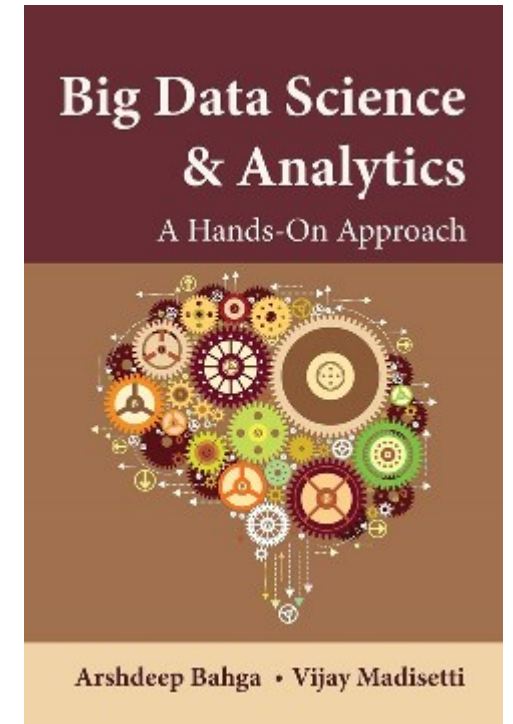


Introduction to Big Data

Prof. Gheith Abandah

Reference

- Chapter 1: **Introduction to Big Data**



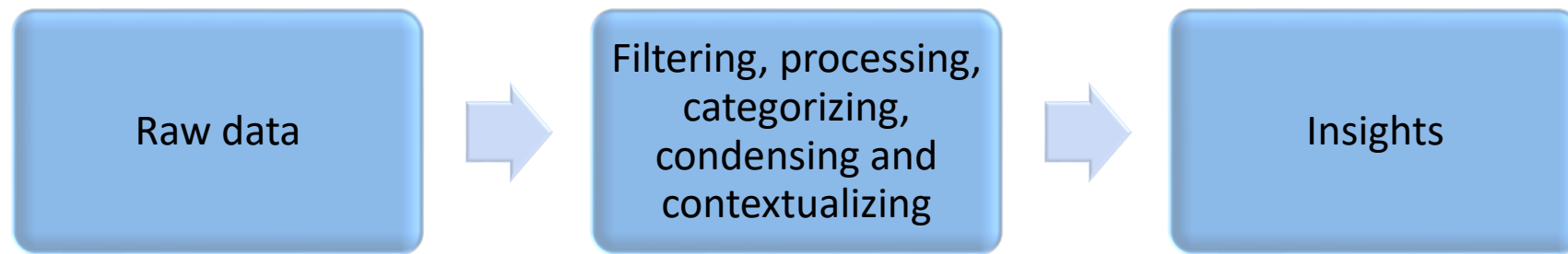
- Arshdeep Bahga and Vijay Madisetti, **Big Data Science and Analytics: A Hands-On Approach**, 2019.
 - Web site: <http://www.hands-on-books-series.com/>

Outline

- What is Analytics?
- What is Big Data?
- Characteristics of Big Data
- Domain Specific Examples of Big Data
- Analytics Flow for Big Data
- Big Data Stack

