(Big) Data Engineering In Depth

From Beginner to Professional

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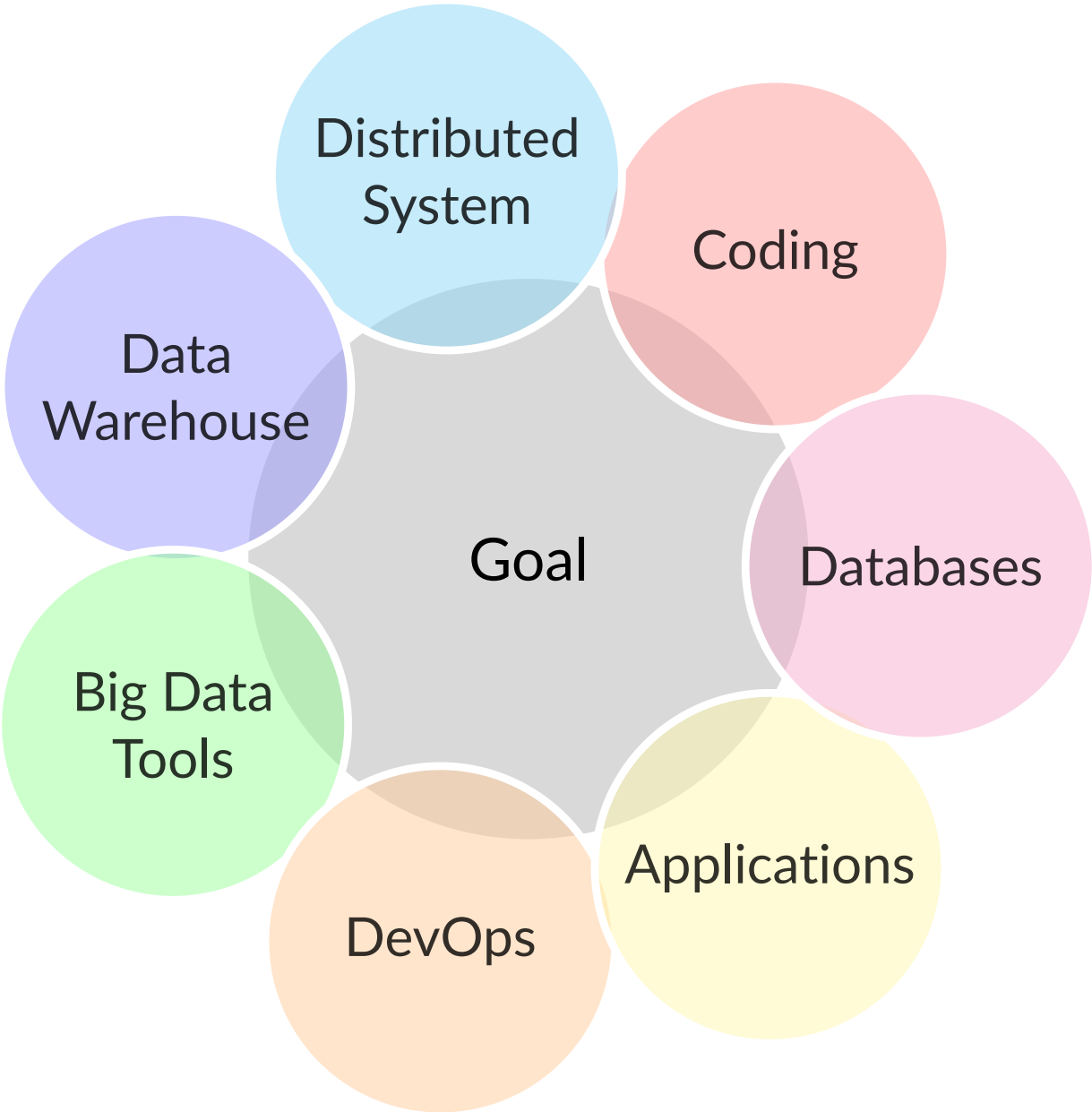
[1]Big Data & Analytics Department, Epam Systems

The Definitive Guide to Big Data Engineering Tasks

Course Introduction

Course Target



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- Build and scale your data product.
- Simplify the concepts in data management.

Audience: Who Should Take This Course?

