Amirkabir University of Technology
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Cloud Computing

Big Data and Analytics in Cloud-Part1

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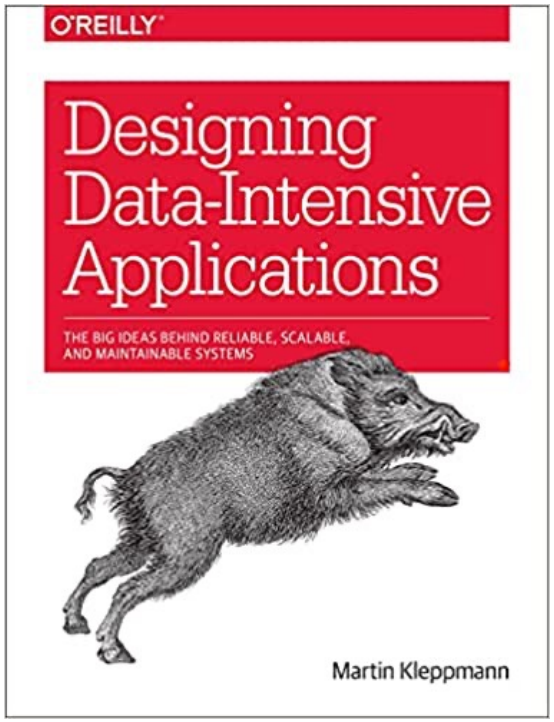
The age of big data has begun, and exploiting big data is changing our world.

Data-Intensive Computing

- Data-intensive computing is about
  - **production,**
  - **manipulation,**
  - **and analysis of large-scale data**



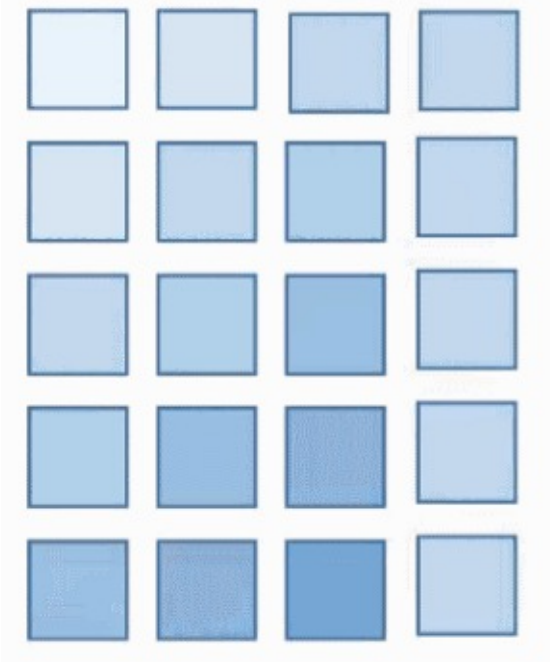
in the range of hundreds of megabytes to ***petabytes & beyond***.

Types of Data

- Structured data
- Semi-structured data
- Unstructured data

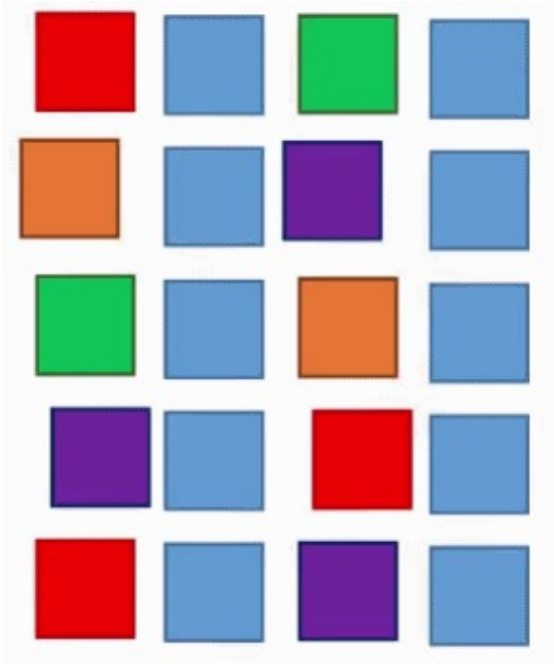
Structured Data

- Data that is organized in a structure
- Examples
  - Fixed fields inside a record (e.g., relational database)
  - Well-formed format (XML or JSON).