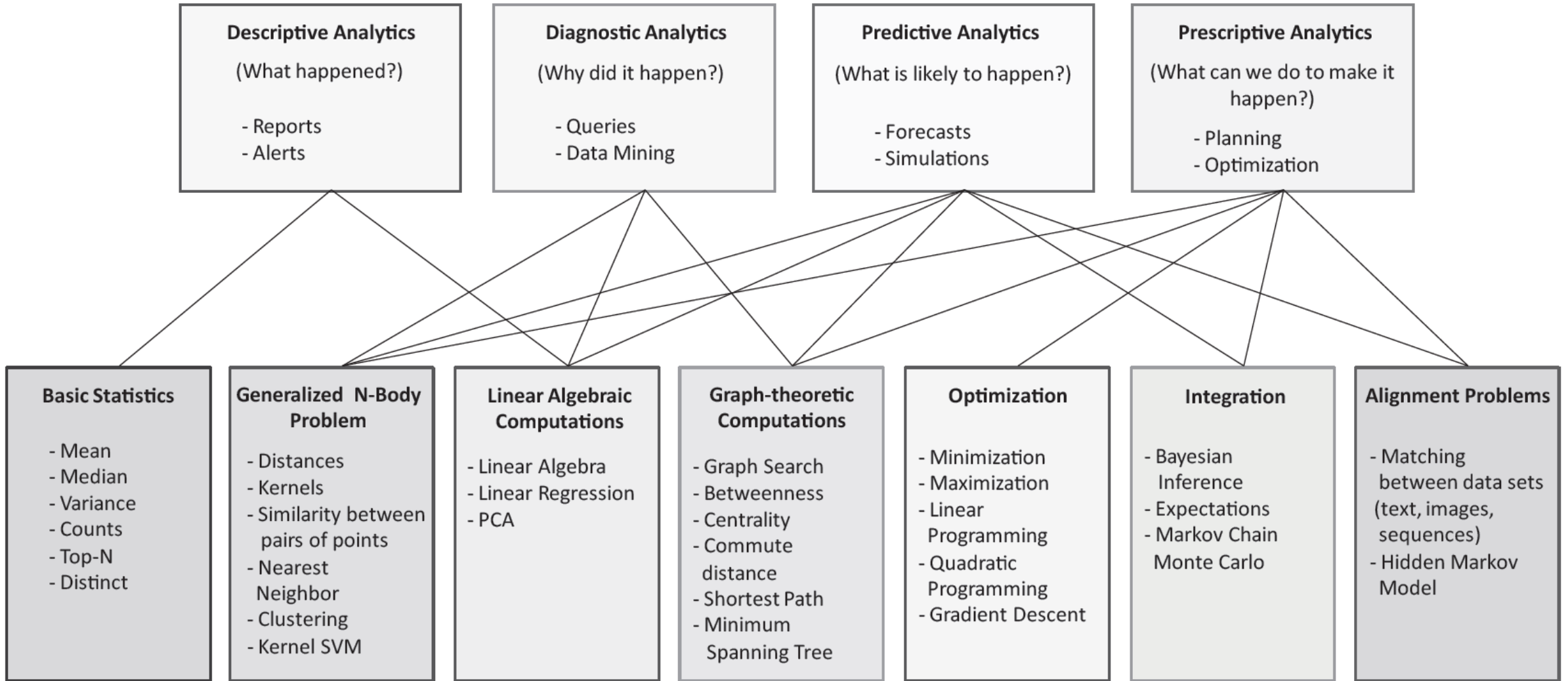
What is Analytics?

- Processes, technologies, frameworks and algorithms to extract meaningful **insights from data**.



- **Goals** of the analytics task:
 - To **predict** something
 - To find **patterns** in the data
 - To find **relationships** in the data

Types of Analytics



Computational Giants of Massive Data Analysis

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What is Big Data?

- Big data is defined as collections of datasets whose **volume**, **velocity** or **variety** is **so large** that it is difficult to store, manage, process and analyze the data using traditional databases and data processing tools.
- **Every minutes:**
 - **Facebook** users share nearly **4.16 million** pieces of content
 - **Twitter** users send nearly **300,000** tweets
 - **Instagram** users like nearly **1.73 million** photos
 - **YouTube** users upload **300 hours** of new video content
 - **Apple** users download nearly **51,000** apps
 - **Skype** users make nearly **110,000** new calls
 - **Amazon** receives **4300** new visitors
 - **Uber** passengers take **694** rides
 - **Netflix** subscribers stream nearly **77,000** hours of video

What is Big Data?

- **Big data analytics** deals with **collection**, **storage**, **processing** and **analysis** of this massive-scale data.
- **Specialized tools** and frameworks are required for big data analysis.
- Big data tools and frameworks have **distributed** and **parallel processing architectures** and can leverage the storage and computational resources of a large cluster of machines.
- Big data analytics involves several **steps**:
 - data **cleansing**
 - data **munging** (or wrangling)
 - data **processing** and **visualization**

What is Big Data?

- Some **examples** of big data are listed as follows:
 - **Data** generated by **social networks** including text, images, audio and video data
 - **Click-stream data** generated by web applications such as e-Commerce to analyze user behavior
 - **Machine sensor data** collected from sensors embedded in industrial and energy systems for monitoring their health and detecting failures
 - **Healthcare data** collected in electronic health record (EHR) systems
 - **Logs** generated by web applications
 - **Stock markets data**
 - **Transactional data** generated by banking and financial applications

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Characteristics of Big Data

1. **Volume**: Big data is a form of data whose volume is so large that it would not fit on a single machine
2. **Velocity**: Data arrives at very high velocities.
3. **Variety**: Big data comes in different forms such as structured, unstructured or semi-structured, including text data, image, audio, video and sensor data.
4. **Veracity**: Veracity refers to how accurate is the data. To extract value from the data, the data needs to be cleaned to remove noise.
5. **Value**: Refers to the usefulness of data for the intended purpose.

