Introduction to Big Data & Hadoop

Venkat Ankam
Big Data Architect
venkat@cloudwick.com

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Agenda

- What is Big Data and Hadoop?
- Challenges of Big Data
- Technologies support Big Data
- What is Hadoop? And Why Hadoop?
- Hadoop Eco System
- Use Cases of Hadoop
- HDFS
- Map Reduce
- Statistics

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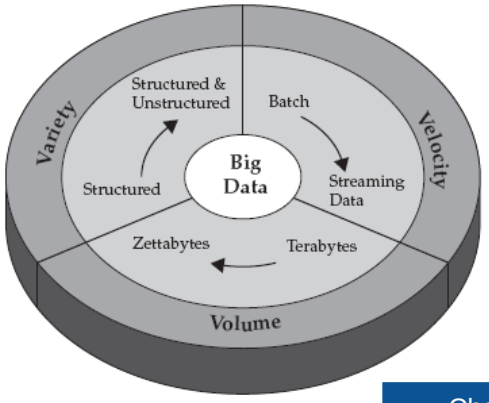
What is Big Data?

Big data is a term applied to data sets whose size is beyond the ability of commonly used software tools to capture, manage, and process the data within a tolerable elapsed time.

Sources :: Web logs; RFID; sensor networks; social networks; social data; Internet text/Index; call detail records; astronomy, atmospheric science, biological; military surveillance; medical records; photography & video archives



Gartner Predicts 800% data growth over next 5 years

80-90% of data produced today is unstructured

Characteristic	"Traditional" Data	BIG DATA
Data size	Gigabytes to Tera bytes	Peta Bytes to Exa Bytes
Architecture	Centralized	Distributed
Structure	Structured	Semi structured/ Unstructured
Data Model	Stable Data model	Flat Schemas
Schema	Known complex interrelationships	Few complex inter relationships
Access	Interactive and Batch	Batch
Language	SQL	Procedural (Java, C++, Ruby, etc)
Integrity	High	Low
Scaling	Non-linear	Linear
Updates	Read and Write	Write once, read many times
Latency	Low	High

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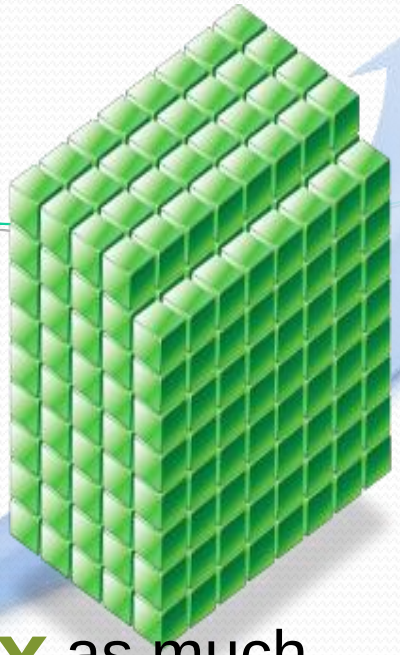
What is Big Data?

The volume, variety, and velocity of information is driving unprecedented complexity – and opportunity

gigabyte (GB)	10^9	2^{30}
terabyte (TB)	10^{12}	2^{40}
petabyte (PB)	10^{15}	2^{50}
exabyte (EB)	10^{18}	2^{60}
zettabyte (ZB)	10^{21}	2^{70}
yottabyte (YB)	10^{24}	2^{80}

2009
800,000 petabytes



2020
35 zettabytes

i.e. 35Billion TBs

44x as much Data and Content Over Coming Decade

Source: IDC, The Digital Universe Decade – Are You Ready?, May 2010

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Challenges of Big Data

- How we can capture and deliver data to right people in real-time?
- How we can understand and use big data when it is in Variety of forms?
- How we can store/analyze the data given its size and computational capacity?
- While the storage capacities of hard drives have increased massively over the years, access speeds—the rate at which data can be read from drives— have not kept up. Example: Need to process 100TB datasets
  - On 1 node:
  - scanning @ 50MB/s = 23 days
  - On 1000 node cluster:
  - scanning @ 50MB/s = 33 min
- Hardware Problems / Process and combine data from Multiple disks

Traditional Systems: They can't scale, not reliable and expensive.

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Technologies to support Big Data

Scale-out everything:

- Storage
- Compute
- Analytics

BIG DATA Market Segments

Hardware	Big Data Distributions	Data Management Components	Analytics Layer	Applications Layer	Services
• Storage • Servers • Networking Vendors include Dell, HP, Arista, IBM, Cisco, EMC, NetApp.	• Open source Hadoop distributions • Enterprise Hadoop distributions • Non-Hadoop Big Data frameworks Vendors/ providers include Apache, Cloudera, Hortonworks, IBM, EMC, MapR, LexisNexis.	• Distributed file stores • NoSQL databases • Hadoop-optimized data warehousing • Data integration • Data quality and governance Vendors/providers include Apache, DataStax, Pervasive Software, Couchbase, IBM, Oracle, Informatica, Syncsort, Talend.	• Analytic application development platforms • Advanced analytics applications Vendors/providers include Apache, Karmasphere, Hadapt, Attivio, 1010data, EMC, SAS Institute, Digital Reasoning, Revolution Analytics.	• Data visualization tools • Business intelligence applications Vendors include Datameer, ClickFox, Platfora, Tableau Software, Tresata, IBM, SAP, Microstrategy, Pentaho, QlikTech, Japersoft.	• Consulting • Training • Technical support • Software maintenance • Hardware maintenance • Hosting/Big-Data-as-a-Service/cloud Vendors include Tresata, Tidemark, Think Big Analytics, Amazon Web Services, Accenture, Cloudera, Hortonworks.
Next Generation Data Warehouse Appliances					
• MPP, columnar data warehouse appliances. • In-memory analytics engines • Fast data loading Vendors include EMC Greenplum, HP Vertica, Teradata Aster, IBM Netezza, Kognitio, ParAccel.					

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What is Hadoop?

- Apache Hadoop is a software framework that supports data-intensive distributed applications under a free license.

- It enables applications to work with thousands of nodes and petabytes of data.

- Hadoop was inspired by Google's MapReduce and Google File System (GFS) papers

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Why Hadoop?

Characteristics

- Accessible—Hadoop runs on large clusters of commodity machines or on cloud (EC2).
- Robust—Hadoop is architected with the assumption of frequent hardware malfunctions. It can gracefully handle most such failures.
- Scalable—Hadoop scales linearly to handle larger data by adding more nodes to the cluster.
- Simple—Hadoop allows users to quickly write efficient parallel code.
- Data Locality—Move Computation to the Data.
- Replication - Use replication across servers to deal with unreliable storage/servers

Adoption Drivers

- Business Drivers
  Bigger the data, Higher the **value**
- Financial Drivers
  Cost advantage of Open Source + Commodity H/W
  Low cost per TB
- Technical Drivers
  Existing systems failing under growing requirements – 3 Vs

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Low Cost per TB?

- Typical Hardware:
  - Two Quad Core Processor
  - 24GB RAM
  - 12 * 1TB SATA disks (JBOD mode, no need for RAID)
  - 1 Gigabit Ethernet card
- Cost/node: $5K/node
- Effective HDFS Space:
  - ¼ reserved for temp shuffle space, which leaves 9TB/node
  - 3 way replication leads to 3TB effective HDFS space/node
  - But assuming 7x compression that becomes ~ 20TB/node

Effective Cost per user TB: $250/TB

Other solutions cost in the range of $5K to $100K per user TB

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Comparison with RDBMS

RDBMS
- SQL designed for Structured Data
- Scales up – Need Database-class servers
- Not economical - a machine with four times the power of a standard PC costs a lot more than putting four such PCs in a cluster
- Key Value Pairs instead of Relational Tables
- Functional Programming (Map Reduce) instead of SQL
- Offline processing instead of online transaction processing

	Traditional RDBMS	MapReduce
Data size	Gigabytes	Petabytes
Access	Interactive and batch	Batch
Updates	Read and write many times	Write once, read many times
Structure	Static schema	Dynamic schema
Integrity	High	Low
Scaling	Nonlinear	Linear

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Comparison with HPC, GRID Computing and Volunteer Computing

The High Performance Computing (HPC) and Grid Computing communities and Volunteer Computing (like SETI@HOME) have been doing large-scale data processing for years, using such APIs as Message Passing Interface (MPI). Broadly, the approach is to distribute the work across a cluster of machines, which access a shared filesystem, hosted by a SAN.

This works well for predominantly compute-intensive jobs, but becomes a problem when nodes need to access larger data volumes (hundreds of gigabytes, the point at which MapReduce really starts to shine), since the network bandwidth is the bottleneck and compute nodes become idle.