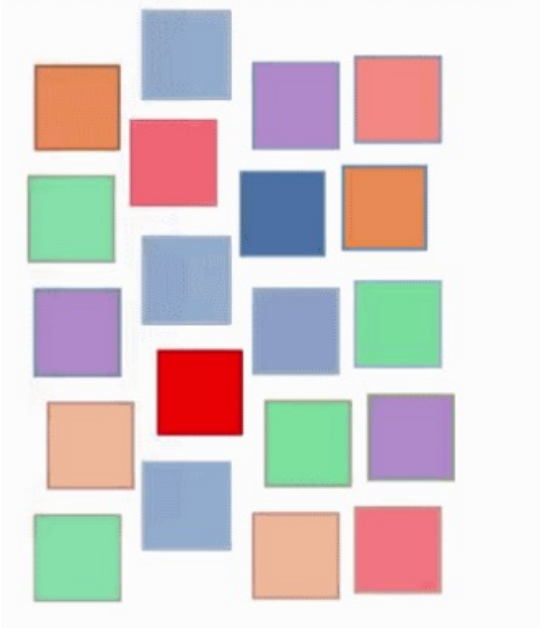
Semi-Structured Data

- Has some structure, but the data isn't expressed in terms of rows and columns.
- Examples:
  - An HTML page



Unstructured Data

- Does not have fields in fixed locations, nor does it follow a standard format such as XML or JSON.
- Examples:
  - Raw text files such as a server log
  - A Microsoft Word document
  - A Portable Document Format (PDF) file.



Sources of Data

- Sources of big data include:
  - Business operational data
  - Scientific data
  - Social networking
  - Web logs
  - Video streaming
  - Sensor data
  - Smartphone data
  - Many more …

Streams

- Some data is produced in streams.
- A data stream is “a sequence of digitally encoded signals used to represent information in transmission”.

Streams-Examples

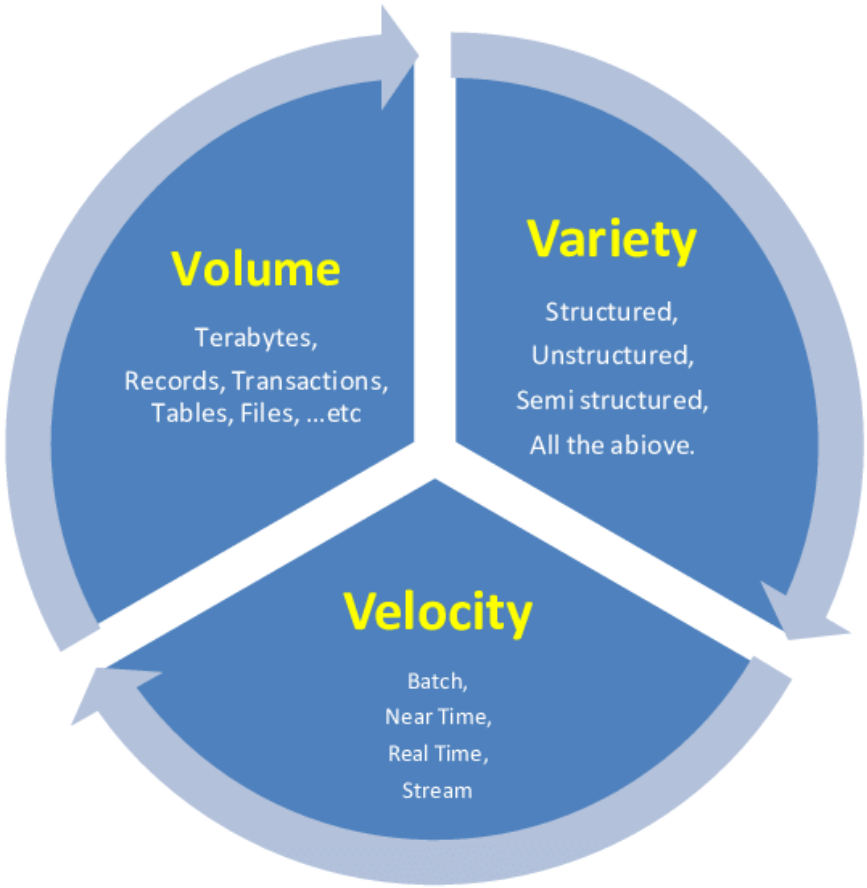
- Click streams
- Packet streams
- Sensor data
- Satellite data
- A video stream produced by an online video camera
- Financial data such as stock-market data.
- ...