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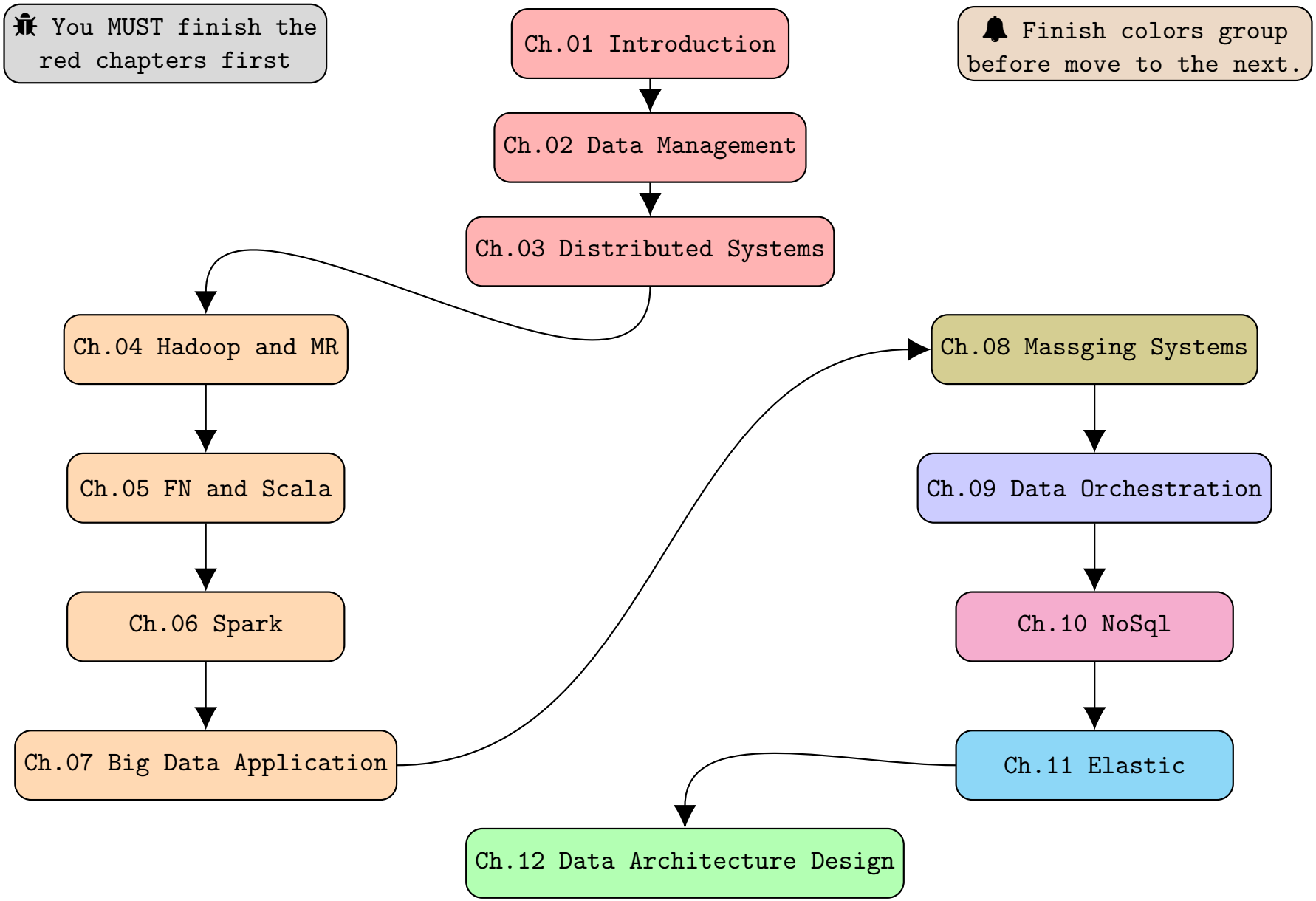