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Domain Specific Examples of Big Data

1. Web

- Web analytics
- Performance monitoring
- Ad targeting & analytics
- Content recommendations

2. Financial

- Credit risk modeling
- Fraud detection

3. Healthcare

- Epidemiological surveillance
- Patient similarity-based decision intelligence application
- Adverse drug events prediction
- Detecting claim anomalies
- Evidence-based medicine
- Real-time health monitoring

Domain Specific Examples of Big Data

4. Internet of Things

- Intrusion detection
- Smart parking
- Smart roads
- Structural health monitoring
- Smart irrigation

5. Environment

- Weather monitoring
- Air pollution monitoring
- Noise pollution monitoring
- Forest fire detection
- River floods detection
- Water quality monitoring

Domain Specific Examples of Big Data

6. Logistics & Transportation

- Real-time fleet tracking
- Shipment monitoring
- Remote vehicle diagnostics
- Route generation & scheduling
- Hyper-local delivery
- Cab/taxi aggregators

7. Industry

- Machine diagnosis & prognosis
- Risk analysis of industrial operations
- Production planning and control

Domain Specific Examples of Big Data

8. Retail

- Inventory management
- Customer recommendations
- Store layout optimization
- Forecasting demand

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Analytics Flow for Big Data

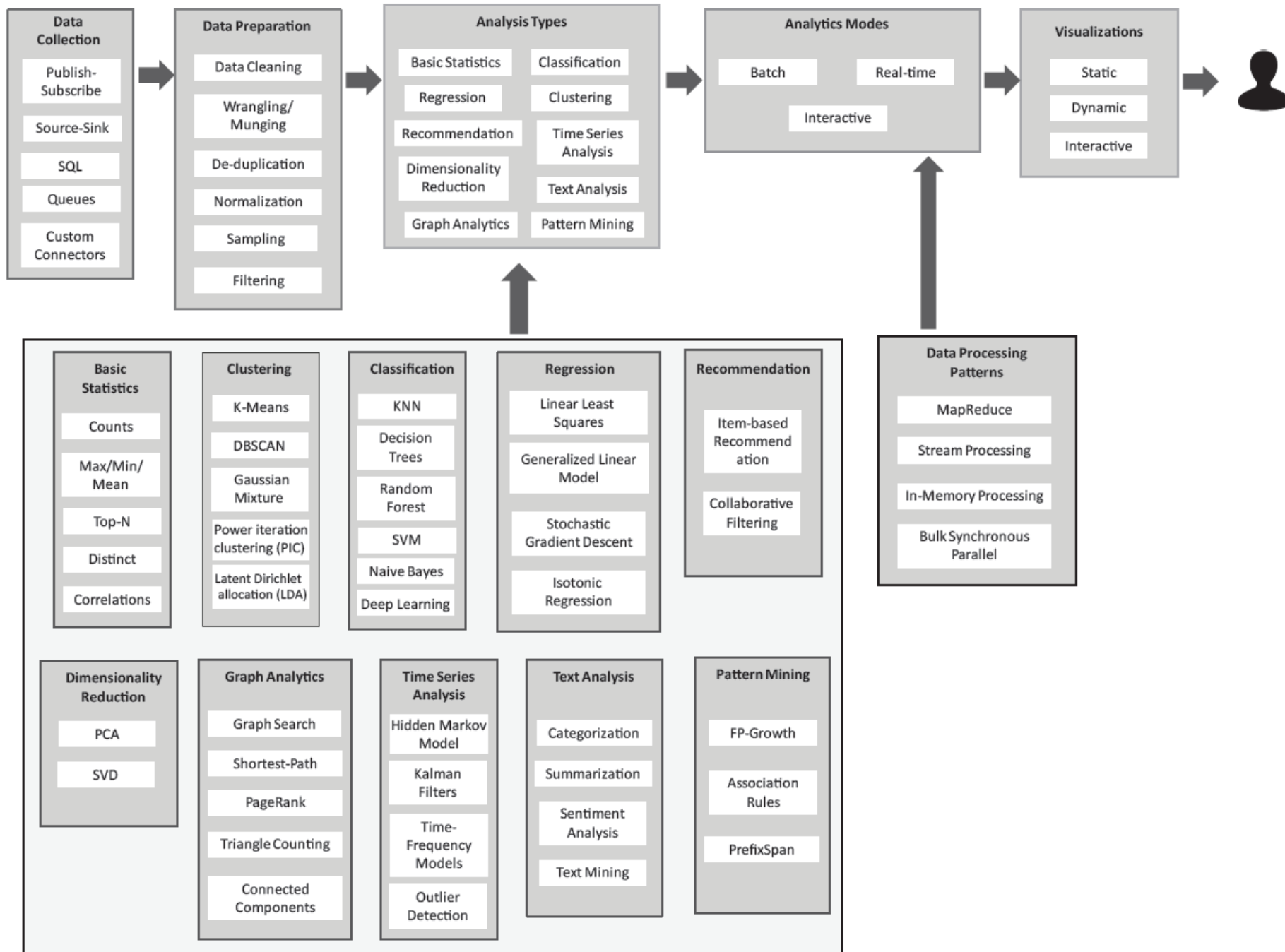
1. Data Collection

2. Data Preparation

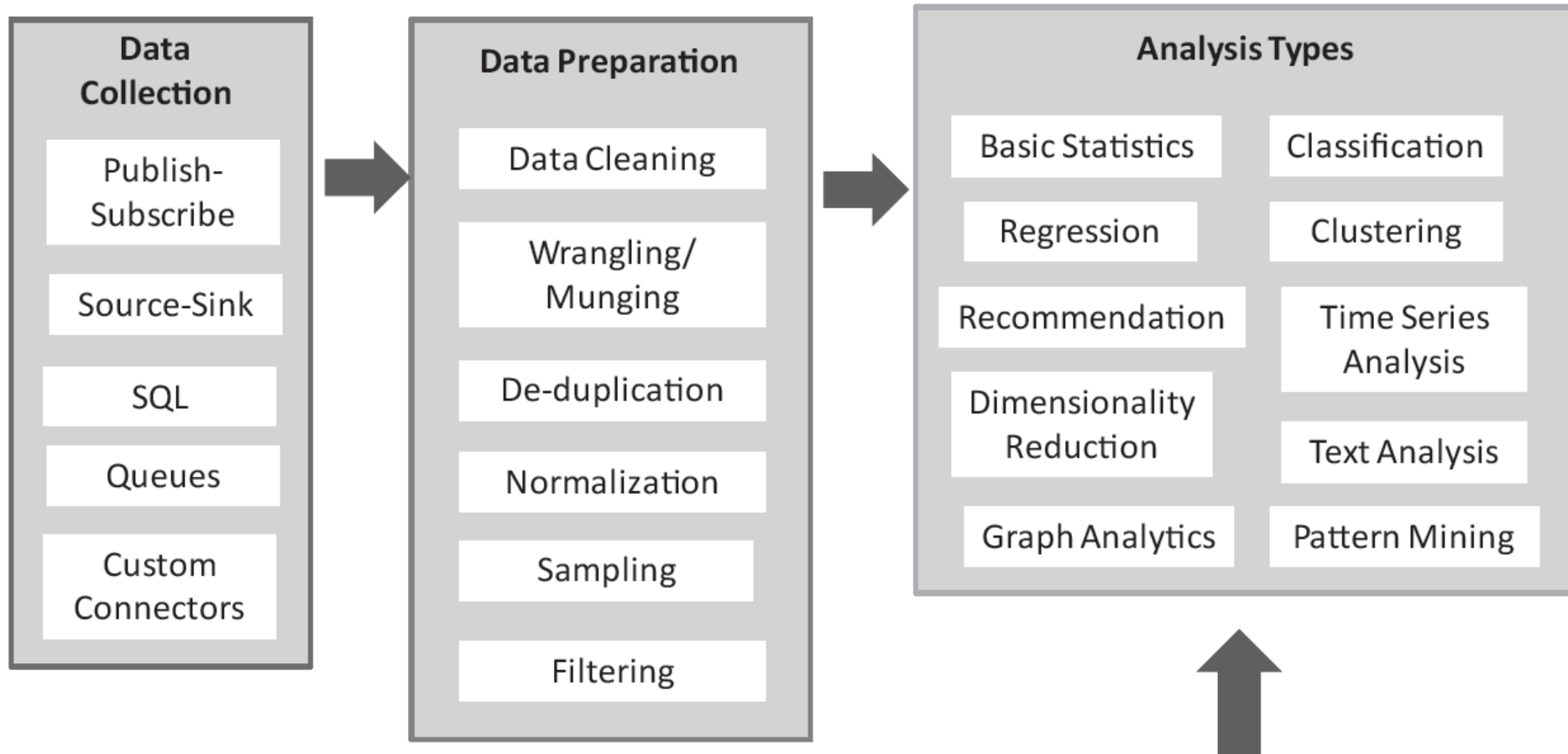
- Corrupt records, missing values, duplicates, inconsistent abbreviations, inconsistent units, typos and incorrect spellings, incorrect formatting