Big Data Definition

- **First Definition Butler** (2013)
  - Data that has grown to a ***size*** that requires ***new techniques*** to store, organize, and analyze the data.

The three “Vs” Definition

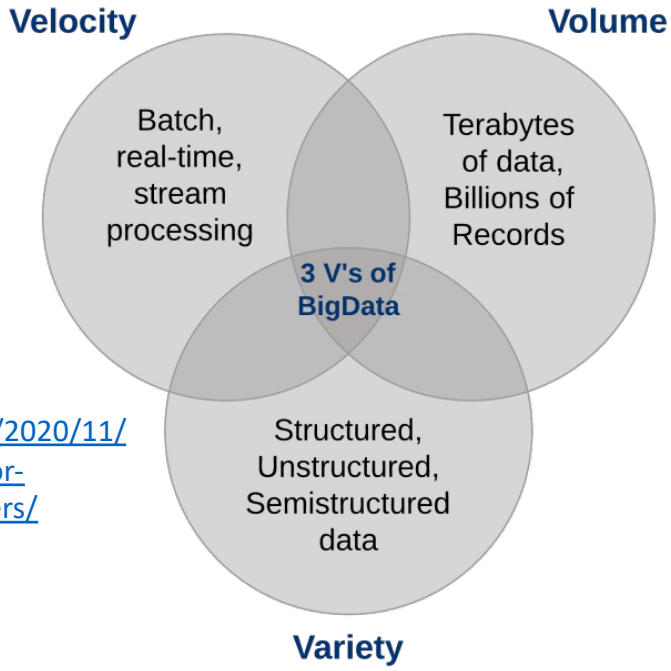
- The three “Vs” definition: ***volume***, ***velocity***, and ***variety***.



Three Key Features

- Big data has ***one or more*** of three key features

1. *A large volume of data*
2. *A high velocity with which the data is created*
3. *A high degree of variety in the data.*



https://www.analyticsvidhya.com/blog/2020/11/what-is-big-data-a-quick-introduction-for-analytics-and-data-engineering-beginners/

Volume

- **Volume** simply means the **amount of data**.
  - How Big?
  - Generally the term “big data” is used to indicate data > 100 GB
  - Often it deals with hundreds of terabytes, and possibly a PB or more.

Three Key Features (cont.)

- ***Velocity*** means that **the data is being created rapidly**
  - For example, hundreds of messages per second
  - Velocity is typically associated with streams

Three Key Features (cont.)

- ***High variety*** is usually associated with **unstructured data**

Three Main Preconditions for the Rise of Big Data

- The ***ability to store large volumes*** of data in a form that is accessible
  - On hard drives or solid-state drives, not tape drives
- The ***ability to process big data rapidly*** at a reasonable cost.
  - Inexpensive computing power (e.g., cloud computing)
- The existence of producers of big data.

Big Data Analytics

- The ability to store and process that data into something that is ***understandable by humans in a reasonable amount of time*** that has allowed the exploitation of that data.

- Successful big data analytics must be able to process the data into something **smaller than the raw data**
  - Allowing an application to present the results in a way that makes sense to a human.

