(Big) Data Engineering In Depth

From Beginner to Professional

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[1]Big Data & Analytics Department, Epam Systems

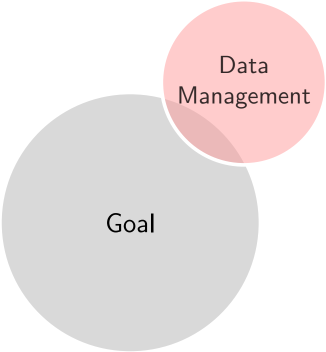
The Definitive Guide to Big Data Engineering Tasks

Course Introduction

Course Target

Goal

Course Target



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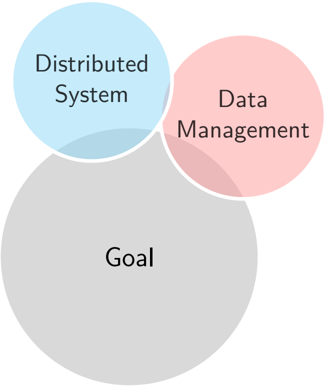

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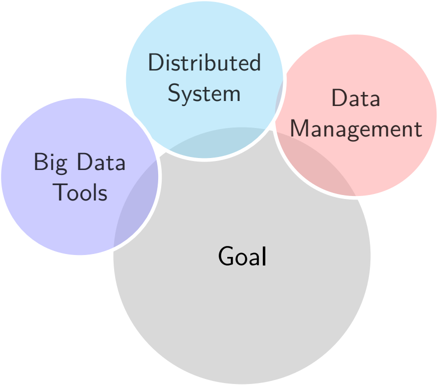
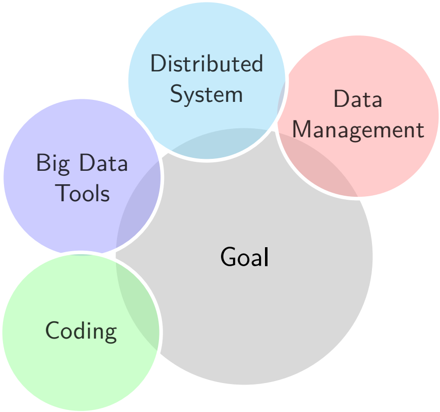
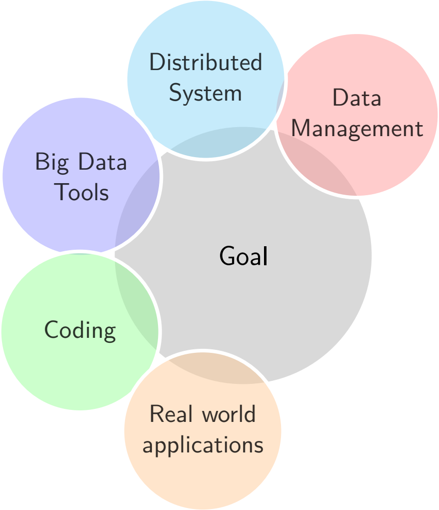



Distributed
System
Data
Management
Big Data
Tools
Goal
Coding

Course Target



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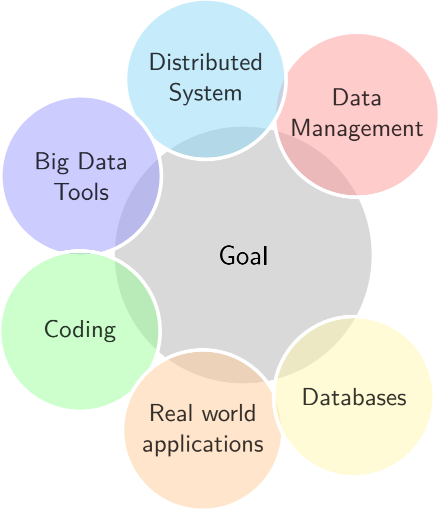

