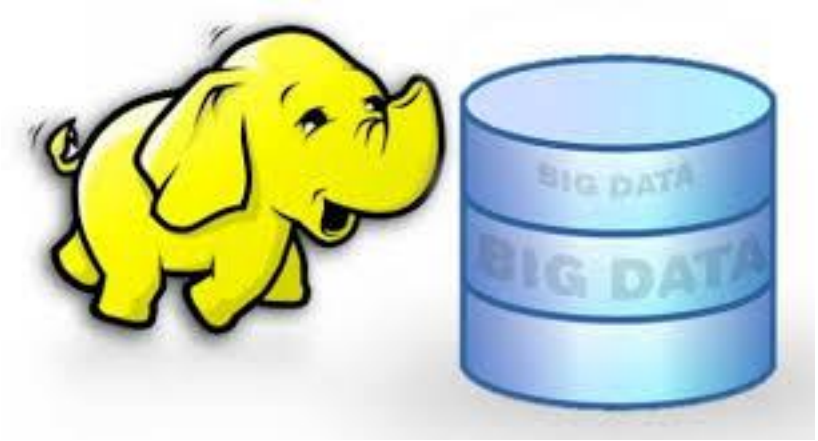
Hadoop



What is Big Data

- Wikipedia big data
  - An all-encompassing term for any collection of data sets so **large** and **complex** that it becomes **difficult** to process **using on-hand data management tools or traditional data processing applications.**

How Big is **Big**?

- 2008: Google processes 20 PB a day
- 2009: Facebook has 2.5 PB user data + 15 TB /day
- 2011: Yahoo! has 180-200 PB of data
- 2012: Facebook ingests 500 TB/day
- 2013: YouTube 1000 PB video storage; 4 billion views/day

