Further Readings and Assignment