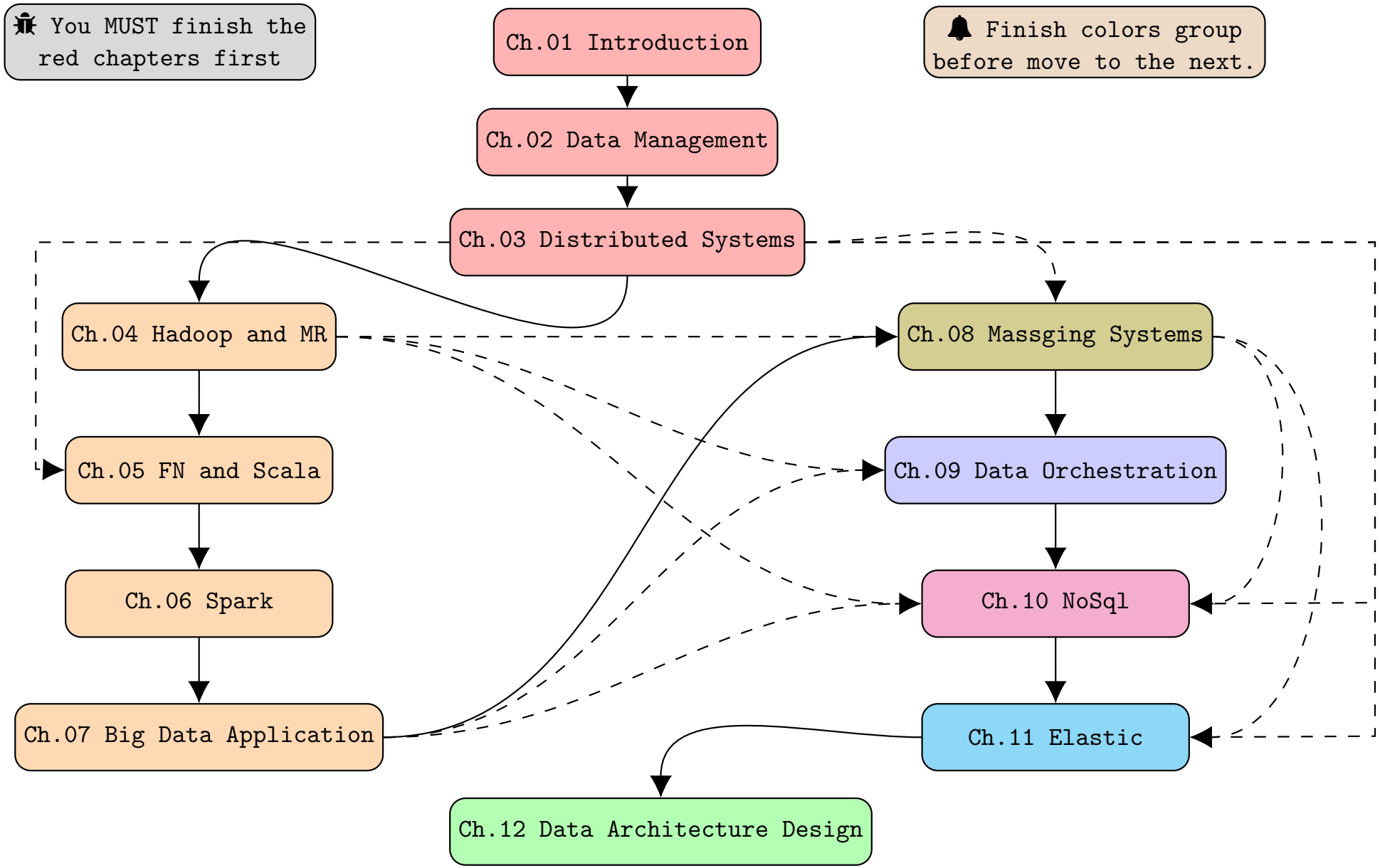
Chapter Dependencies



