ISIT312 Big Data Management

Cluster Computing

Dr Fenghui Ren

School of Computing and Information Technology -
University of Wollongong

Cluster Computing

Outline

Computer Cluster

What is a computer cluster ?

A computer cluster is a collection of computers (also called as nodes) connected through high speed network that work together to simulate a single much more powerful computer system

Each node in a computer cluster is controlled by its own operating system

Each node in a computer cluster performs a different version of the same task

A difference between computer cluster and computer grid is such that the nodes in a computer grid perfrom different tasks

An architecture of computer cluster ranges from a simple two-node system connecting two personal computers to a supercomputer with a cluster architecture

Computer Cluster

Computer clusters are used to speed up computing through shared nothing (sharding) partitioning of data and paralellization of data procesing on the nodes of a cluster

Computer clusters provide high availability through automatic replacement of a failed node with a replica node

Advantages of computer clusters: faster processing speed, larger storage capacity, better data integrity, greater reliability and wider availability of resources

A Linux cluster is a collection of connected computers that can be viewed and managed as a single system

A sample computer cluster: 54 regular compute nodes (with two 32-Core Intel 8358 processors, 1.6TB of local NVME storage and 512GB of memory each) and 5 GPU nodes with two 24-Core AMD EPYC 7413 processors, eight A100 GPU cards, 960GB of local storage and 512GB of memory each

Computer Cluster

What is a cluster computing ?

Cluster computing is the process of sharing the computation tasks among multiple computers included in a computer cluster

Advantages of cluster computing: cost efficiency, processing speed, expandability, high vailability of resources

At the moment cluster computing is an attractive paradigm for processing large scale science, engineering and commercial applications

Cluster computing requires the specialized algorithms like load balancing, resource sharing and resource scheduling for optimization of data processing

Cluster computing is an attractive alternative to data processing on large parallel supercomputers

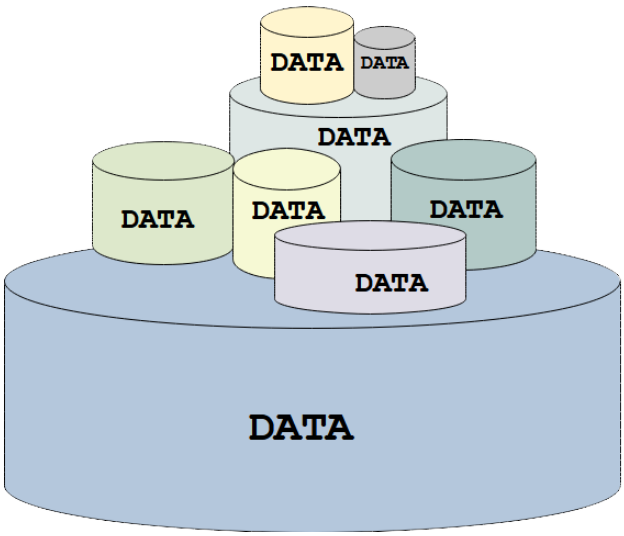
The simplest configuration of nodes for cluster computing consists of a master node and slave nodes

Cluster Computing

Outline

Big Data

What does Big Data mean and how big is Big Data ?