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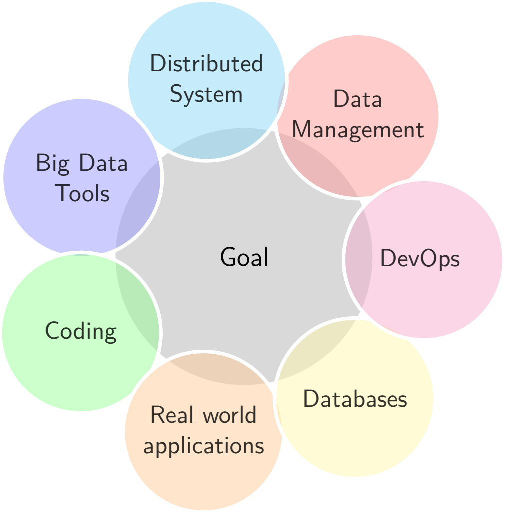

Learning Objectives and Audience

Learning Objectives

Ch.2

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Simplify the concepts in data management.
Understand the data management life-cycle

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Ch.9/12

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Videos classification

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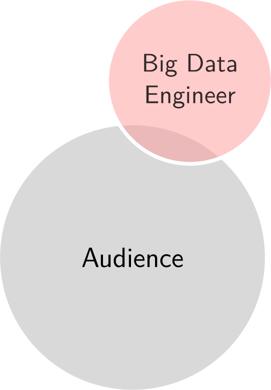

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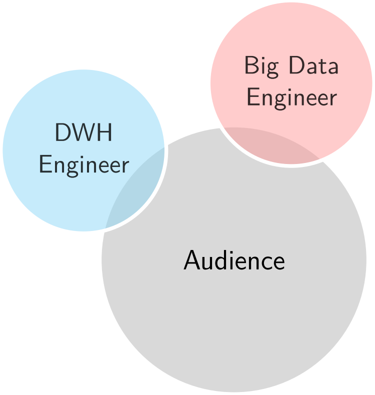

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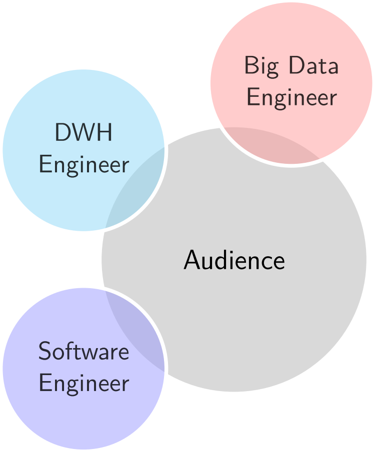

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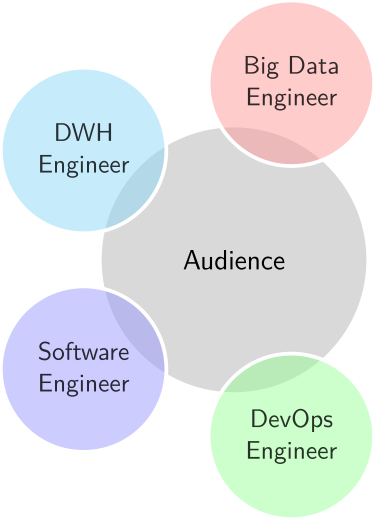

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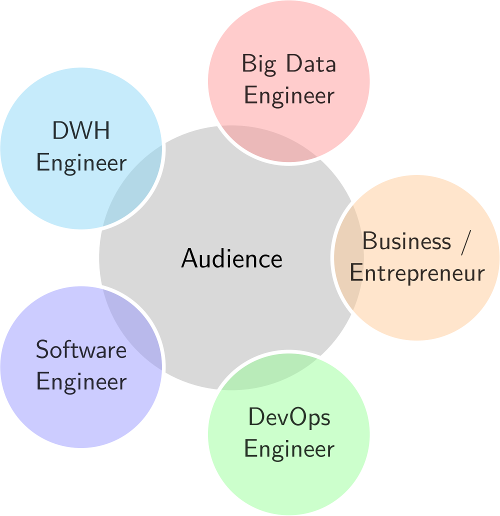

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- Ask your questions.
- Join online meetings or discussions.