Thinking at Scale

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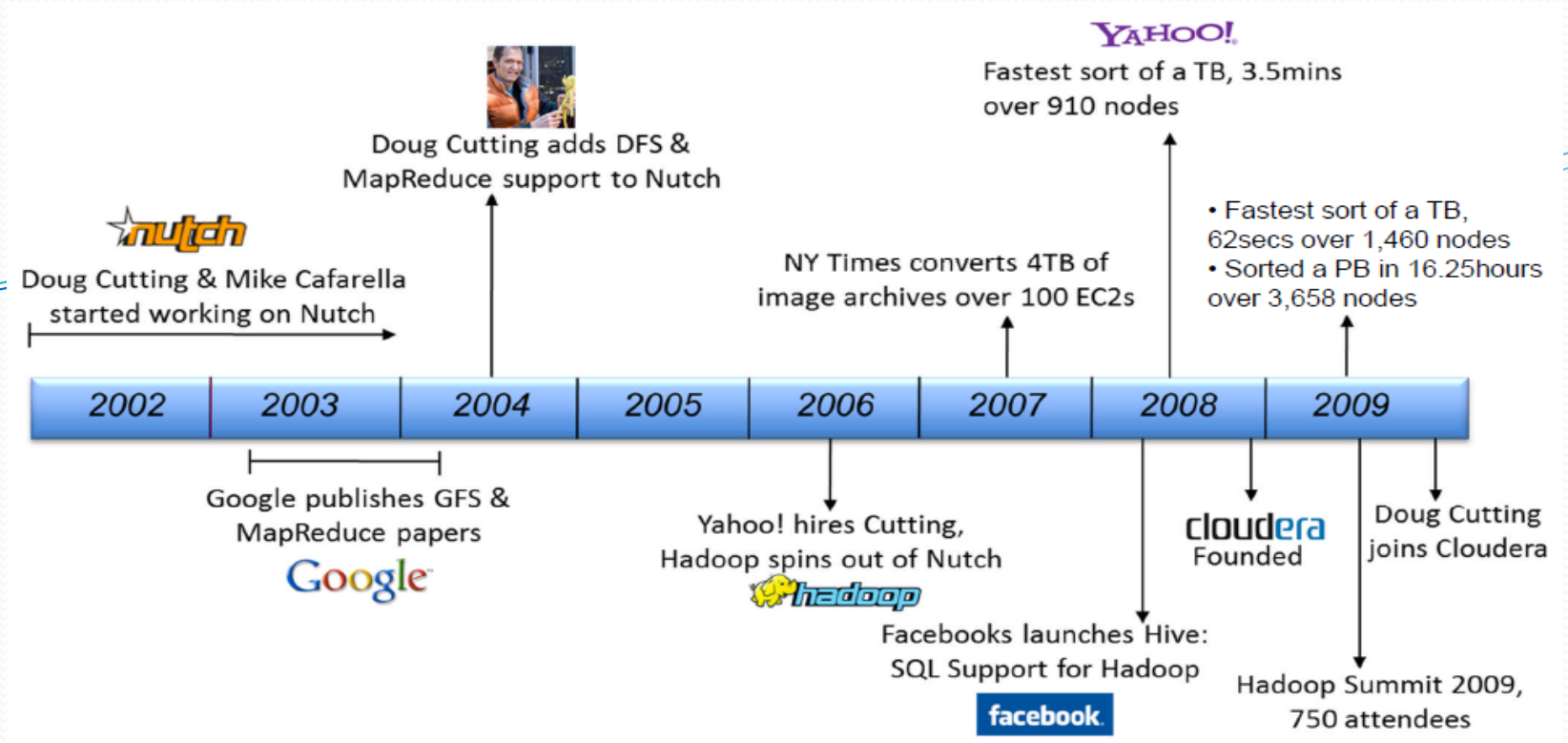
History of Hadoop



The name Hadoop is not an acronym; it's a made-up name. The project's creator, Doug Cutting, explains that it was named after his kid's stuffed yellow elephant.

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Who Uses Hadoop?

Few Users of Hadoop:

- **Yahoo** - 100,000 CPUs in >36,000 computers
- **Facebook** - 1100-machine cluster with 8800 cores and about 12 PB storage and A 300-machine cluster with 2400 cores and about 3 PB raw storage
- **Linkedin** –
- **Twitter**
- **Ebay**
- **IBM**
- **IIIT, Hyderabad** - 10 to 30 nodes ,Quad 6600s, 4GB RAM and 1TB disk
- **PSG Tech, Coimbatore** - 5 to 10 nodes. Cluster nodes vary from 2950 Quad Core Rack Server, with 2x6MB Cache and 4 x 500 GB SATA Hard Drive to E7200 / E7400 processors with 4 GB RAM and 160 GB HDD.
- **Rackspace**
- **Google** – University initiative
- **Adobe**
- **NewYork Times**

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Use Cases of Hadoop

Financial services	Discover fraud patterns based on multi-years worth of credit card transactions and in a time scale that does not allow new patterns to accumulate significant losses. Measure transaction processing latency across many business processes by processing and correlating system log data.
Internet retailer	Discover fraud patterns in Internet retailing by mining Web click logs. Assess risk by product type and session/Internet Protocol (IP) address activity.
Retailers	Perform sentiment analysis by analyzing social media data.
Drug discovery	Perform large-scale text analytics on publicly available information sources.
Healthcare	Analyze medical insurance claims data for financial analysis, fraud detection, and preferred patient treatment plans. Analyze patient electronic health records for evaluation of patient care regimes and drug safety.
Mobile telecom	Discover mobile phone churn patterns based on analysis of CDRs and correlation with activity in subscribers' networks of callers.
IT technical support	Perform large-scale text analytics on help desk support data and publicly available support forums to correlate system failures with known problems.
Scientific research	Analyze scientific data to extract features (e.g., identify celestial objects from telescope imagery).
Internet travel	Improve product ranking (e.g., of hotels) by analysis of multi-years worth of Web click logs.