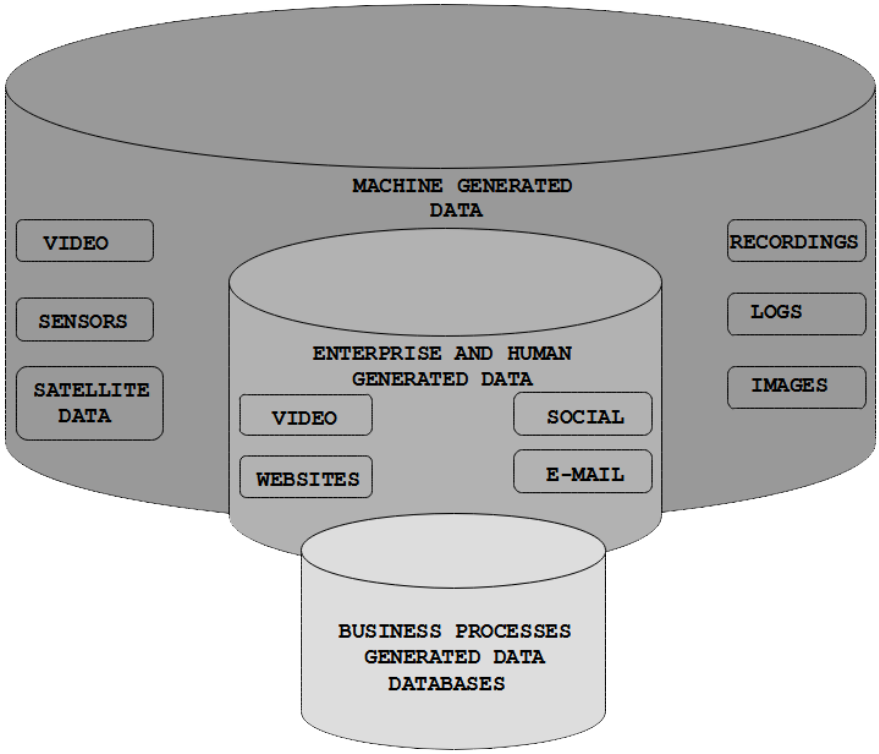


Big Data is so big that it cannot be stored on the persistent storage devices attached to a single computer system

Big Data may also mean an infinite amount of data

Big Data

What are the sources of Big Data ?



Big Data

Big Data is characterized by so called 3V features:

- Volume: e.g., billions of rows ? millions of columns
- Variety: Complexity of data types and structures
- Velocity: Speed of new data creation and growth

Additional Vs:

- Veracity: Ability to represent and process uncertain and imprecise data
- Value: Data is the driving force of the next-generate business
- Viability: Benefits we can potentially have from data analysis

There are many, many other Vs, the largest number of Vs I found on Web was 42 !

- Vagueness: The meaning of found data is often very unclear, regardless of how much data is available
- Validity: Rigor in analysis is essential for valid predictions where data is the driving force of the next-generate business
- Vane: Data science can aid decision making by pointing in the correct direction
- ... and many, many others ... :)

Big Data

Examples of Big Data:

- Clickstream data
- Call centre data
- E-mail and instant-messaging
- Sensor data
- Unstructured data
- Geographic data
- Satellite data
- Image data
- Temporal data
- and more ...

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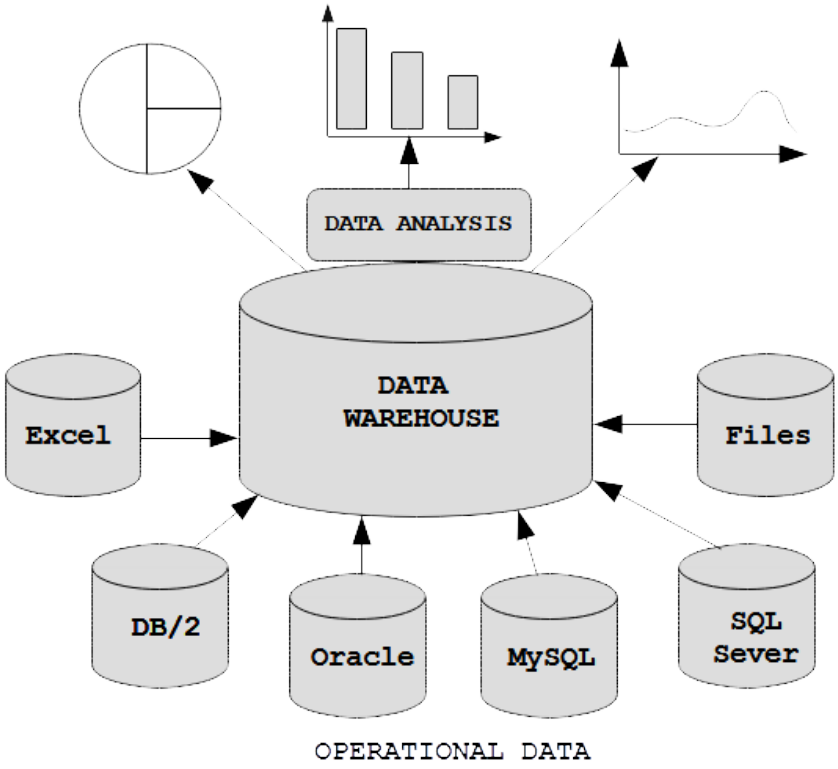
Traditional Data Architectures

Data warehousing technologies



Traditional Data Architectures

The strength of traditional data architectures:

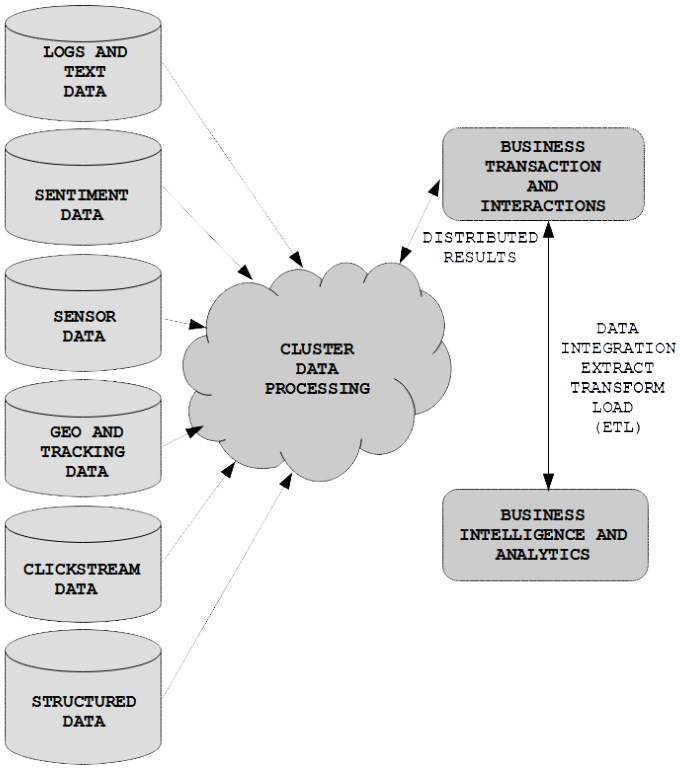
- Centralised governance of data repositories
- Light-fast inquires performed regularly in daily business
- Optimisation for OLTP and OLAP
- Security and access control
- Fault-Tolerance and backup

The challenges for traditional data architectures:

- New types of data such as unstructured data and semi-structured data
- Increasingly large amounts of data flowing into organisations
- New computational paradigms use non-traditional NoSQL databases to rapidly mine and analyse very large data sets
- Increasing cost of storing and analysing the large amounts of data
- Increasing use of data analytics, which requires significant storage and processing capabilities

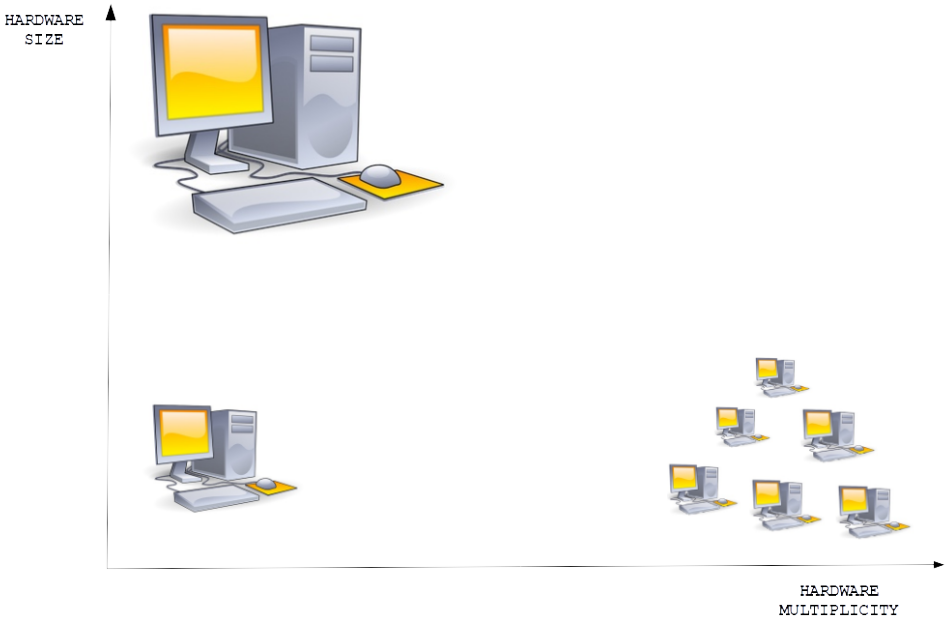
Traditional Data Architectures

A sample Data Lake architecture



Traditional Data Architectures

Hardware for Big Data has two scalability dimensions



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Outline

Meet Hadoop !