Chapter Dependencies

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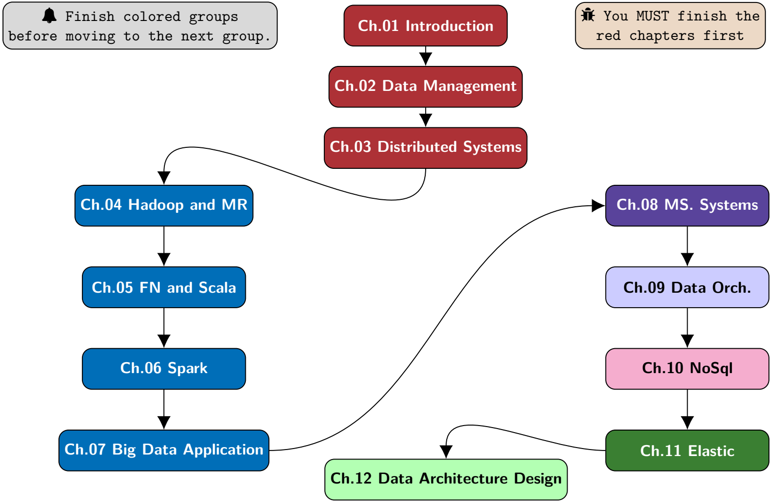
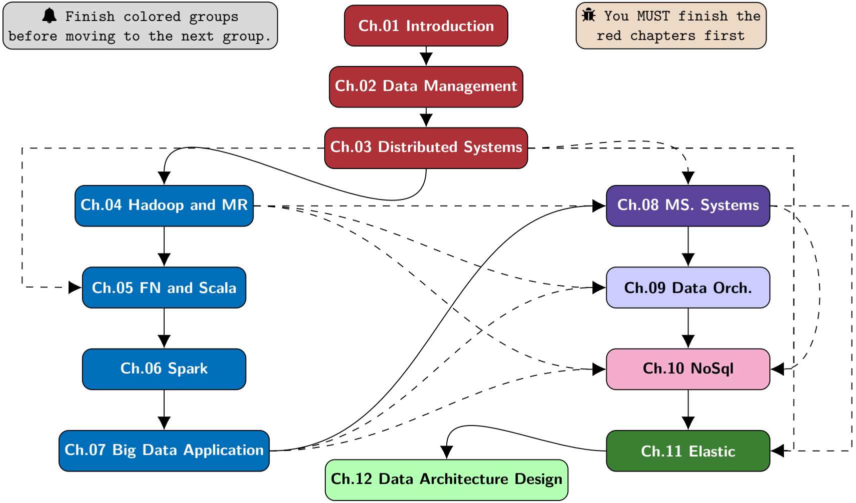


Chapter Dependencies (Jump Out Path)



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Assignments, Labs, and Text Books

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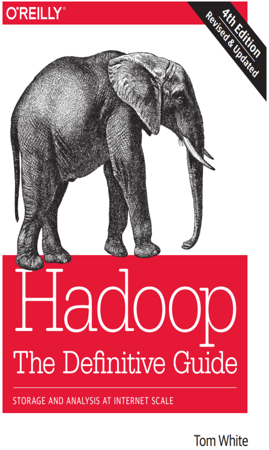
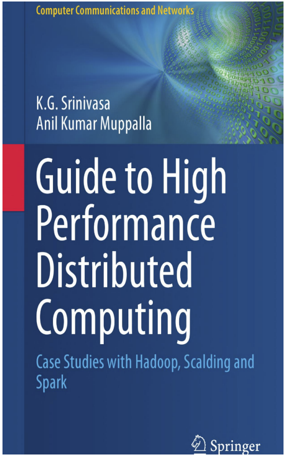
Textbooks-1

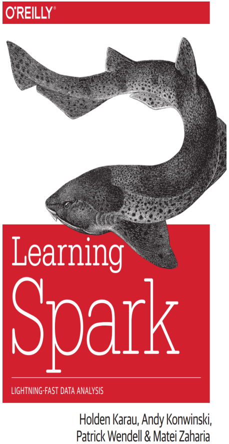

O'REILLY
4th Edition
Revised & Updated
Hadoop
The Definitive Guide
STORAGE AND ANALYSIS AT INTERNET SCALE
Tom White


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

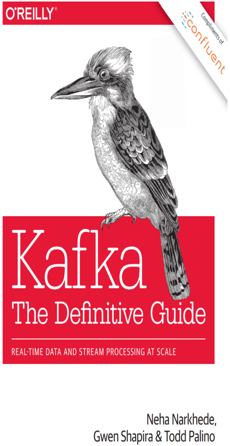
Functional Programming
in
Scala
Paul Chiusano
Rúnar Bjarnason
Foreword by Martin Odersky
MANNING