Chapter Dependencies (Jump Out Path)



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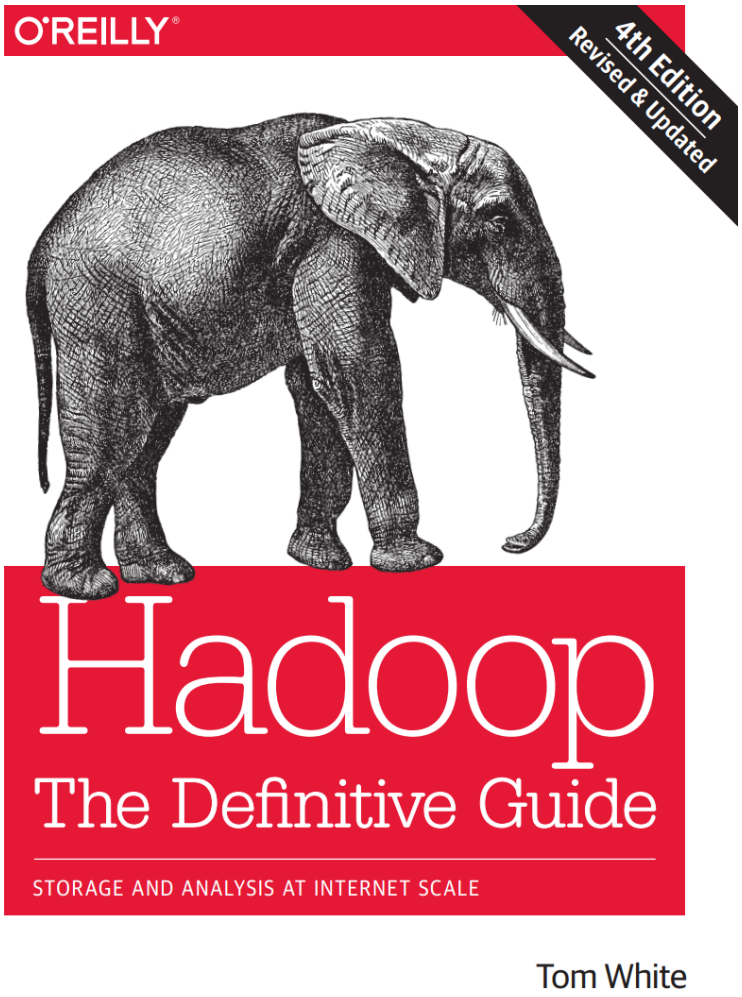
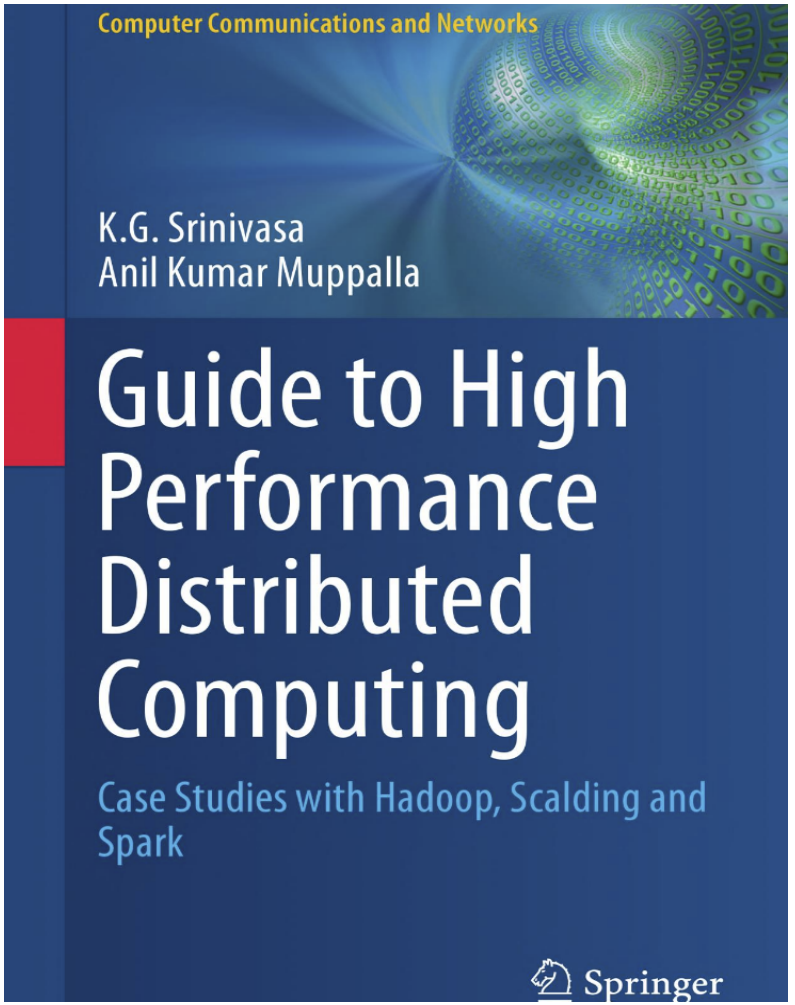
Textbooks-1