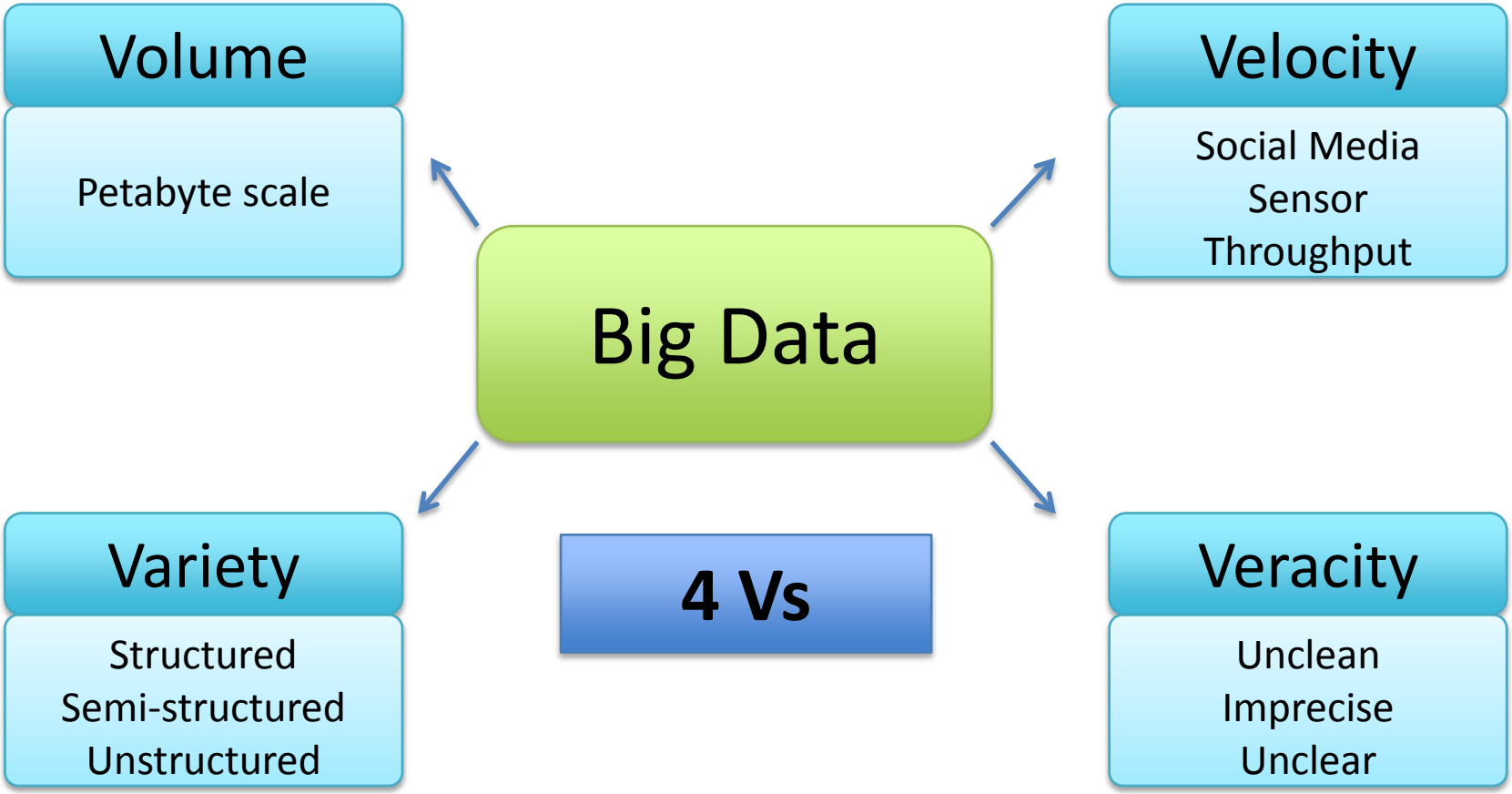
1 PB=10^3 TB=10^6 GB=10^15 B

1 Exabyte = 1000 PB

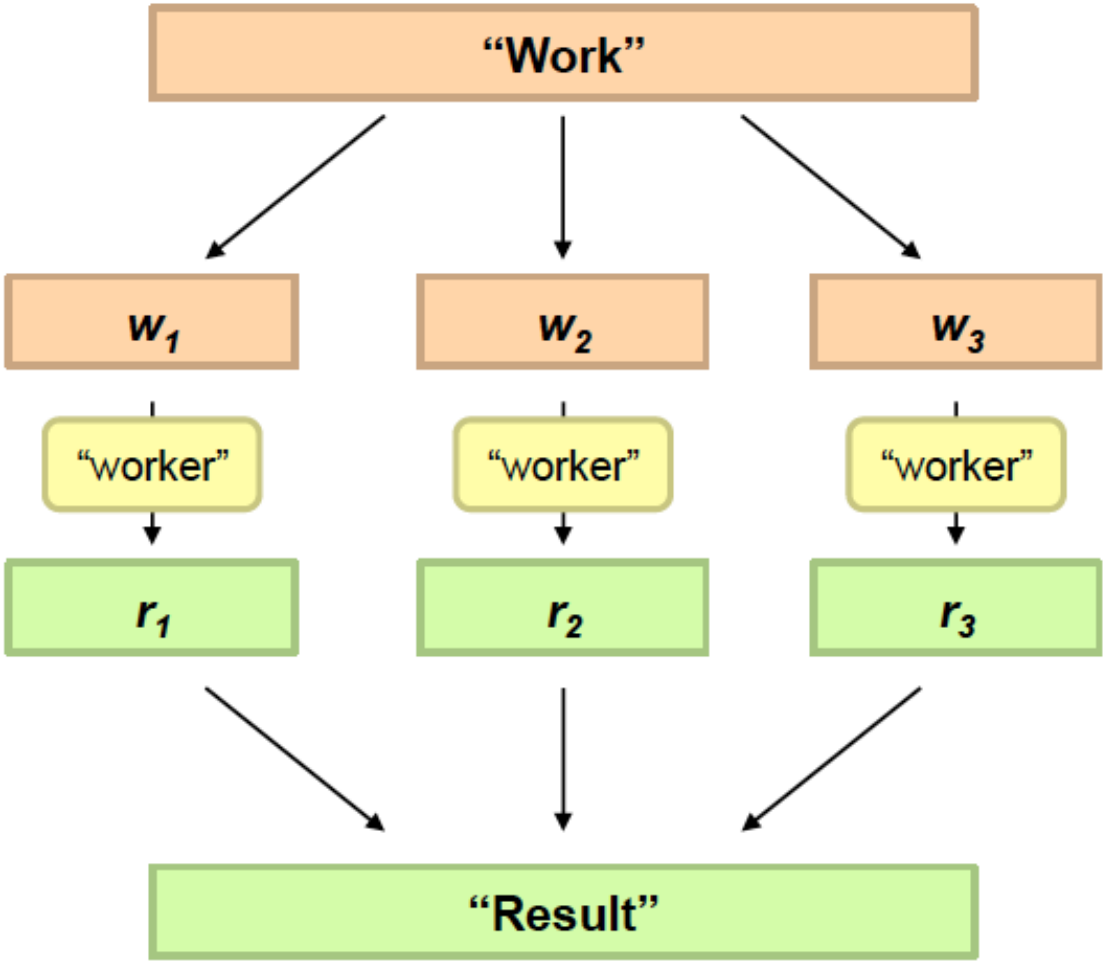
Zettabyte, Yottabyte …

Philosophy to Scale for Big Data?