Hadoop Eco System

Hadoop Common: The common utilities that support the other Hadoop subprojects.
HDFS: A distributed file system that provides high throughput access to application data.
MapReduce: A software framework for distributed processing of large data sets on compute clusters.
Other Hadoop-related projects at Apache include:
Avro: A data serialization system.
Cassandra: A scalable multi-master database with no single points of failure.
Chukwa: A data collection system for managing large distributed systems.
HBase: A scalable, distributed database that supports structured data storage for large tables.
Hive: A data warehouse infrastructure that provides data summarization and ad hoc querying.
Mahout: A Scalable machine learning and data mining library.
Pig: A high-level data-flow language and execution framework for parallel computation.
ZooKeeper: A high-performance coordination service for distributed applications

HDFS

Distributed storage system

- Files are divided into large blocks and distributed across the Cluster
- Blocks replicated to handle hardware failure
- Data placement exposed so that computes can be migrated to data

Architecture

- Master-Slave Architecture
- HDFS Master "Namenode"
  - Manages all filesystem metadata
- Transactions are logged, merged at startup
  - Controls read/write access to files
  - Manages block replication
- HDFS Slaves "Datanodes"
  - Notifies NameNode about block-IDs it has
  - Serve read/write requests from clients
  - Perform replication tasks upon instruction by namenode
  - Rack-aware

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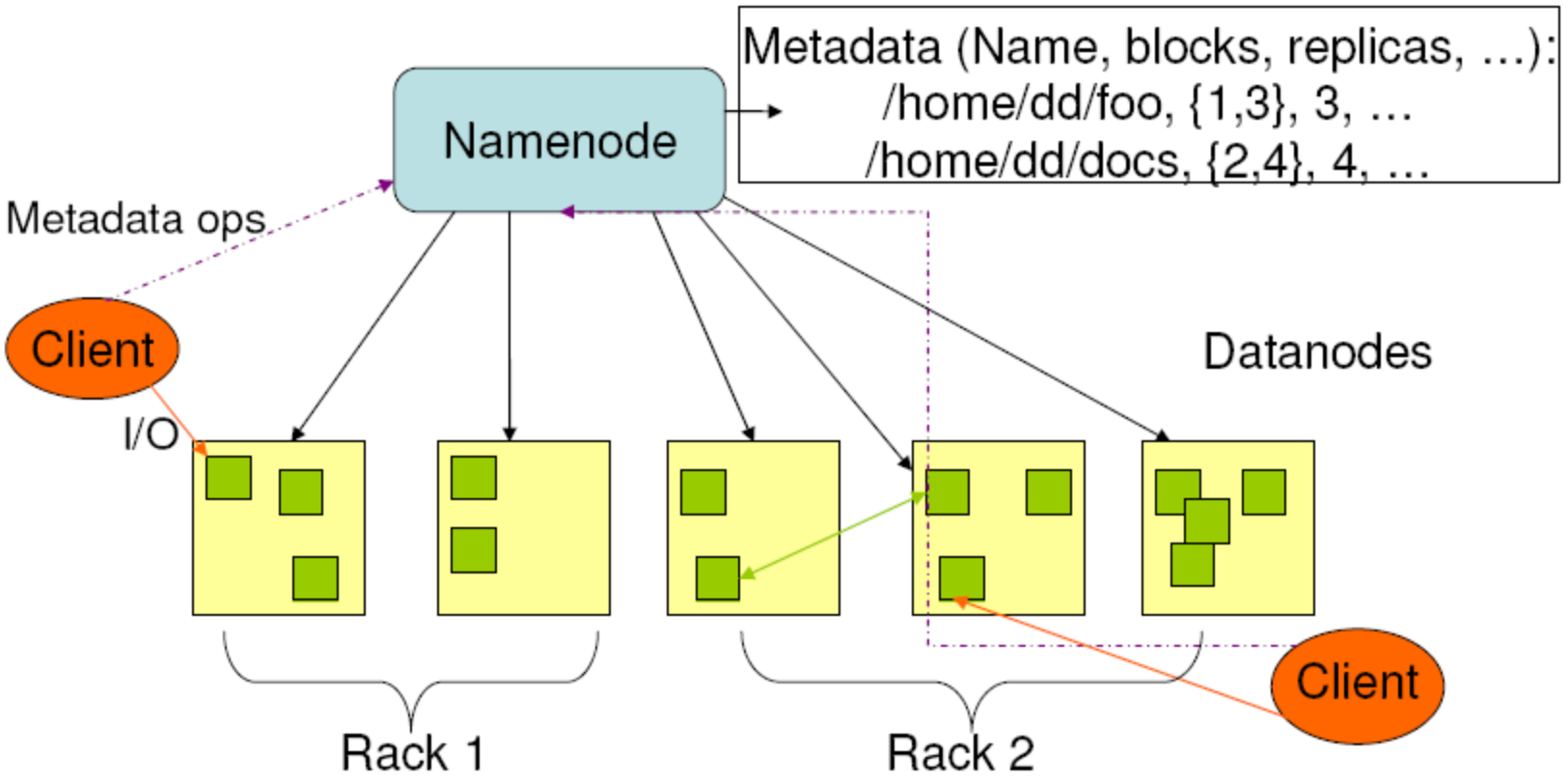
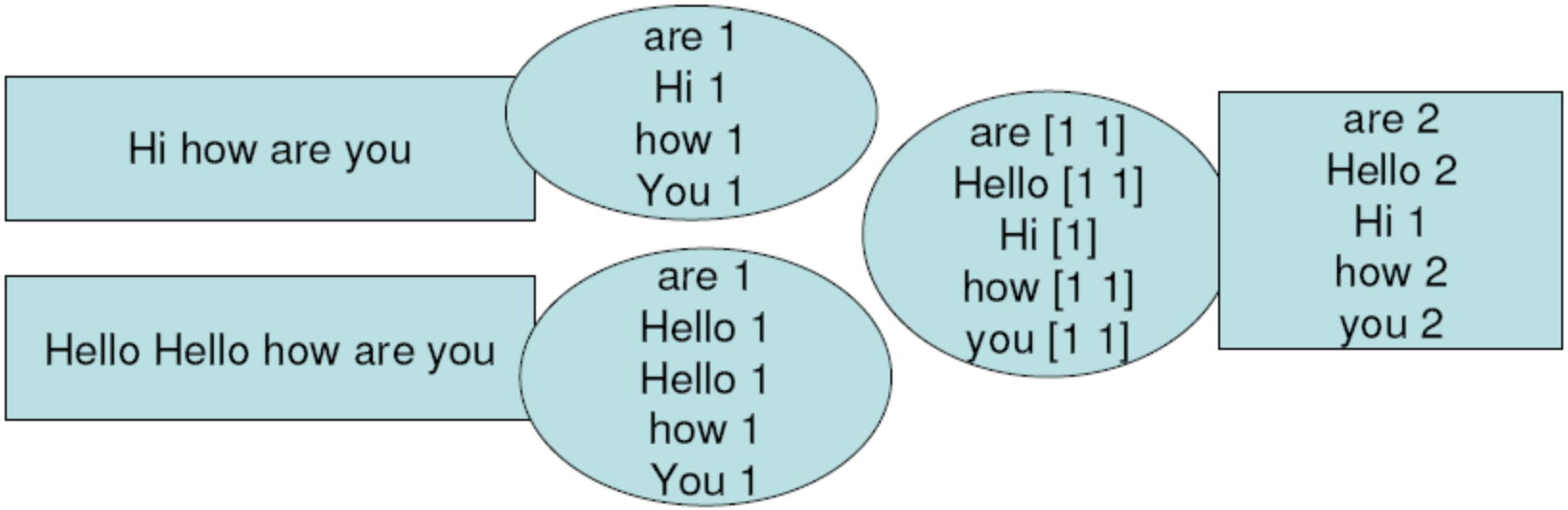
HDFS Architecture