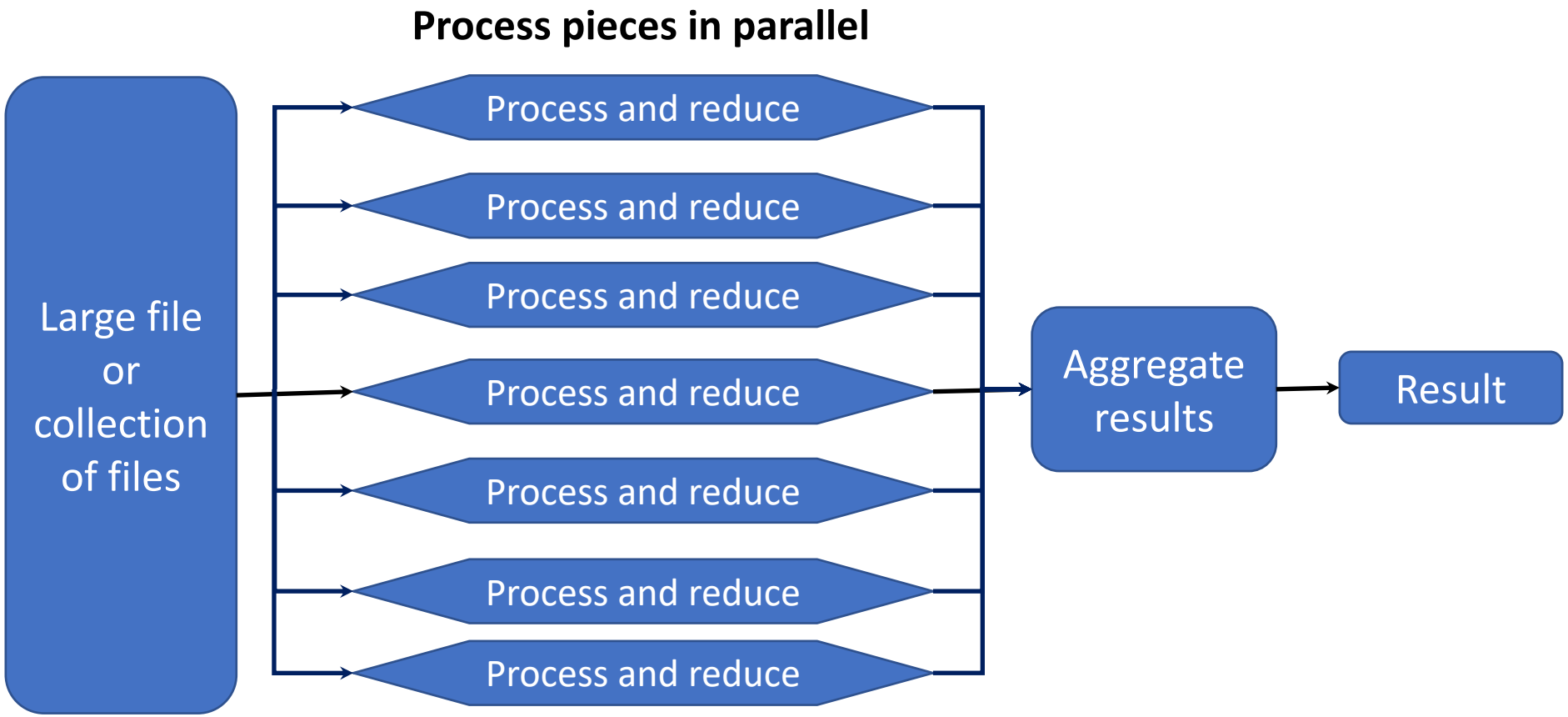
Big Data Analytics (cont.)

- Because big data is so large, **it normally cannot be processed sequentially in a reasonable amount of time.**

- So the **data is broken up into chunks**, which are analyzed by a set of processes running in parallel.

- The results of the parallel analysis are then **joined** together to create the result.

High-level Big Data Analytics



Technologies for Big Data

- **Storage Systems**
  - Distributed file systems and storage clouds
  - NoSQL Databases

- **Programming Platforms**
  - Map-Reduce: Apache Hadoop, Aneka
  - Stream Processing: Heron, Apache Storm, Apache Spark
  - Graph Processing: Pregel, Apache Giraph

Storage Systems

- Traditionally, **database management systems** constituted the de facto storage support for several types of applications.

- The relational model in its original formulation **does not seem to be the preferred solution for supporting data analytics on a large scale.**
  - Due to the explosion of unstructured data (e.g., blogs, Web pages,...),

High-performance distributed file systems and storage clouds

- **Distributed file systems** constitute the primary support for data management.
- They provide an interface whereby to store information in the form of files and later access them for read and write.
- Mostly these file systems constitute the data storage support for large computing clusters, supercomputers, massively parallel architectures, and lately, storage/computing clouds.

High-performance distributed file systems and sto rage clouds

- Lustre
- Google File System (GFS)
- **Hadoop Distributed File System (HDFS)**
- Amazon Simple Storage Service (S3)
- And many more

Hadoop Distributed File System (HDFS)

- HDFS stores **very large files** (many terabytes and petabytes).
- It could store **tens of millions of files**.
- It can run on **hundreds or thousands of commodity servers**.
- A general assumption about HDFS is that **hardware failure is a norm – not an exception**.
- It is suitable for **big data analytics**
  - **It is optimized to** write **very-big files** once and to read them many times
  - It is not suitable for random reads/writes.