Key Features of Big Data



Divide and Conquer



Divide Work

Combine Results

Distributed processing

- How to assign tasks to different workers in an efficient way?
- What happens if tasks fail?
- How do workers exchange results?
- How to synchronize distributed tasks allocated to different workers?

Big data storage is challenging

- Data Volumes are massive
- Reliability of Storing PBs of data is challenging
- All kinds of failures: Disk/Hardware/Network Failures
- Probability of failures simply increase with the number of machines

One popular solution: Hadoop

Hadoop Cluster at Yahoo! (Credit: Yahoo)

Hadoop offers

- Redundant, Fault-tolerant data storage
- Parallel computation framework
- Job coordination

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Programmers

No longer need to worry about

Q: Where file is located?

Q: How to handle failures & data lost?

Q: How to divide computation?

Q: How to program for scaling?

New York Times Faced Challenge in 2007

Challenging and Complicated Computing Chore

http://www.greenm3.com/gdcblog/2008/11/5/nytimes-aws-cloud-computing-mistake-cost-240.html

A real world example of New York Times

- **Goal:** Make entire archive of articles available online: 11 million, from 1851
- **Task:** Translate 4 TB TIFF images to PDF files
- **Solution:** Used Amazon Elastic Compute Cloud (EC2) and Simple Storage System (S3)
- **Time:** **?**
- **Costs:** **?**

The New York Times

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- **Time:** **< 24 hours**
- **Costs:** **$240**

The New York Times

A little history on Hadoop

- Hadoop is an open-source implementation based on **Google File System** (GFS) and **MapReduce** from Google
- Hadoop was created by **Doug Cutting** and **Mike Cafarella** in 2005
- Hadoop was donated to **Apache** in 2006

Who are using Hadoop?