3. Analysis

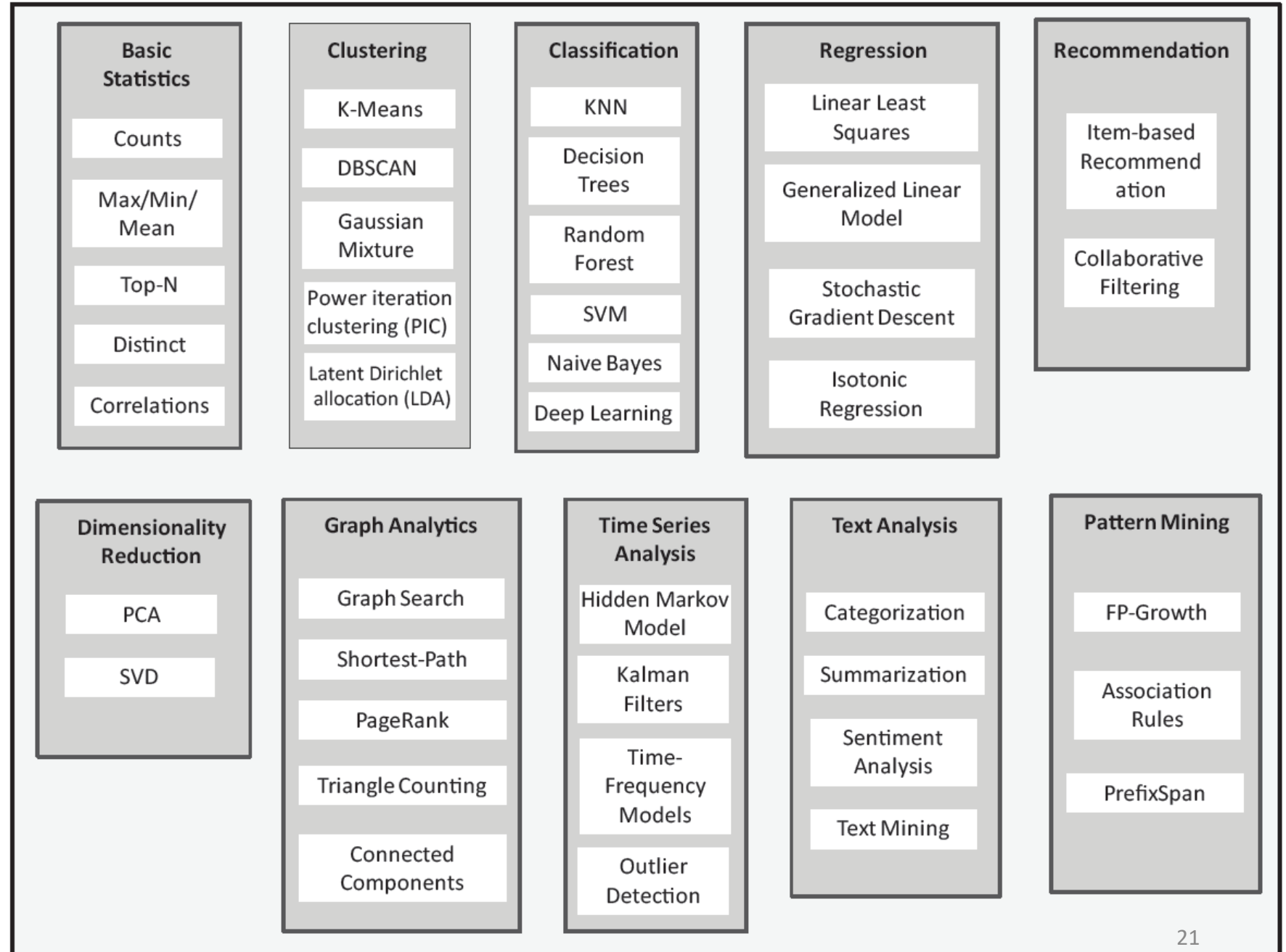
4. Visualization