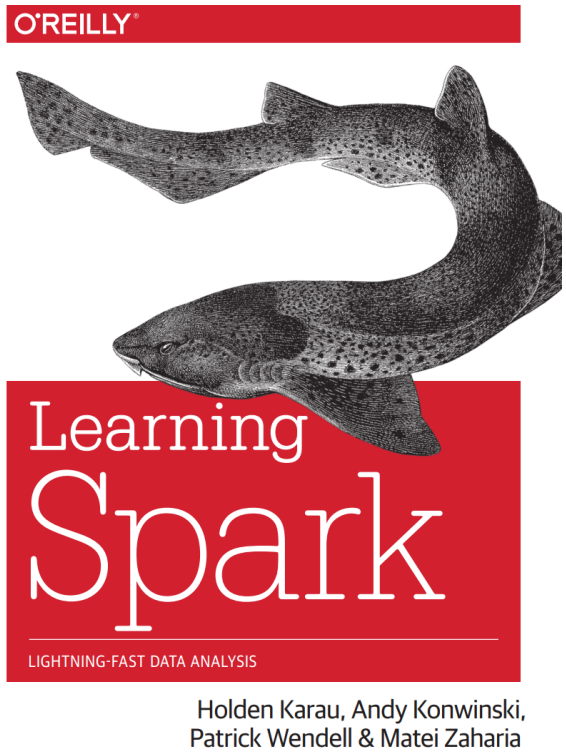

O'REILLY
4th Edition
Revised & Updated
Hadoop
The Definitive Guide
STORAGE AND ANALYSIS AT INTERNET SCALE
Tom White