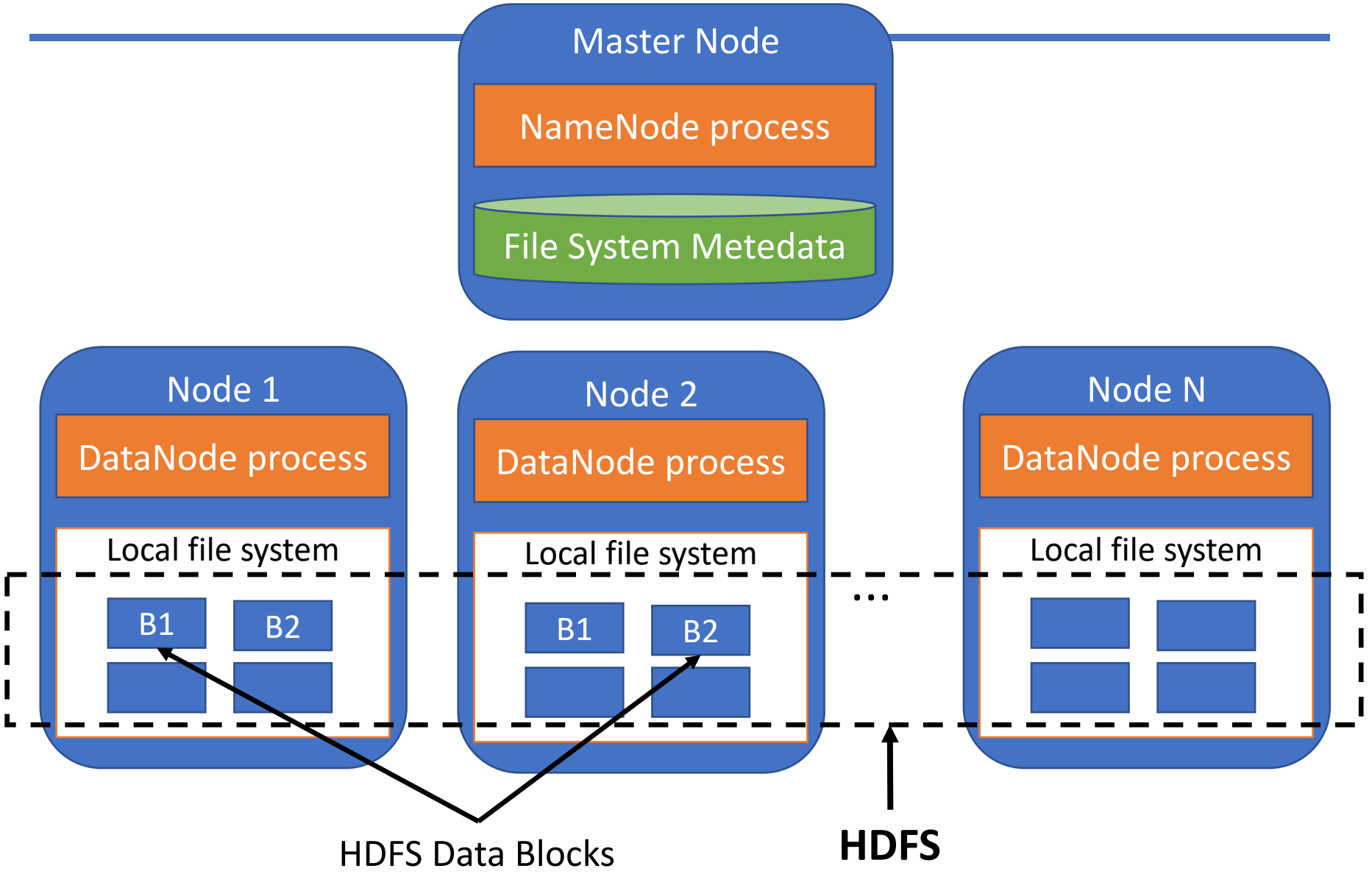
Hadoop Distributed File System (HDFS)

- An HDFS file is a sequence of **blocks stored in a cluster of multiple servers**.
- **Fault tolerance is at block level**.
- HDFS blocks are big ones – 64 MB by default.
- **HDFC is designed for applications that access (streaming) data sets successively**, it is not suitable for small files or for direct reads and writes.
- Hadoop moves the computations to the storage nodes
  - It is the best approach for cases **when the computing programs are relatively small**, and the stored data are big enough.