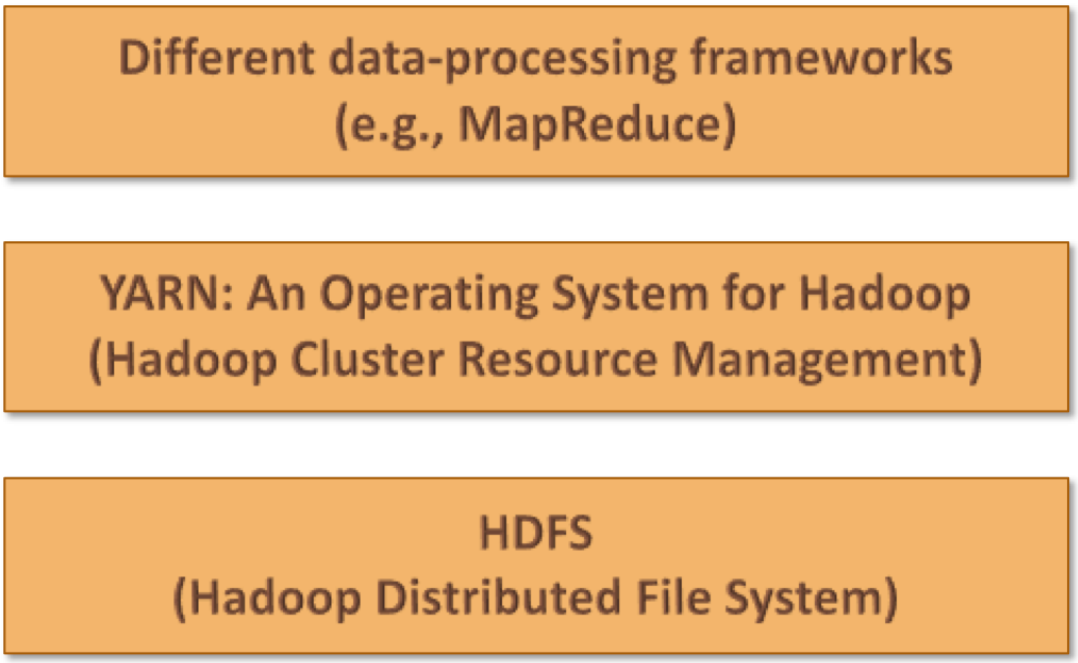
Hadoop, in terms of its developers, is a project that develops open-source software for reliable, scalable, distributed computing

Features of Hadoop

- Capability to handle large data sets, e.g. simple scalability and coordination
- File size range from gigabytes to terabytes
- Can store millions of those files
- High fault tolerance
- Supports data replication
- Supports streaming access to data
- Supports batch processing
- Support interactive, iterative and stream processing
- Implements a data consistency model of write-once-read-many access model
- Run on commodity hardware, not high-performance computers
- Inexpensive
- It can be deployed on premises or in the cloud

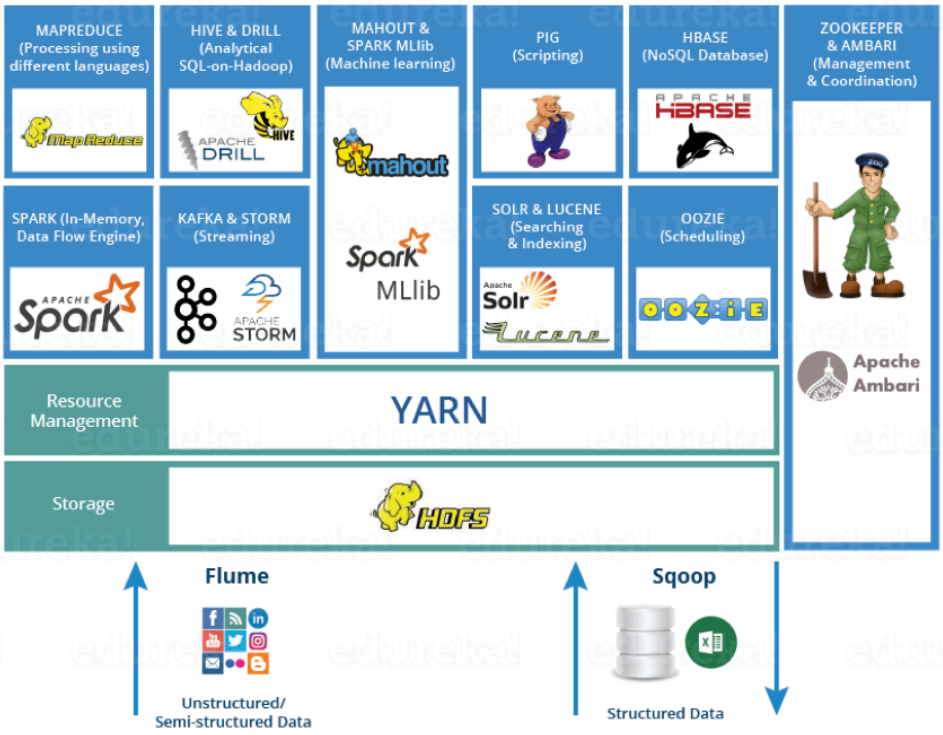
Meet Hadoop !