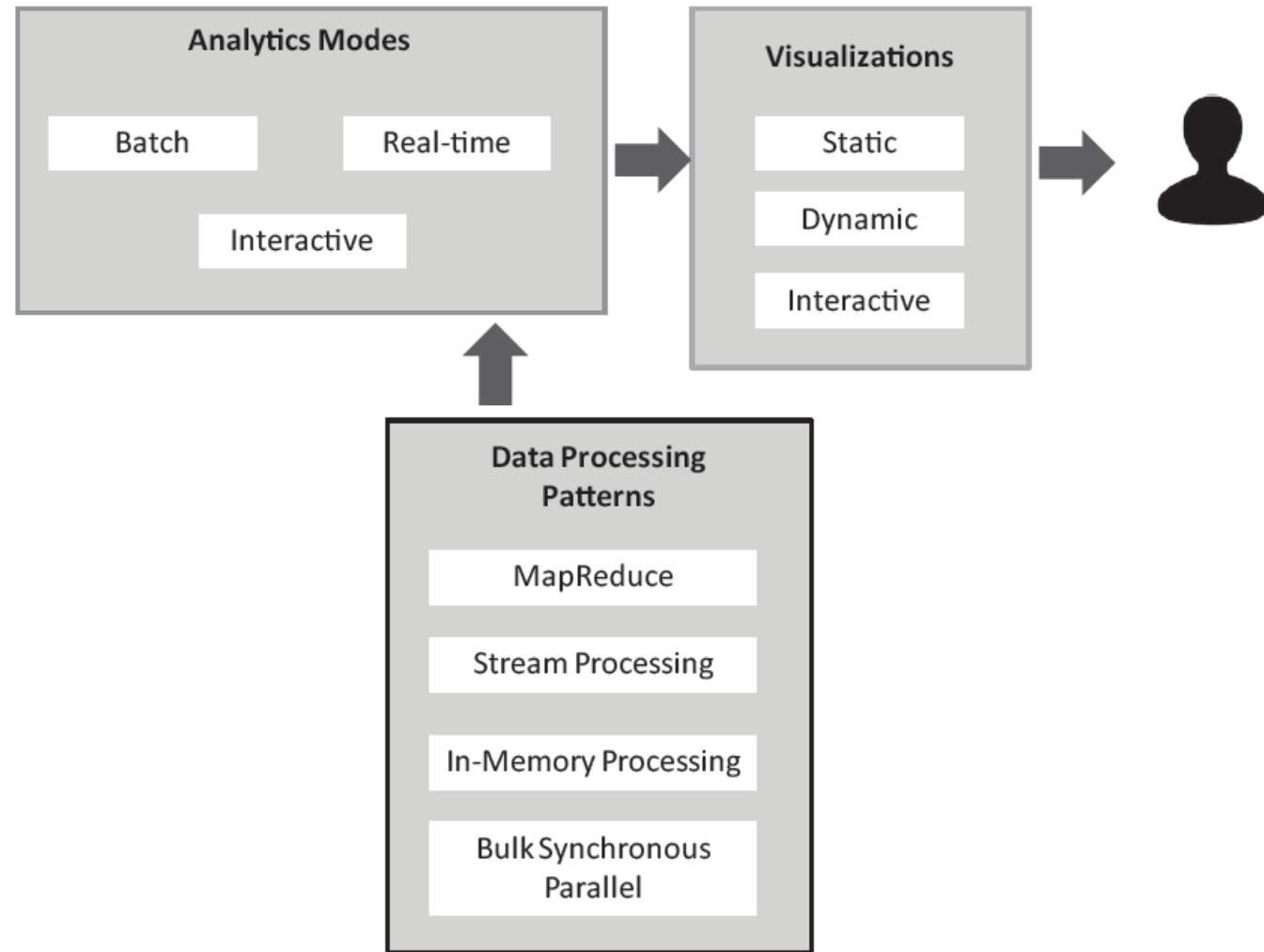
Data Collection, Preparation and Analysis