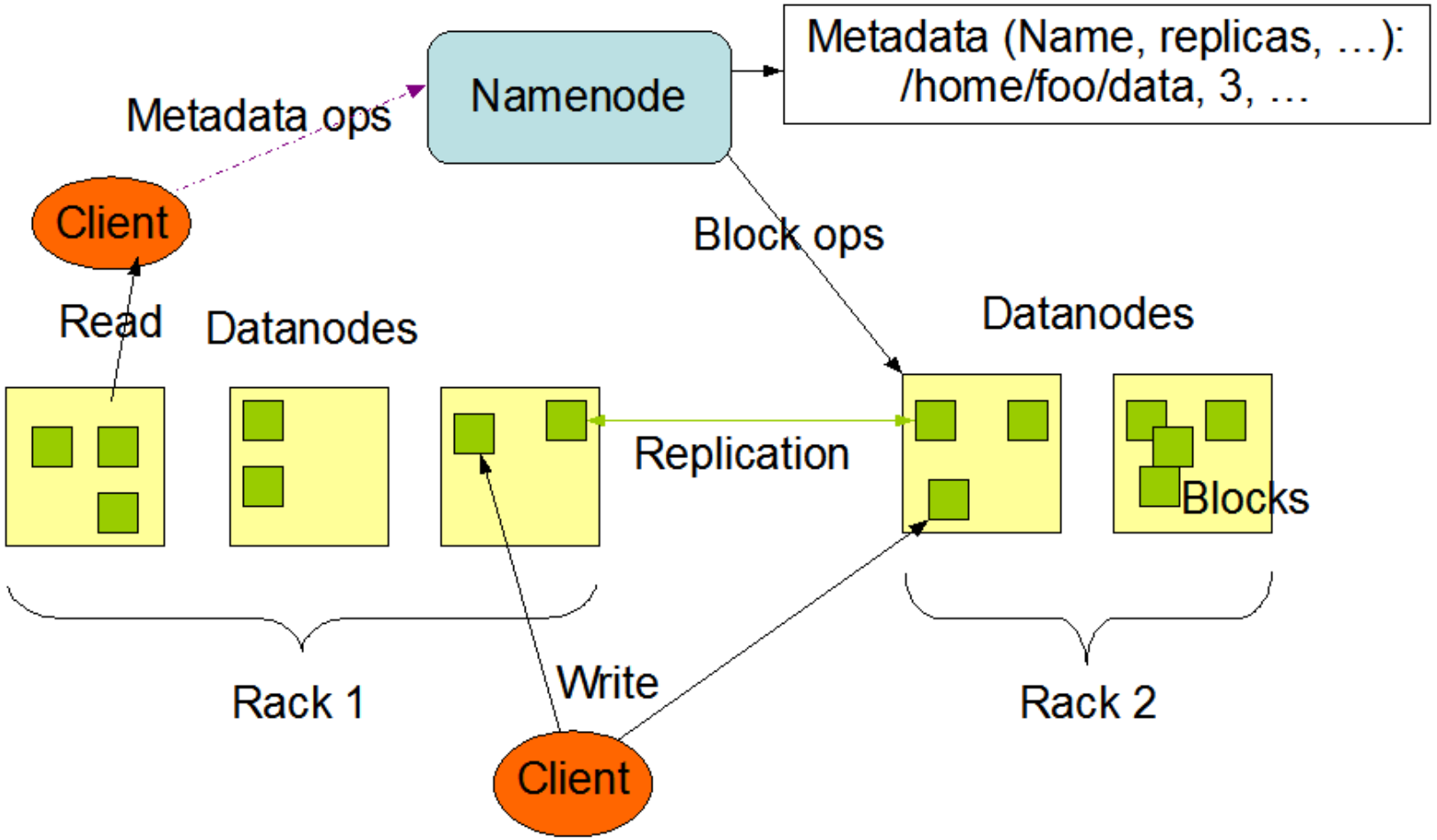
HDFS Structure

- There are namenode and datanode nodes (see next slide)
  - The namenode contains metadata for files, directories, file block locations, and so forth.
  - The datanode stores data blocks.
- The client opens files or directories using the metadata from a namenode, after that, the file datanodes execute the operations.
- The read operations directly access datanodes in a sequential read access mode.
- If a read fails, then the datanode uses a block replica.
- When HDFS has read all the data from a given block, it chooses the next block among all next block replicas.

HDFS Architecture



HDFS Architecture (Cont.)



Source: https://hadoop.apache.org/docs/current/hadoop-project-dist/hadoop-hdfs/HdfsDesign.html