Map Reduce

Wordcount on a huge file



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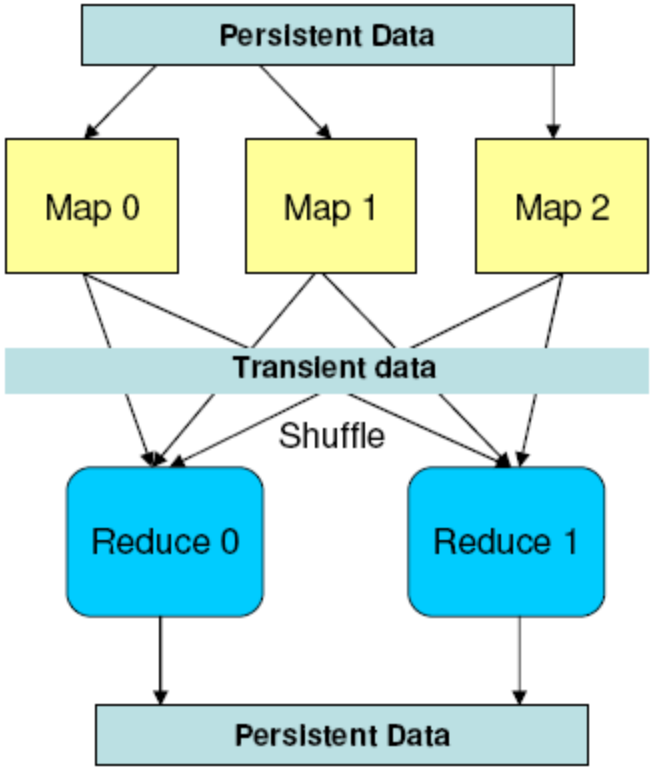
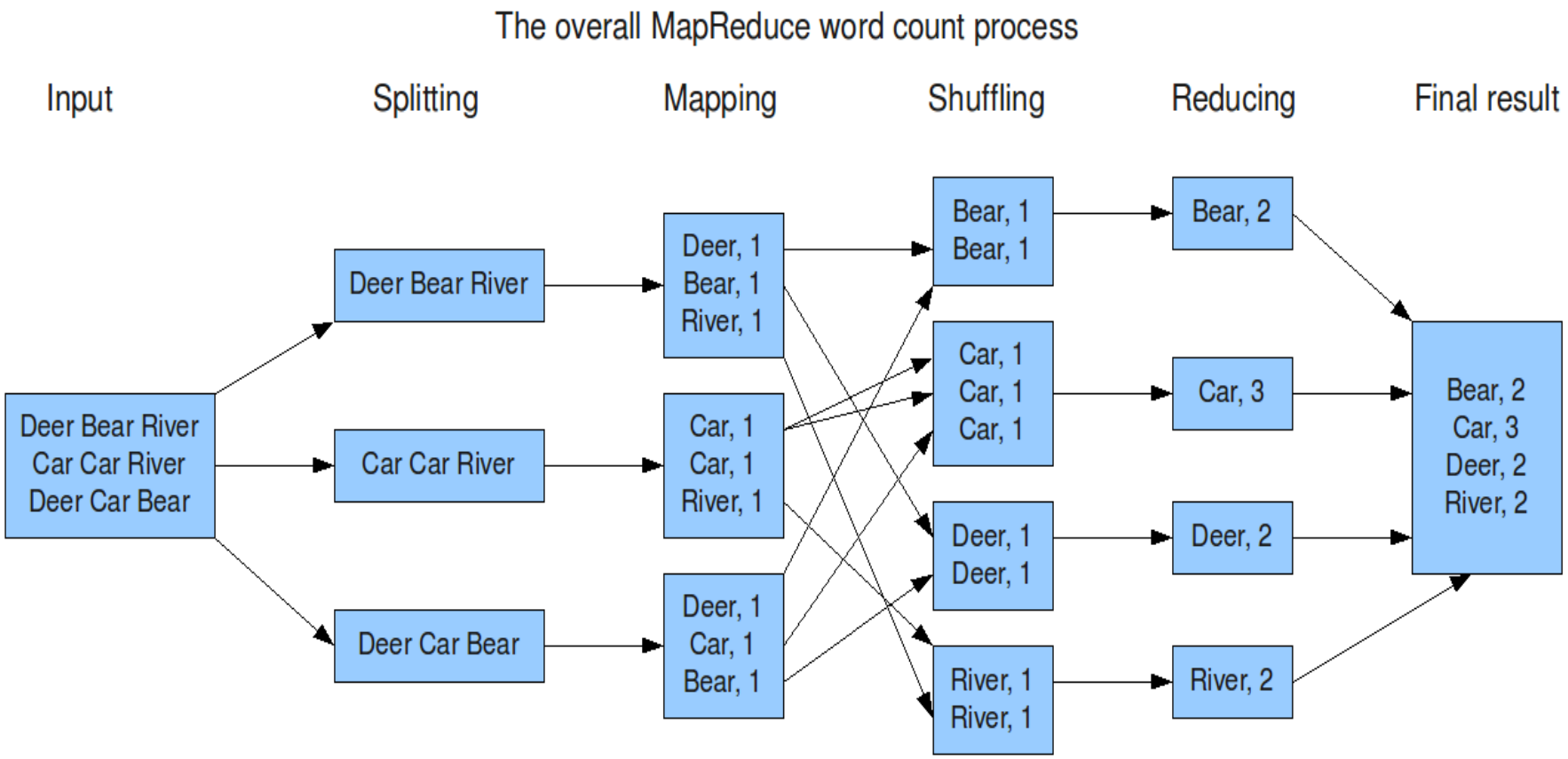
MapReduce: Data Flow

- User jobs are broken into Map tasks and Reduce tasks
- Data is sequence of *keys* and *values*
- Map Task: invokes Mapper
  - Input: *key1,value1* pair
  - Output: *key2, value2* pairs
- Reduce Task: invokes Reducer
  - Called once per a key, in sorted order
  - Input: *key2*, stream of *value2*
  - Output: *key3, value3* pairs



Map Reduce



Map Reduce Architecture

- **Master-Slave architecture**
- **Map-Reduce Master "Jobtracker"**
  - Accepts MR jobs submitted by users
  - Assigns Map and Reduce tasks to Tasktrackers
  - Monitors task and tasktracker status, re-executes tasks upon failure
- **Map-Reduce Slaves "Tasktrackers"**
  - Run Map and Reduce tasks upon instruction from the Jobtracker
  - Manage storage and transmission of intermediate output
- **Generic Reusable Framework supporting pluggable user code**
  - Pluggable FileSystem - DFS, Kosmix, S3, ..
  - Pluggable input/output format
  - Many more

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Gartner's View

Gartner's View on Hadoop

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12 Hadoop Vendors to watch in 2012