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

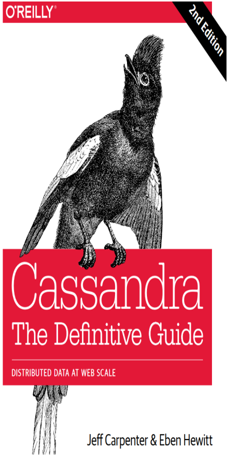


O'REILLY
Learning
Spark
LIGHTNING-FAST DATA ANALYSIS
Holden Karau, Andy Konwinski,
Patrick Wendell & Matei Zaharia

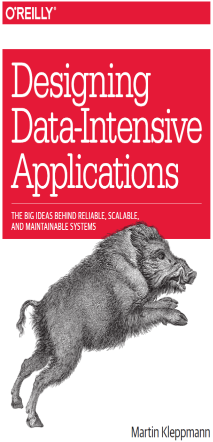
Textbooks-3



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

Ugly but important

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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.

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Table of Contents I

Table of Contents II

Table of Contents III

Table of Contents IV

Table of Contents V

Table of Contents VI

Table of Contents VII

Table of Contents VIII

Table of Contents IX

Introduction To Data Management and Data Warehouse

Chapter Objectives

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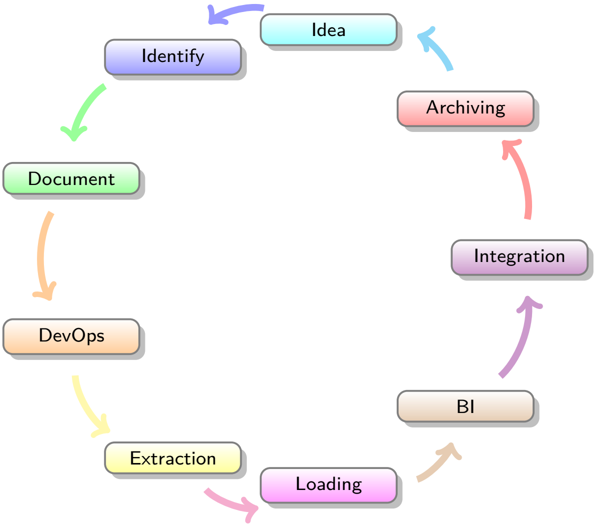
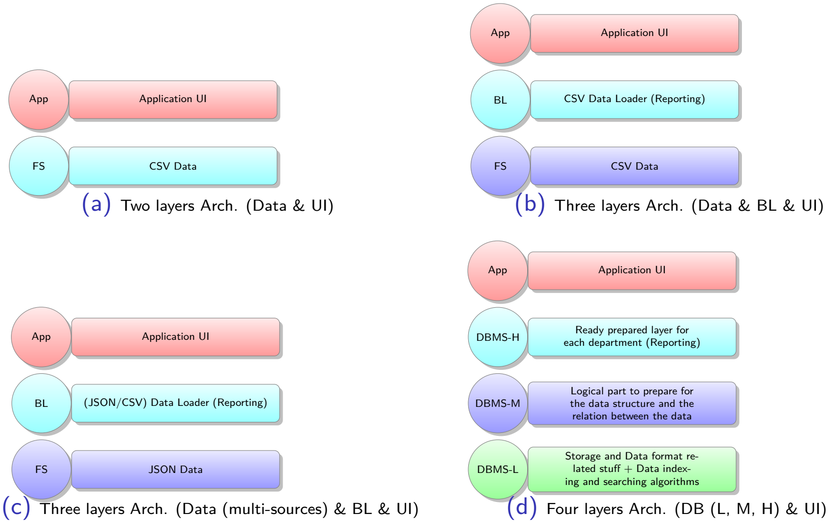
    - Data retention or **archiving** process ex: (Hot or Cold storage).

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

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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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  - Logical/ Conceptual Level.
  - View Level.