Social

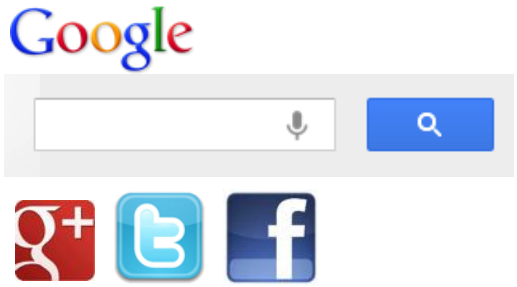
User Tracking & Engagement

Homeland Security

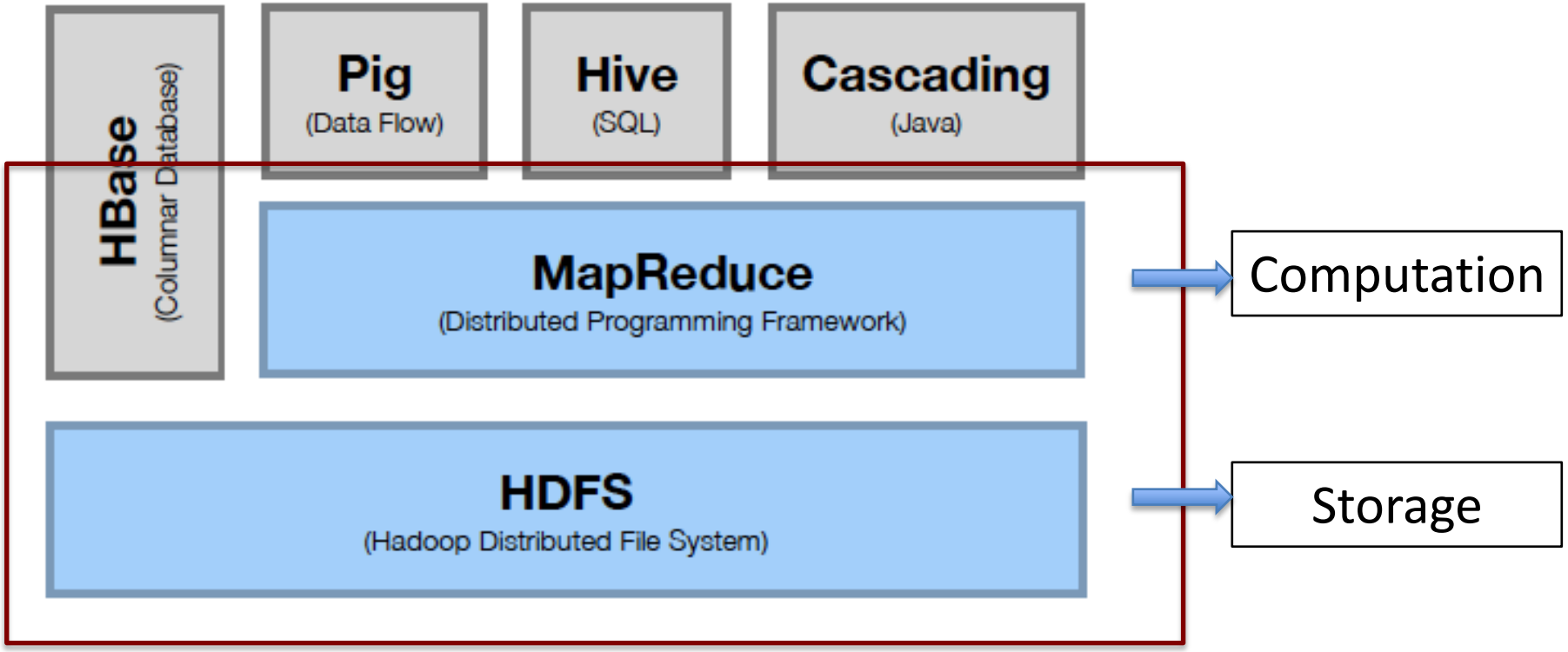
eCommerce

Financial Services

Real Time Search



Hadoop Stack



HDFS

Hadoop Distributed File System

Motivation Questions

- **Problem 1:** Data is too big to store on one machine.

- **HDFS:** Store the data on multiple machines

Motivation Questions

- **Problem 2:** Very high end machines are too expensive

- **HDFS:** Run on commodity hardware

Motivation Questions

- **Problem 3:** Commodity hardware will fail!

- **HDFS:** Software is intelligent enough to handle hardware failure

Motivation Questions

- **Problem 4:** What happens to the data if the machine stores the data fails?