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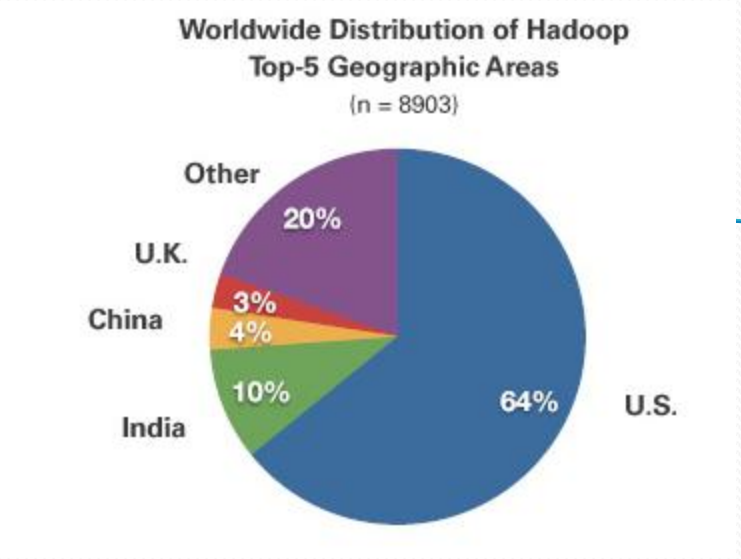
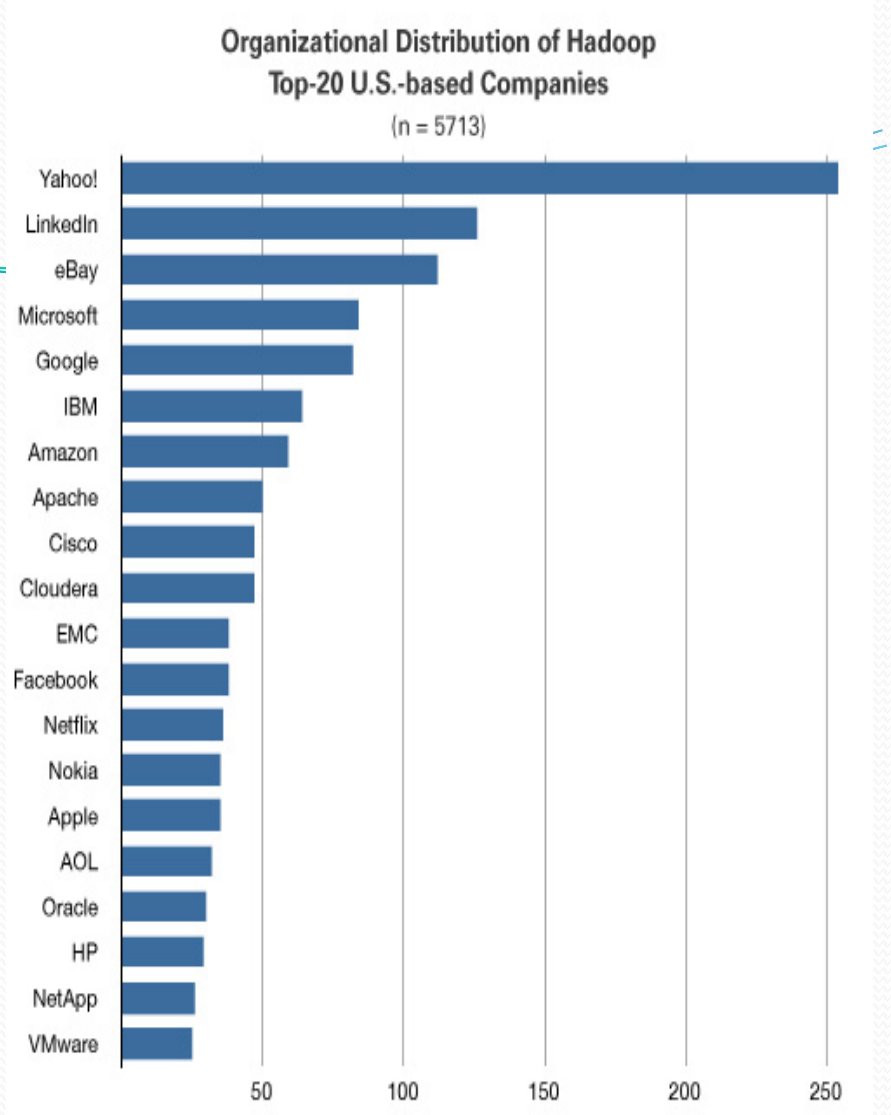
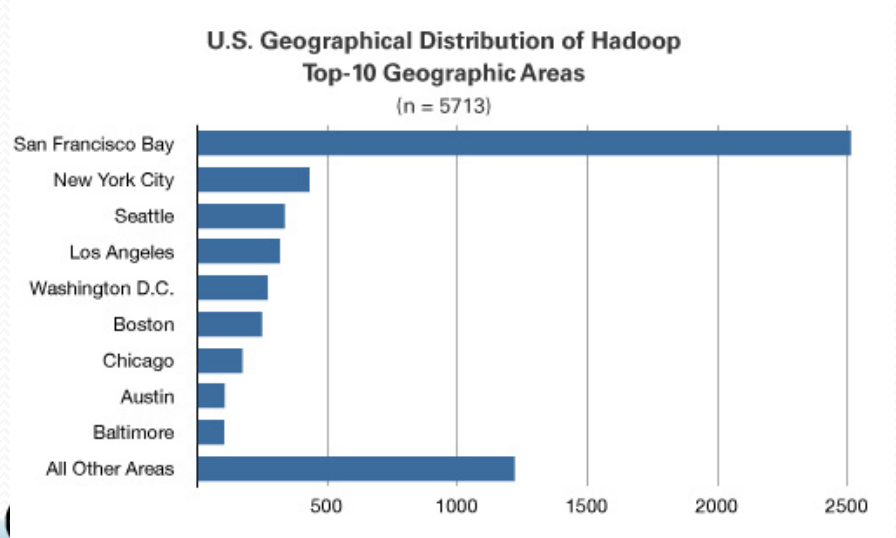
Few Statistics