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

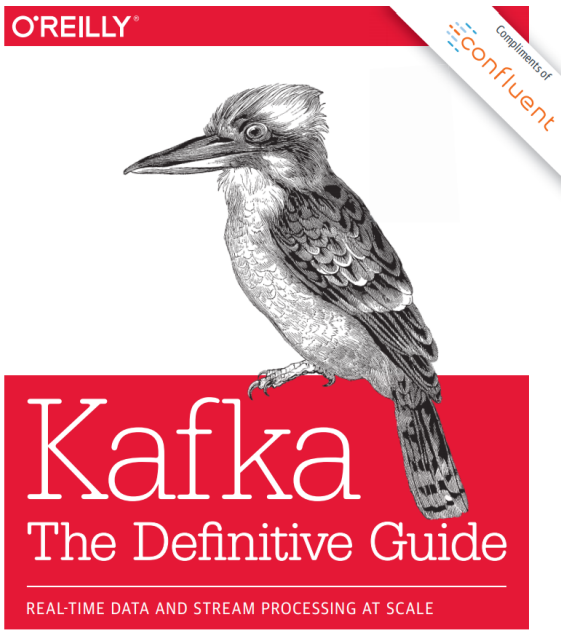
Textbooks-2

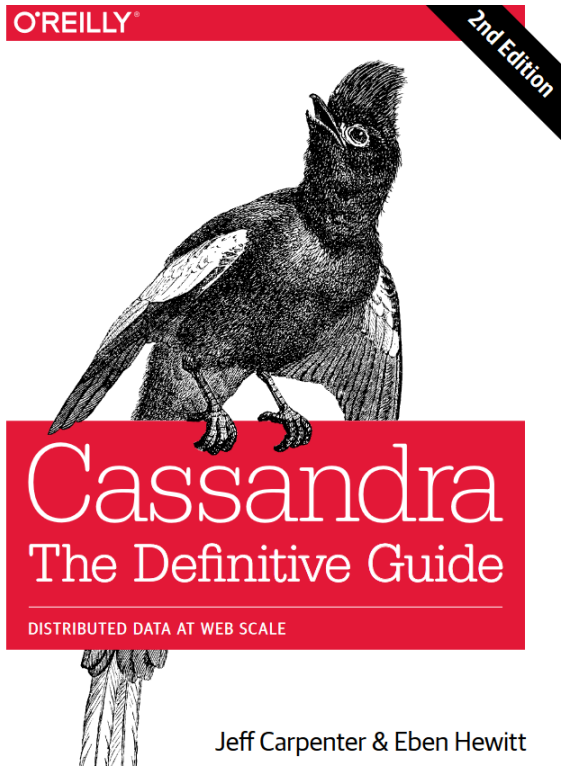

CATEGORY THEORY
FOR PROGRAMMERS
Bartosz Milewski

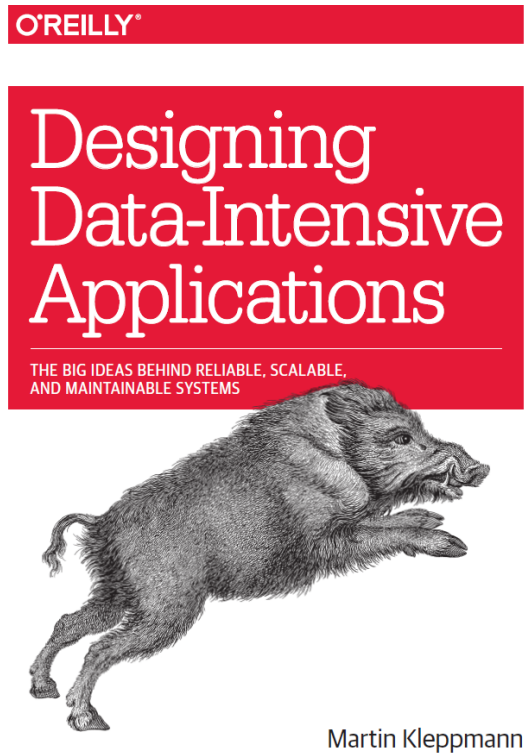

O'REILLY
High Performance
Spark
BEST PRACTICES FOR SCALING
& OPTIMIZING APACHE SPARK
Holden Karau &
Rachel Warren