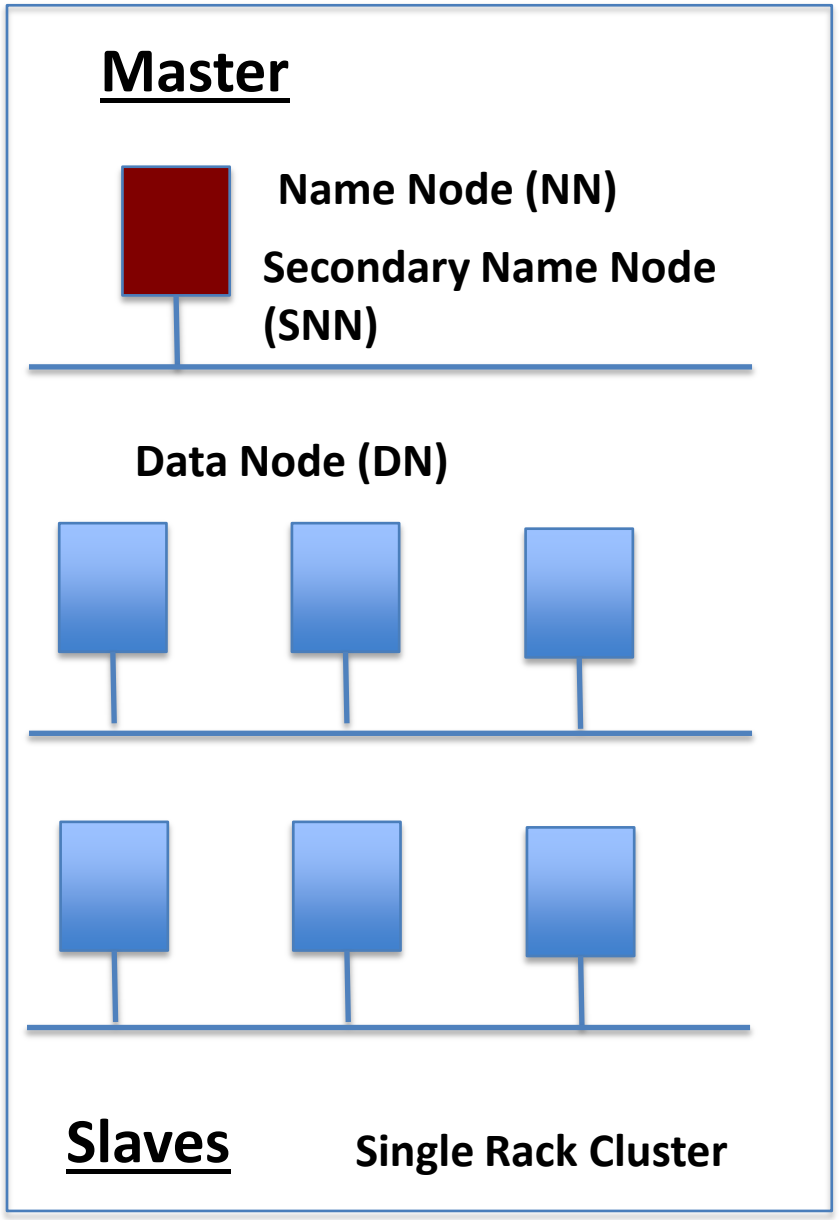
- **HDFS:** Replicate the data

Motivation Questions

- **Problem 5:** How can distributed machines organize the data in a coordinated way?