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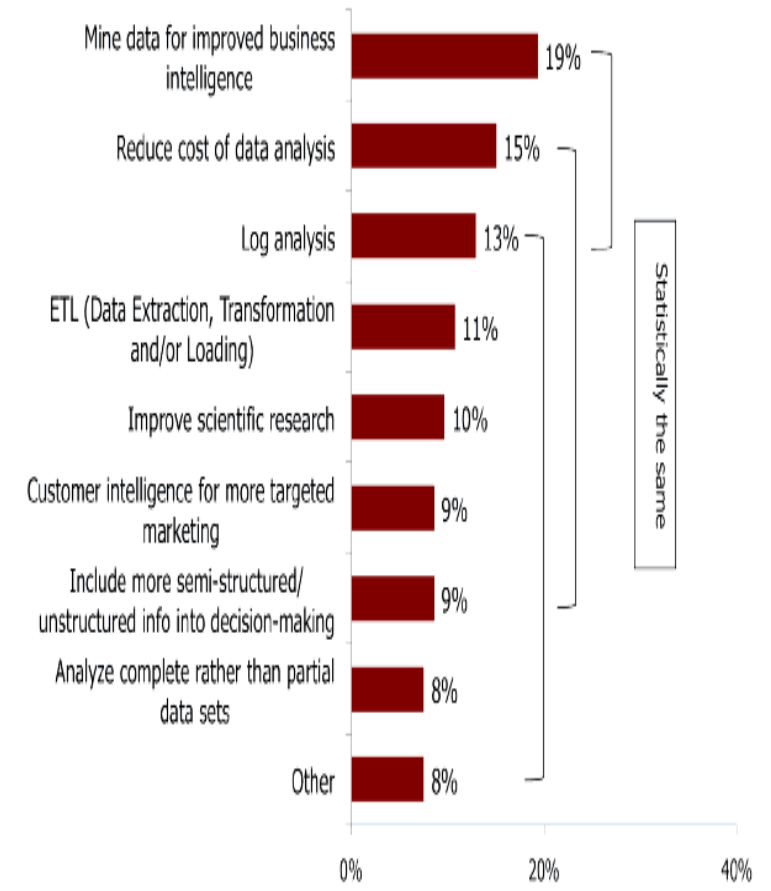
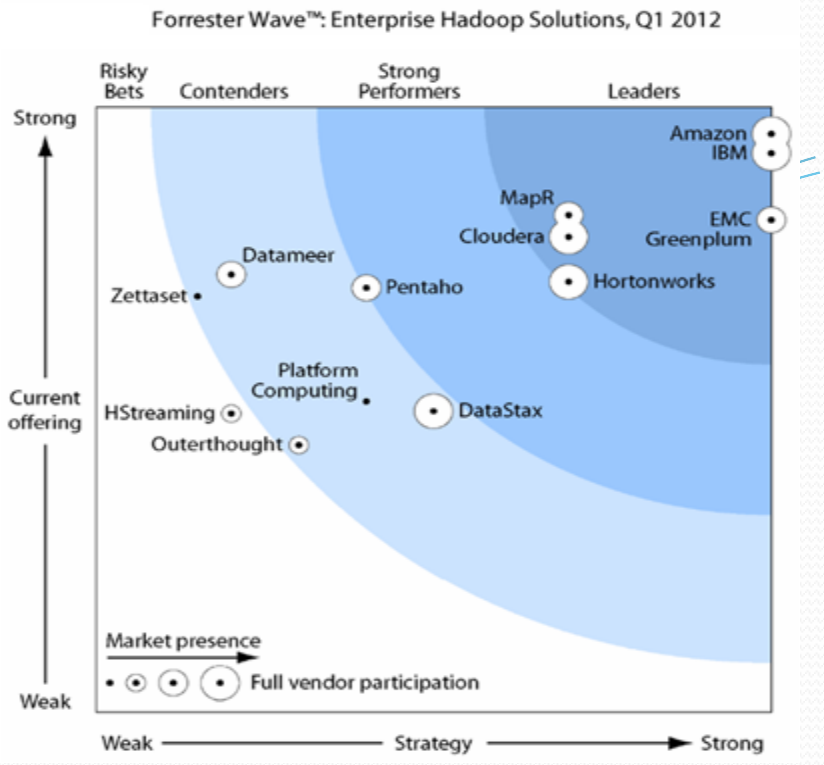
Few Statistics

Main Reason for Using/Evaluating Hadoop





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Questions?