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

- 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 own responsibilities.

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Introduction To Data Management and Data Warehouse

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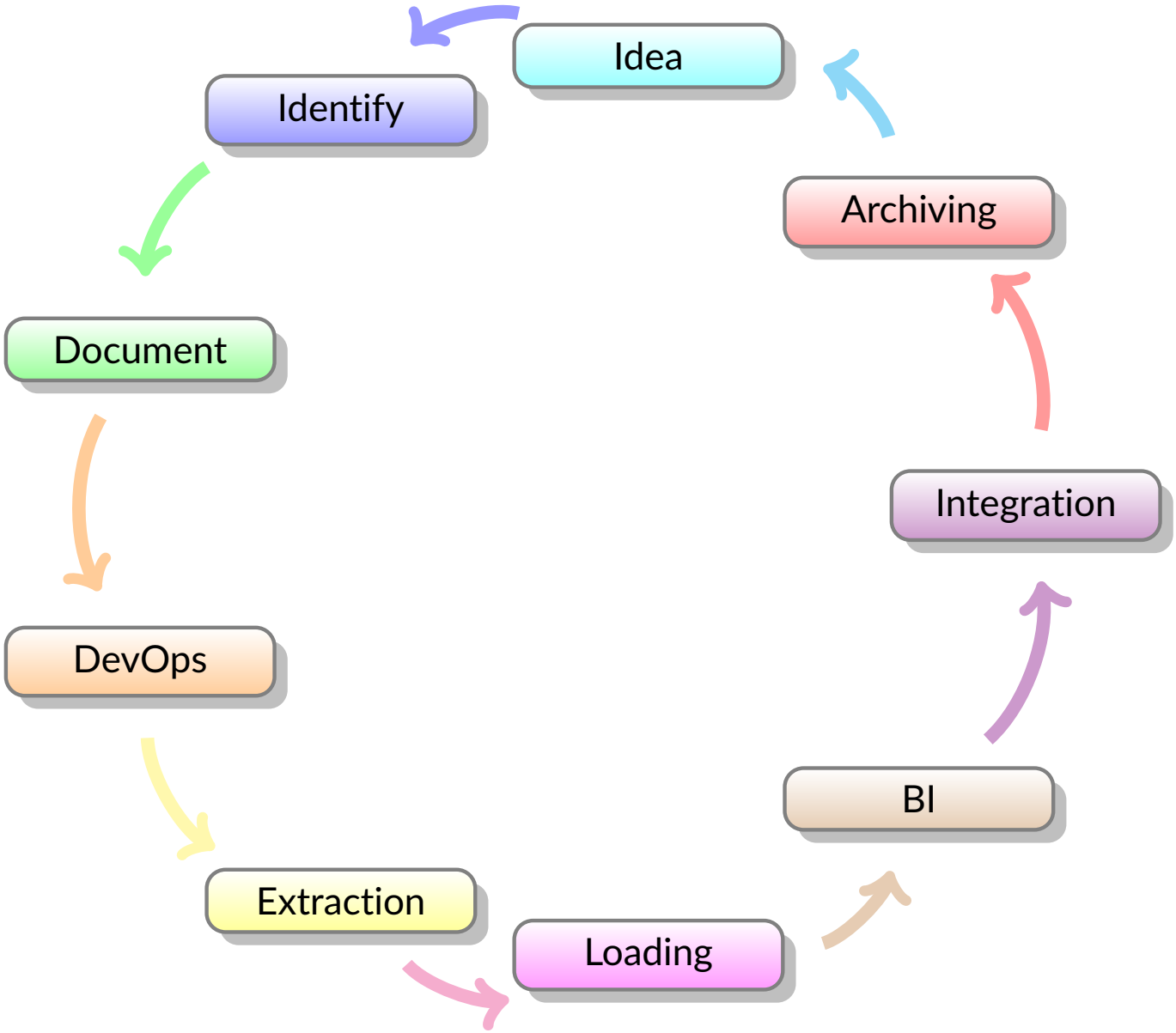
Data Management