Analysis Types



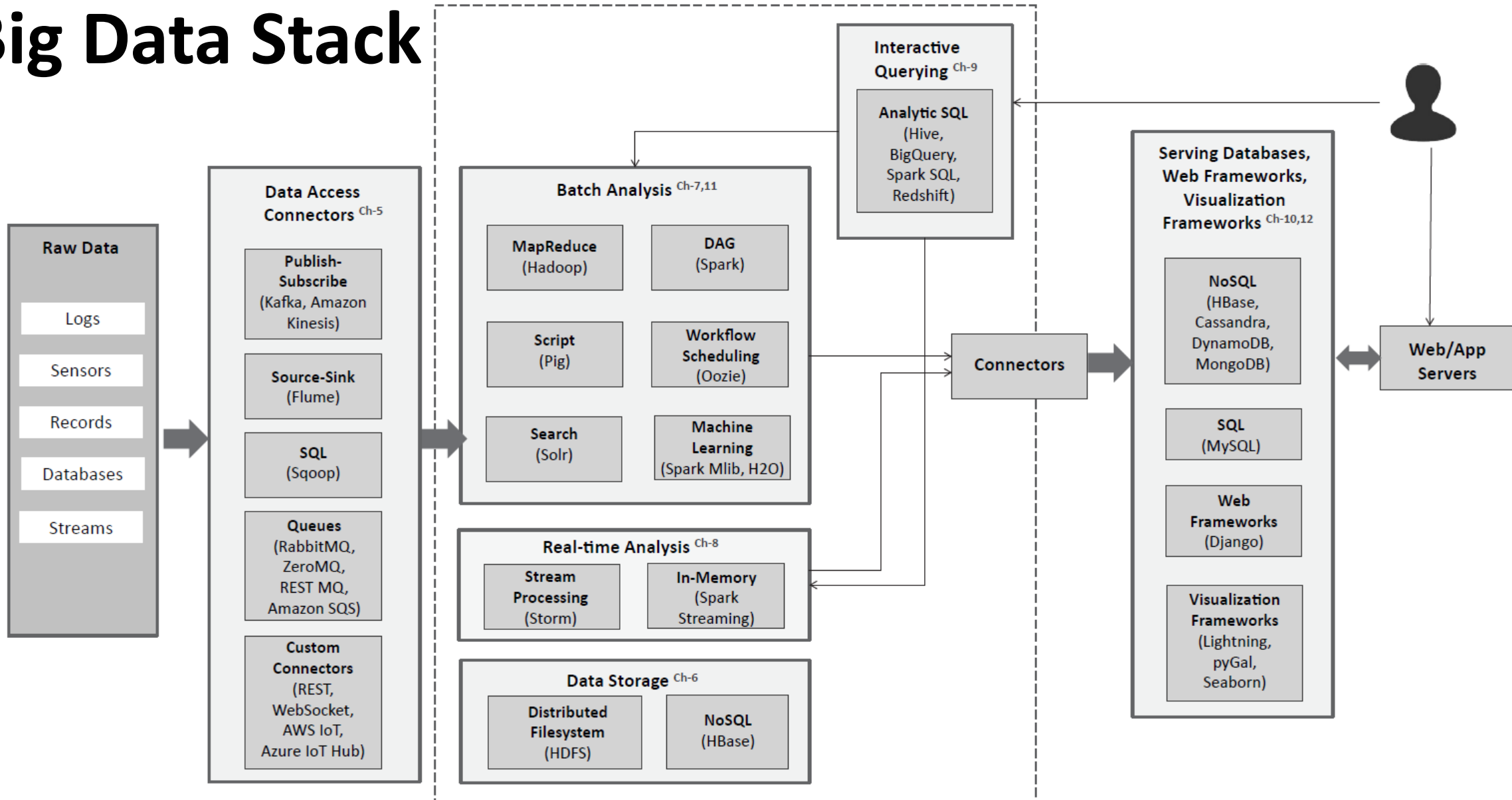
Analytics and Visualization Modes



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Big Data Stack



1. Raw Data Sources

1. **Logs** generated by web applications and servers for performance monitoring
2. **Transactional data** generated by applications such as eCommerce, banking and financial
3. **Social media data** generated by social media platforms
4. **Databases**: structured data residing in relational databases
5. **Sensor data** generated by Internet of Things (IoT) systems
6. **Clickstream data** generated by web applications which can be used to analyze browsing patterns of the users
7. **Surveillance data**: Sensor, image and video data generated by surveillance systems
8. **Healthcare data** generated by Electronic Health Record (EHR) and other healthcare applications
9. **Network data** generated by network devices such as routers and firewalls

2. Data Access Connectors

1. **Publish-Subscribe Messaging** is a communication model that involves publishers, brokers and consumers. E.g., **Apache Kafka** and **Amazon Kinesis**.
2. **Source-Sink Connectors** allow efficiently collecting, aggregating and moving data from various sources into a centralized data. E.g., **Apache Flume**.
3. **Database Connectors** can be used for importing data from relational database management systems into big data storage. E.g., **Apache Sqoop**.