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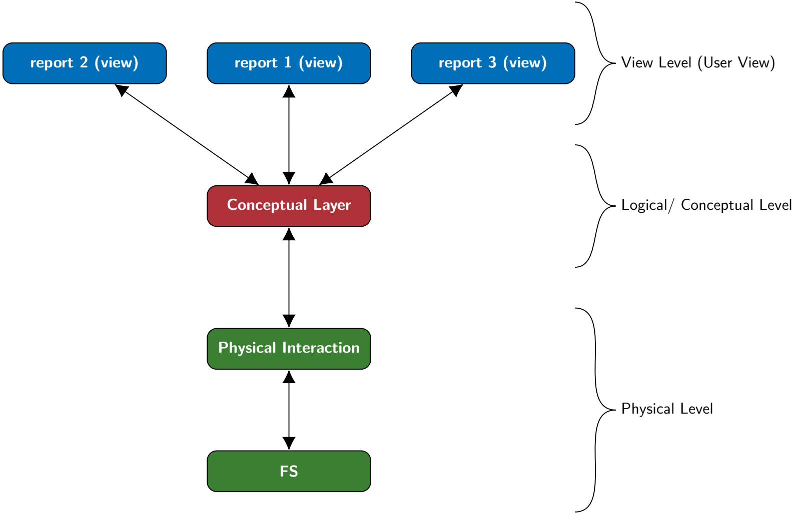

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    - Change the compression algorithm or hashing technique.

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  - Usually this layer abstracted from the programmers.

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  - How this product interact with other entities in the database.
  - 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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- 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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    - 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

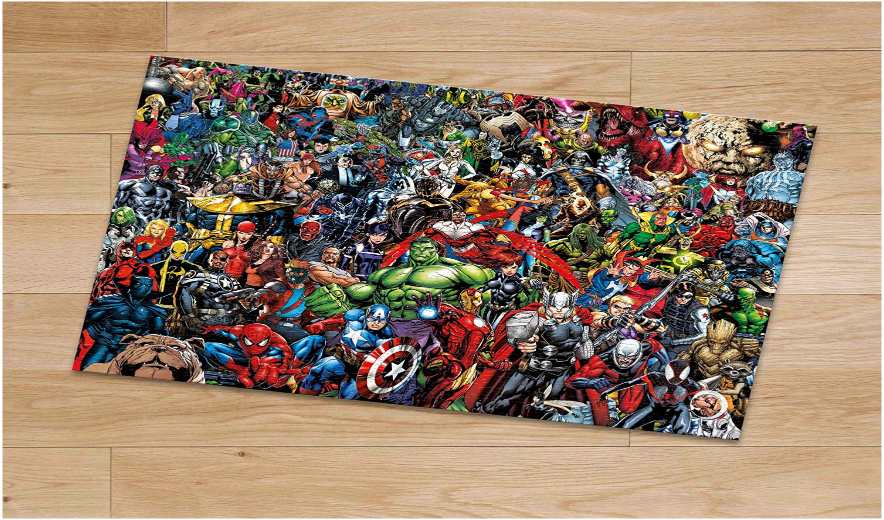
DWH vs Operational databases

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

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 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?

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- 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.

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  - 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).

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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

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

DWH Architecture Overview

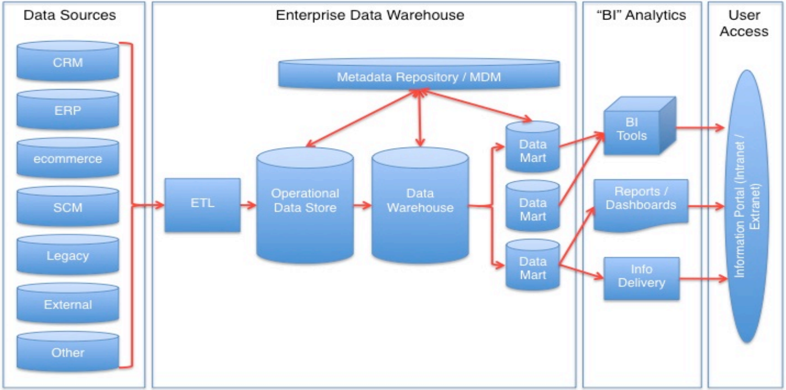

Figure: taken from

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  - All tasks should be clear what is the expected output for example (analysis means to document data structure, format, column names, etc..).

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- 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.

Source System Integration Process

- Requirements gathering.
- Identify the stakeholders (Data owner(s)).
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- Connectivity analysis and security (assessment).
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- 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

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  - Data latency will affect the tool and the methodology (stream or batch).
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  - 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

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- 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.

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- 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?

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.

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- a science.

