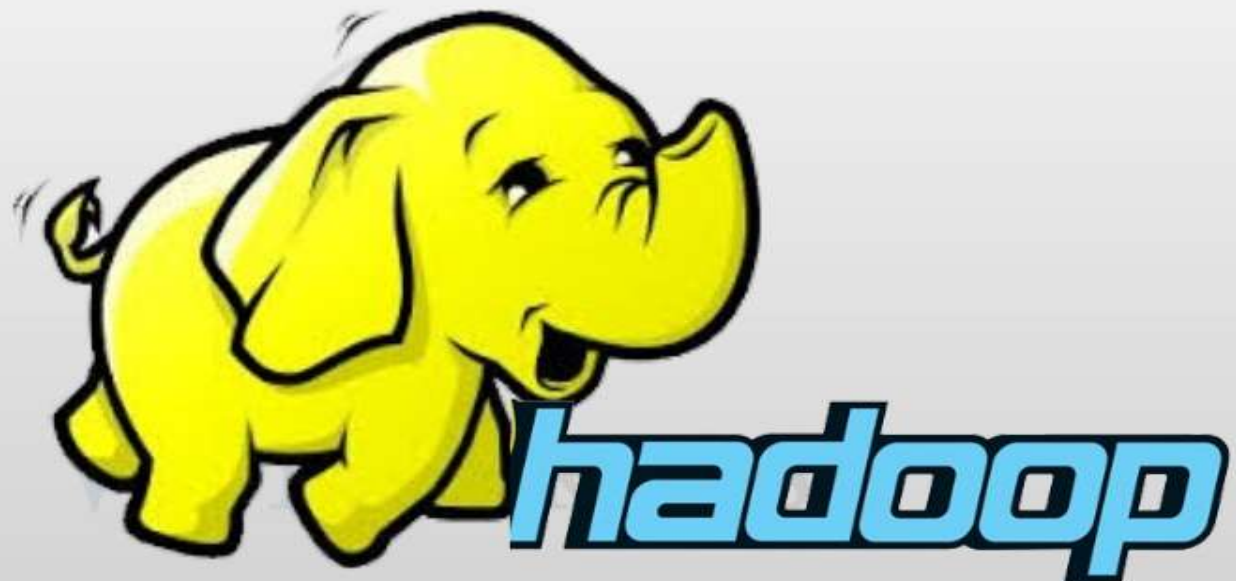


```
<!-- Package WordPress
-->
<!-- Package Default Theme
-->
?>
<!DOCTYPE html PUBLIC "-//W3C//DTD
html 4.01//EN" "http://www.w3.
head profile="http://
meta http-equiv="C
<title></?op>
<link rel="
<link rel="
<sty/
```

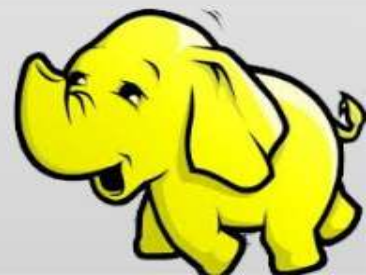
Hadoop, a distributed framework for Big Data



1. Introduction: Hadoop's history and advantages

2. Architecture in detail

3. Hadoop in industry

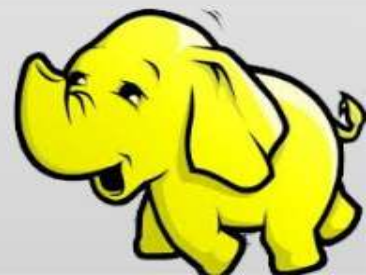
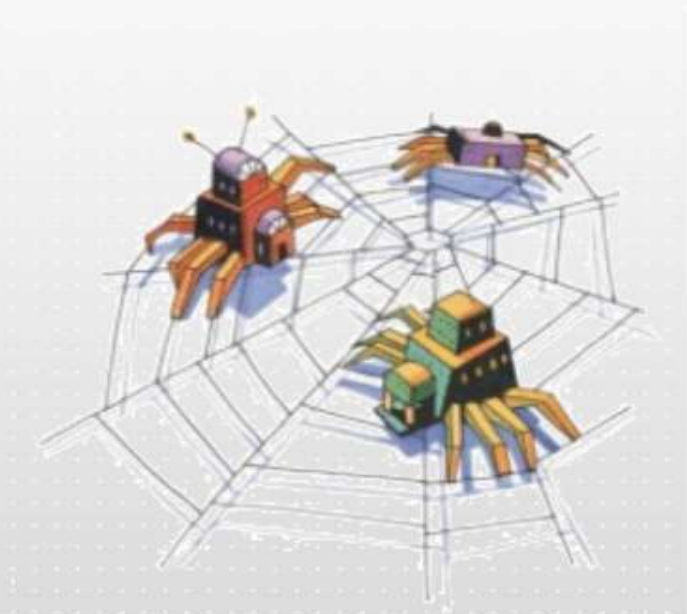




- Apache top level project, open-source implementation of frameworks for reliable, scalable, distributed computing and data storage.
- It is a flexible and highly-available architecture for large scale computation and data processing on a network of commodity hardware.

Brief History of Hadoop

- Designed to answer the question:
“How to process big data with reasonable cost and time?”