2. Data Access Connectors

4. **Messaging Queues** are useful for push-pull messaging where the producers push data to the queues and the consumers pull the data from the queues. E.g., **RabbitMQ**, **ZeroMQ**, **RestMQ** and **Amazon SQS**.
5. **Custom Connectors** can be built based on the source of the data and the data collection requirements. Some examples of custom connectors include custom connectors for collecting data from social networks, and connectors for Internet of Things (IoT). E.g., **REST**, **WebSocket**, **MQTT**, and IoT connectors such as **AWS IoT** and **Azure IoT Hub**.

3. Data Storage

- The data storage block in the big data stack stores the data collected from the raw data sources using the data access connectors
- Includes
 - 1. Distributed file systems**, e.g., Hadoop Distributed File System (HDFS)
 - 2. Non-relational (NoSQL) databases**

4. Batch Analytics Frameworks

1. **Hadoop-MapReduce** is a framework for distributed batch processing of big data. Its programming model is used to develop batch analysis jobs which are executed in Hadoop clusters.
2. **Pig** is a high-level data processing language which makes it easy for developers to write data analysis scripts which are translated into MapReduce programs by the Pig compiler.
3. **Oozie** is a workflow scheduler system that allows managing Hadoop jobs. With Oozie, you can create workflows which are a collection of actions (such as MapReduce jobs).

4. Batch Analytics Frameworks

4. **Apache Spark** is an open-source cluster computing framework for data analytics. Spark includes various high-level tools for data analysis such as **Spark Streaming** for streaming jobs, **Spark SQL** for analysis of structured data, **MLlib**, and **GraphX** for graph processing.
5. **Apache Solr** is a scalable and open-source framework for searching data.
6. **Machine Learning: Spark MLlib** is the Spark's machine learning library which provides implementations of various machine learning algorithms. **H2O** is an open-source predictive analytics framework which provides implementations of various machine learning algorithms.

5. Real-time Analytics Frameworks

- 1. Apache Storm** is a framework for distributed and fault-tolerant real-time computation. Storm can be used for real-time processing of streams of data. Storm can consume data from a variety of sources such as publish-subscribe messaging frameworks (such as **Kafka** or **Kinesis**), messaging queues (such as **RabbitMQ** or **ZeroMQ**) and other custom connectors.
- 2. Spark Streaming** is a component of **Spark** which allows analysis of streaming data such as sensor data, click stream data, and web server logs. The streaming data is ingested and analyzed in micro-batches. Spark Streaming enables scalable, high throughput and fault-tolerant stream processing.

6. Interactive Querying Systems

1. **Spark SQL** enables interactive querying and is useful for querying structured and semi-structured data using SQL-like queries.
2. **Apache Hive** is a data warehousing framework built on top of **Hadoop**. It provides an SQL-like query language called **Hive Query Language**, for querying data residing in HDFS.
3. **Amazon Redshift** is a fast, massive-scale managed data warehouse service. It specializes in handling queries on datasets of sizes up to a petabyte or more parallelizing the SQL queries across all resources in the Redshift cluster.
4. **Google BigQuery** is a service for querying massive datasets. It allows querying datasets using SQL-like queries.

7. Serving Databases, Web & Visualization Frameworks

1. **MySQL** is one of the most widely used Relational Database Management System (RDBMS) and is a good choice to be used as a serving database for data analytics applications where the data is structured.
2. **Amazon DynamoDB** is a fully-managed, scalable, high-performance NoSQL database service. It is an excellent choice for a serving database for data analytics applications as it allows storing and retrieving any amount of data and the ability to scale up or down the provisioned throughput.

7. Serving Databases, Web & Visualization Frameworks

3. **Cassandra** is a scalable, highly available, fault tolerant open-source non-relational database system.
4. **MongoDB** is a document oriented non-relational database system. It is powerful, flexible and highly scalable database designed for web applications and is a good choice for a serving database for data analytics applications.
1. **Django** is an open-source web application framework for developing web applications in **Python**. It is based on the Model-Template-View architecture and provides a separation of the data model from the business rules and the user interface.

7. Serving Databases, Web & Visualization Frameworks

1. **Lightning** is a framework for creating web-based interactive visualizations.
2. **Pygal** is an easy-to-use Python charting library which supports charts of various types.
3. **Seaborn** is a Python visualization library for plotting attractive statistical plots.

Summary

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