Core components of Hadoop



Hadoop Ecosystem

Hadoop ecosystem

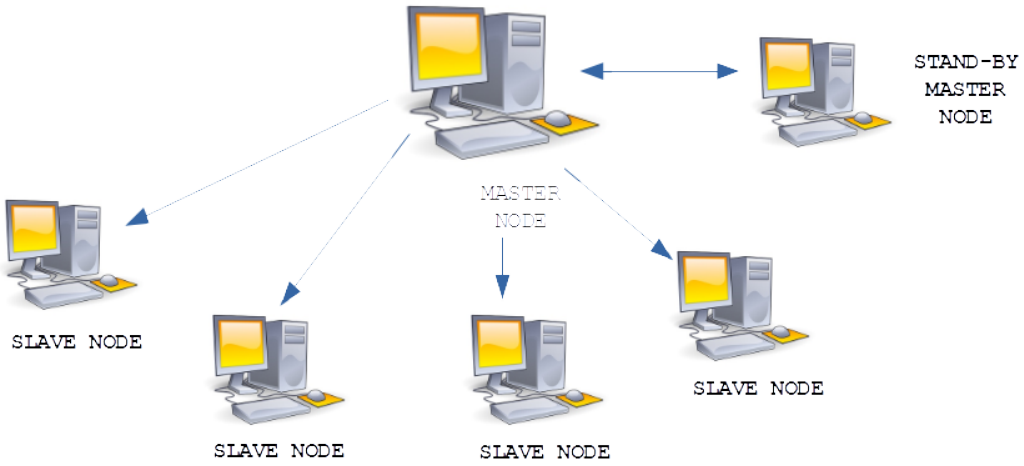


Commercial Hadoop Landscape

Commercial Hadoop landscape

Meet Hadoop !

Master-slave architecture of Hadoop clusters



Meet Hadoop !

Hadoop clusters can support up to 10,000 server and receives near-to-linear scalability in computing power

A typical Hadoop cluster consists of:

- A set of master nodes (servers) where the daemons supporting key Hadoop frame-works run
- A set of worker nodes that host the storage (HDFS) and computing (YARN) work
- One or more edge servers, which are used for accessing the Hadoop cluster to launch applications
- One or more relational databases such as MySQL for storing the metadata repositories
- Dedicated servers for special frameworks such as Kafka

Meet Hadoop !

Hadoop also support the pseudo-distributed mode

- All HDFS and YARN daemons running on a single node.
- Highly simulate the full cluster
- Easy for beginner's practice
- Easy for testing and debug

Our lab setting is the pseudo-distributed mode

- The single node is a Ubuntu 14.04 Virtual Machine (VM)

Cluster Computing

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Big Data on Database Clusters

A database cluster is a collection of databases that is managed by a single instance of a running database server

A very large database in a database cluster is partitioned over a number of smaller databases each located on a separate node of a computer cluster

Database clustering requires replication and sharding

Database clustering improve performance, availability, and scalability

The classes of database system that allow for database clustering:

- NoSQL systems: MongoDB, RavenDB, Cassandra, Amazon Aurora, ...
- NewSQL systems: ClustrixDB, NuoDB, CockroachDB, Pivotal GemFire XD, Altibase, MemSQL, VoltDB, ...
- Improved OldSQL systems: Oracle RAC, SQL Server (Windows server Failover Cluster), DB2 Cluster, PostgreSQL, MySQL Cluster, ...

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Big Data on Kubernetes

Kubernetes (K8) is a container or microservice platform that orchestrates computing, networking, and storage infrastructure workloads

in a plain language Kubernetes is an orchestration platform to manage any containerized application

A Kubernetes cluster consists of a single master node and potentially multiple corresponding worker nodes

The benefits of Kubernetes:

- horizontal scaling,
- automated rollouts and rollbacks,
- service discovery and load balancing,
- storage orchestration,
- self healing,
- batch execution,
- automatic binpacking

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