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- It is also the translation between logical and physical layer.
- It is unified across the all systems and has the same patterns and practices.
- It could be 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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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

- facts, start 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 of capacity.

ETL Characteristics

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ETL Characteristics

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  - ☑ Maintainable.

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ETL Best Practice

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  - ☑ Modularity.
  - ☑ Atomicity.
  - ☑ Error Handling.
  - ☑ Managing Bad Data (Rejection Handling).

ETL Logging

- Logging

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    - Logging.

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- Logging
  - Logging.
  - Logging.

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  - Logging.

ETL Auditing

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ETL Atomicity

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ETL Error Handling

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ETL Error Handling

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ETL Rejection Handling

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ETL Rejection Handling

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  - Logging.
  - Logging.

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

File Formats

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File Formats

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Data Encoding and Formats

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Data Compression Technique

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Data Archiving and Retention

Data Archiving and Retention

- some details about hot vs cold storage,

DWH On Cloud

Further Readings and Assignment

Introduction To Distributed Systems

Chapter Objectives

- Understand the distributed systems concepts.

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- Understand the distributed systems concepts.
- Replication and its usage in distributed systems.

- Understand the distributed systems concepts.
- Replication and its usage in distributed systems.
- Partitioning and its usage in distributed systems .

Distributed Systems Concepts

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Distributed Systems Architecture

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Distributed Systems Challenges

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Design Simple Distributed System

Design Simple Distributed System

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Further Readings and Assignment

Hadoop and Map-Reduce

Chapter Objectives

- Introduction to Hadoop and its echo-systems.

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- Using HiveQL over Map-Reduce.
- Hadoop advantages and disadvantages with use cases?

Hadoop Architecture

Hadoop Architecture

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Storage

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YARN

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Hadoop I/O

Hadoop I/O

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Processing

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Map-Reduce

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Map-Reduce Components

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Word-Count Example

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Pig

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Hive

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ZooKeeper

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Further Readings and Assignment

Introduction to Functional Programming

Why functional programming commonly used in distributed systems?

Introduction to Scala

Further Readings and Assignment

Spark Framework

Spark Philosophy towards the Engine and the Programming languages

Spark Framework: Spark Philosophy towards the Engine and the Programming languages

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Spark Basics

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Spark Programming using RDDs

Spark RDD

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Spark Working With Key/Value Pairs

Spark Programming using RDDs

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Spark Datasets/Dataframe

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Spark SQL

Spark Datasets/Dataframe

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Dataframes/Datasets vs. RDDs

Spark Datasets/Dataframe

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Spark on Production

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Spark For Batch Processing

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Building custom input and output connector using Spark

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Spark Streaming

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Spark using other Programming Languages

PySpsark for Python Geeks

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Spark For Data Scientist

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Spark Graph Dataframe/Graphx

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Tuning your Spark Jobs

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Further Readings and Assignment

Real World Applications

Big Data Development Life Cycle

Template Concept for Data Engineering

Template for ETL Application

Template for QA

Template for Streaming Applications

Template for Machine Learning Applications

Further Readings and Assignment

Massaging Systems

Motivation

Massaging Systems Architecture

JMS as an example

Introduction to Kafka

Kafka Architecture

Kafka Topics

Partitions

Kafka Producers

Kafka Consumers

Kafka Connector

Kafka Custom Connectors

Kafka Configuration

Kafka Configuration Optimizations

Kafka Operations

Kafka Integration with Enterprise tools

Further Readings and Assignment

Data Orchestration

Motivation

Enterprise vs Open source tools

Open source tools (Oozie as an Example)

Enterprise source tools

How to choose the right tool?

Further Readings and Assignment

NOSQL

Introduction to NoSQL Databases.

Cassandra

Why Cassandra?

Introducing Cassandra

The Cassandra Data Model

Architecture

Reading and Writing Data

Integrating Hadoop

Further Readings and Assignment

Elastic

Further Readings and Assignment

Data Architecture Design

Further Readings and Assignment

Appendix

Appendix A- Shell Programming

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Appendix B- Java Programming

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Appendix C- Scala Programming

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Appendix D- SQL Programming

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Appendix E- Oozie Orchestration

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Appendix F- DWH Concepts and Data Modeling Design

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Appendix G- Machine Learning Concepts Data Engineers

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Appendix H- Docker for Data Engineers

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