- Data are a product.
- Data product has a life-cycle as following (simplified):
  - **Question**, Idea, or service.
  - **Identifying** the source of information and the data type ex: (text, images, videos, audio, or sensors).
  - **Document** all details regarding the data including quality, security, efficiency, and access (consideration during the cycle).
  - Delivery automation (Tools and Process) AKA **DevOps** cycle.
  - **Extraction** Process (collection).
  - **Transformation** ex: (cleansing, Apply business logic, Organize).
  - **Loading** or store the transformed data based on our usage or use case.
  - Business Intelligence (**BI**) or data discovery (continues process).
  - **Integration** and publishing.
  - Data retention or **archiving** process ex: (Hot or Cold storage).

Data Management Life-Cycle



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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)

- The DWH is not a product but an environment.
- It is a process of transforming data into information and make it available to users in a **timely manner** to make a difference.
- It is an architectural construct of an information system which provides users with current and historical decision support information which is difficult to access or present in the traditional operational data store.
- The DWH is the core of the BI system which is built for data analysis and reporting.

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.

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.

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

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

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

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Use case (Operational DB)

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  - 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 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).

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

DWH Architecture Overview

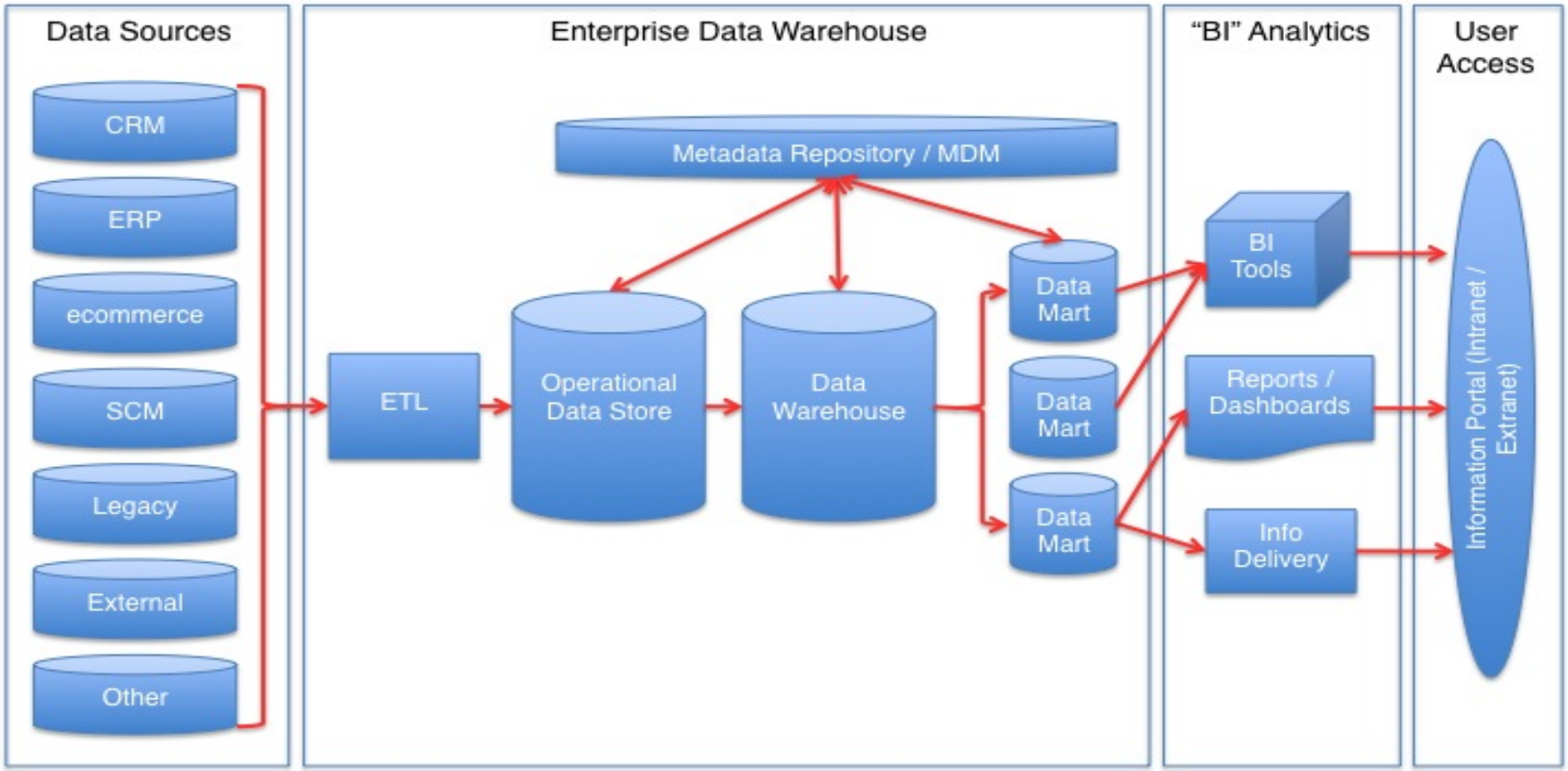

Figure: taken from XXXX

Data Abstraction

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  - Logical/ Conceptual level.
  - View level.

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- **Logical level**: This is the middle level of 3-level data abstraction architecture. It describes what data is stored in database.
- **View level**: Highest level of data abstraction. This level describes the user interaction with database system.

Data Abstraction

Example: Let's say we are storing customer information in a customer table. At physical level these records can be described as blocks of storage (bytes, gigabytes, terabytes etc.) in memory. These details are often hidden from the programmers.
At the logical level these records can be described as fields and attributes along with their data types, their relationship among each other can be logically implemented. The programmers generally work at this level because they are aware of such things about database systems.
At view level, user just interact with system with the help of GUI and enter the details at the screen, they are not aware of how the data is stored and what data is stored; such details are hidden from them. **Data Models is the logical level.** we will discribte the logical level and how can we propsose the external view for the end users. Regarding the physical level we will not dig dive at this level but for the next chapters we will discuss it in Hadoop, Kafka, Cassandra.

What is data model?

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- 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 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)

DWH Characteristics

some details about hot vs cold storage,

Cold storage vs Hot storage

some details about hot vs cold storage,

Data Models

- Any Big Data solution working based distributed systems.

Data Models

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- What is distributed systems in brief?

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.

Chapter Objectives

- 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

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Introduction to Hadoop and Map-Reduce

Chapter Objectives

- Introduction to Hadoop and its echo-systems.

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- Why we need Hadoop?

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

Hadoop Architecture

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Storage

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YARN

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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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Functional Programming

Spark Framework

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

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Spark Framework: Spark Basics

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Spark Programming using RDDs

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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

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Spark Graph Dataframe/Graphx

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Tuning your Spark Jobs

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Real World Applications

Massaging Systems

Data Orchestration

NOSQL

Elastic

Data Architecture Design

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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