- **HDFS:** Master-Slave Architecture

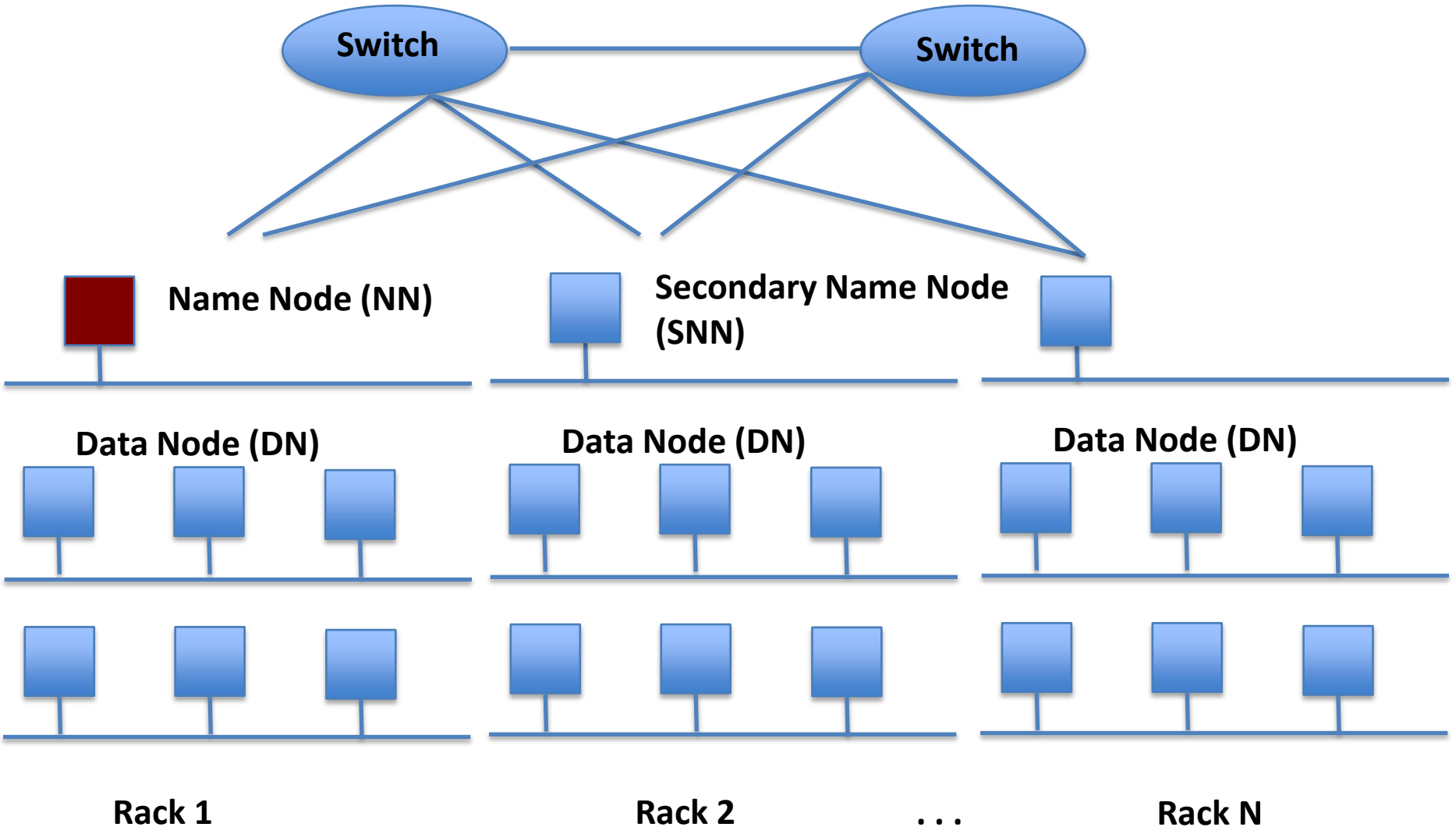
HDFS Architecture: Master-Slave



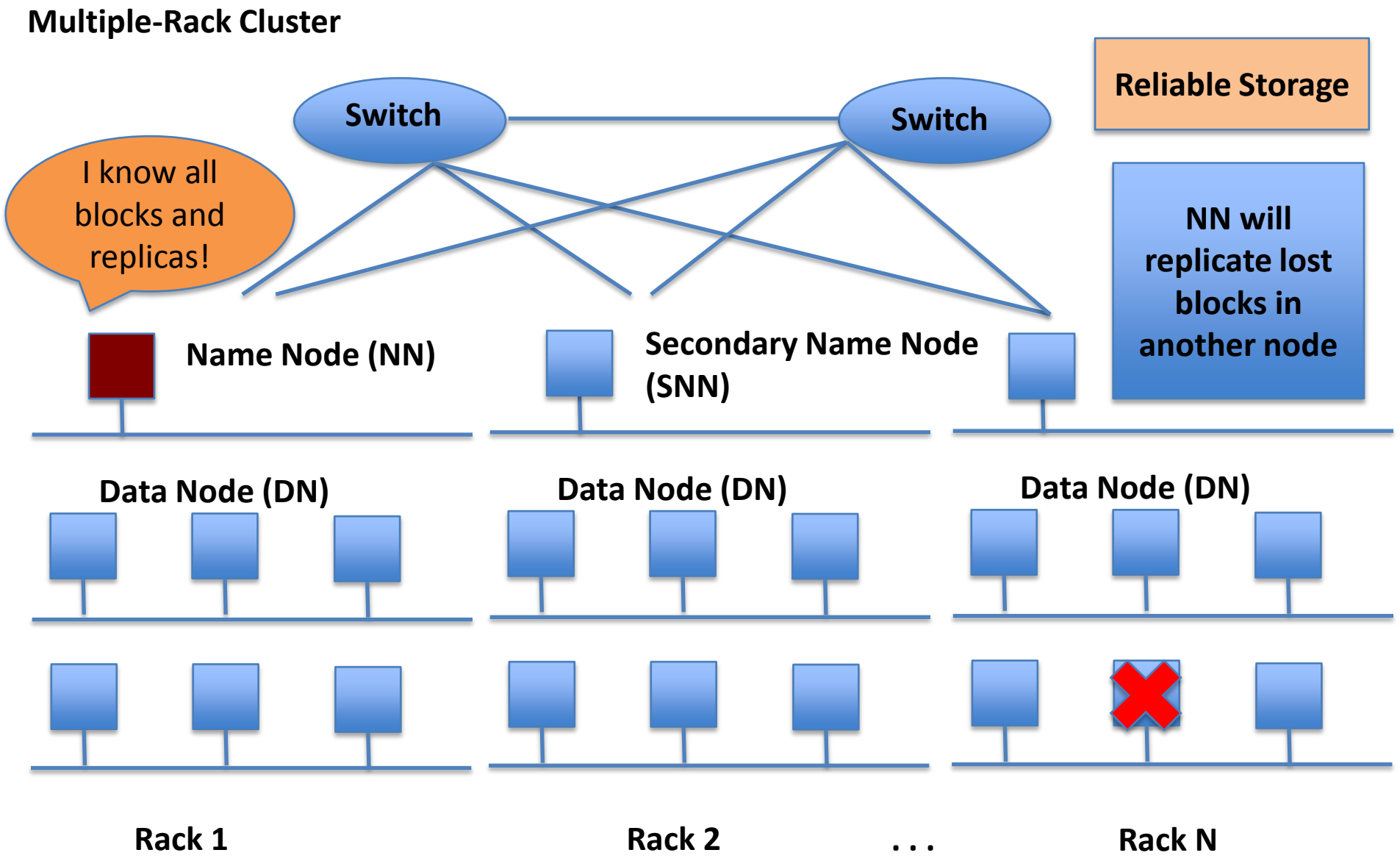
- Name Node: Controller
  - File System Name Space Management
  - Block Mappings
- Data Node: Workers
  - Block Operations
  - Replication
- Secondary Name Node:
  - Checkpoint node

HDFS Architecture: Master-Slave

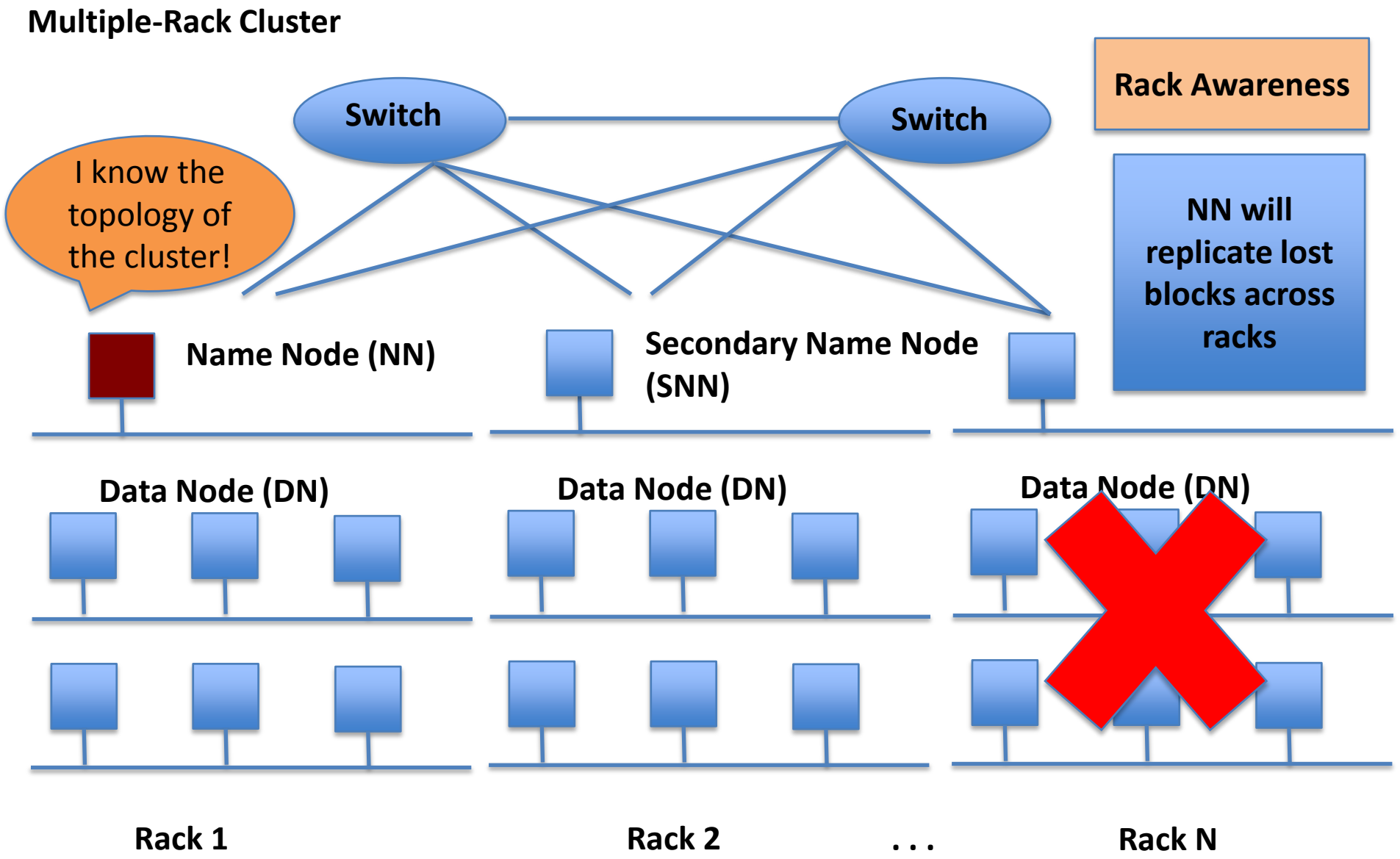
Multiple-Rack Cluster



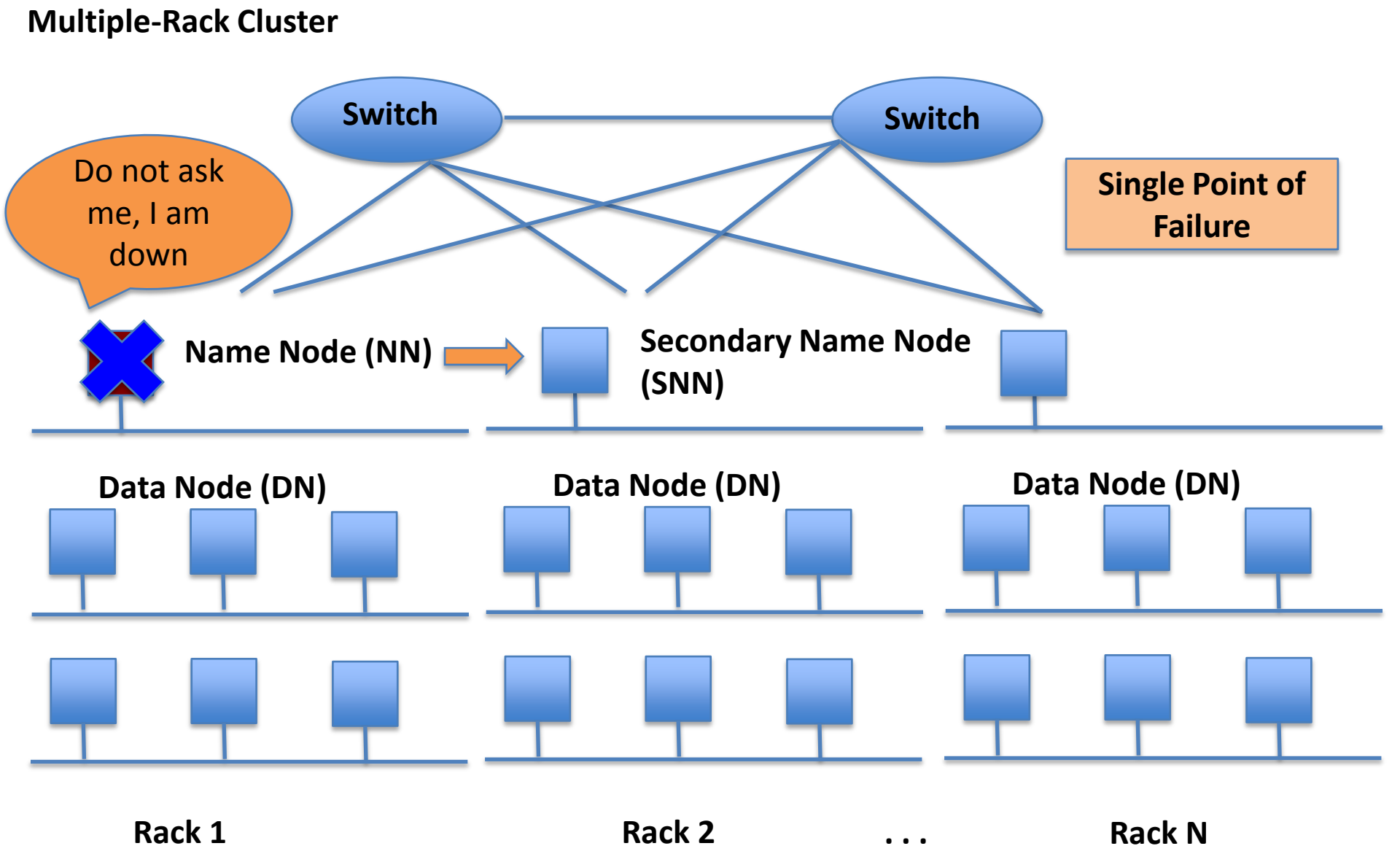
HDFS Architecture: Master-Slave



HDFS Architecture: Master-Slave



HDFS Architecture: Master-Slave



HDFS Architecture: Master-Slave