Search engines in 1990s



MetaCrawler Parallel Web Search Service

by [Erik Selberg](#) and [Oren Etzioni](#)

Try the new [MetaCrawler Beta!](#)
If you're searching for a person's home page, try [Ahoy!](#)

[Examples](#) • [Beta Site](#) • [Add Site](#) • [About](#)

Search for:
☐ as a Phrase ☒ All of these words ☐ Any of these words

For better results, please specify:
 Search Region: The World Search Sites: Any

Performance parameters:
 Max wait: 1 minutes Match type: Loose

[[About](#) | [Help](#) | [Problems](#) | [Add Site](#) | [Search](#)]
webmaster@metacrawler.com
 © Copyright 1997, 1998 Erik Selberg and Oren Etzioni

1996

Serious Sports Fans Only \$1,000,000 in Cash and Prizes!
 For serious sports fans only! Play Fantasy Football!



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Go Get It will get you.

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 Lycos is a trademark of Carnegie Mellon University.
[Questions & Comments](#)

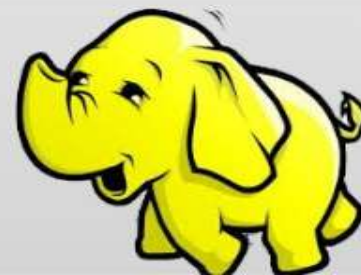
1996

The Excite search engine interface features a red header with the 'excite' logo. Navigation links include 'excite home', 'maps', 'news', and 'people finder'. A search bar is prominently displayed with the text 'Excite Search: twice the power of the competition.' Below the search bar, there are dropdown menus for 'What:' and 'Where: World Wide Web'. A 'search' button is located to the right of the search bar. Below the search bar, there are links for 'Excite Reviews: site reviews by the web's best editorial team.' and a list of categories including Arts, Business, Computing, Education, Entertainment, Health, Hobbies, Life & Style, Money, News & Reference, Personal Pages, Politics & Law, Regional, Science, Shopping, and Sports. A sidebar on the left contains links for 'Researching stocks?', 'Buying a car?', 'Planning a wedding?', 'Check out Excite Seeing Tours.', and 'Bill Mitchell: Snore that clicks!'.

1996

The Wired Search Center interface features a green header with the 'Wired' logo. Navigation links include 'Wired News', 'NotWired', 'Wired Magazine', and 'Suck.com'. A search bar is prominently displayed with the text 'The WIRE Search Center'. Below the search bar, there are dropdown menus for 'Date' and 'Country'. A 'SEARCH' button is located to the right of the search bar. Below the search bar, there are links for 'Sandbox Entertainment', 'Shop WIRED Holiday Gift Guide', and 'SOMETHING HAS SURVIVED.'. A sidebar on the left contains links for 'Search: The Web', 'Usenet', 'Top News', 'City Guide', 'Domain Names', 'Stocks', 'Discussion Groups', 'Search Maps', 'Find', 'Randomness', 'People', and 'Expert Advice'.

1997



Google search engines

Google!
BETA

Search the web using Google!

Google Search

I'm feeling lucky

Special Searches

[Stanford Search](#)

[Linux Search](#)

[Help!](#)

[About Google!](#)

[Company Info](#)

[Google! Legos](#)

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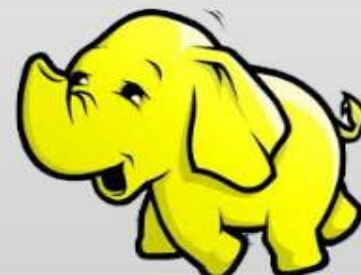
1998

Google

2013

Google Search

I'm Feeling Lucky



Hadoop's Developers



Doug Cutting

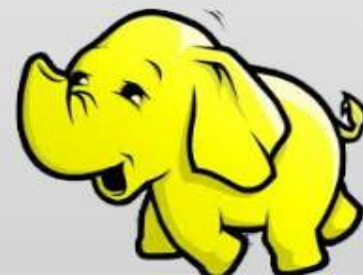


2005: Doug Cutting and Michael J. Cafarella developed Hadoop to support distribution for the [Nutch](#) search engine project.



The project was funded by Yahoo.

2006: Yahoo gave the project to Apache Software Foundation.



Google Origins

2003

The Google File System

Sanjay Ghemawat, Howard Gobioff, and Shun-Tak Leung
Google*



2004

MapReduce: Simplified Data Processing on Large Clusters

Jeffrey Dean and Sanjay Ghemawat

jeff@google.com, sanjay@google.com

Google, Inc.



2006

Bigtable: A Distributed Storage System for Structured Data

Fay Chang, Jeffrey Dean, Sanjay Ghemawat, Wilson C. Hsieh, Deborah A. Wallach,
Mike Burrows, Tushar Chandra, Andrew Fikes, Robert E. Gruber

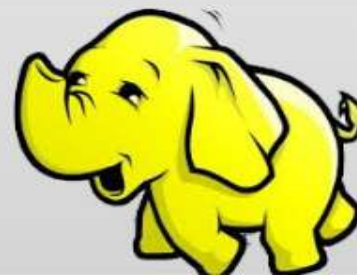
{fay,jeff,sanjay,wilson,hsieh,tushar,deborah,gruber}@google.com

Google, Inc.

Abstract

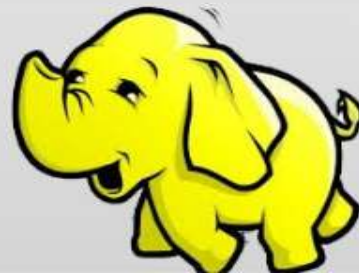
Bigtable is a distributed storage system for managing
structured data that is designed to scale to a very large
number of servers. It provides a simple data model that
allows applications to store data in Bigtable. Many
applications at Google store data in Bigtable, including
Google Earth, Google Maps, and Google News.

Bigtable achieves scalability and high performance, but
does not support a full relational data model; it
provides clients with a simple data model that
allows applications to store data in Bigtable. Many
applications at Google store data in Bigtable, including
Google Earth, Google Maps, and Google News.



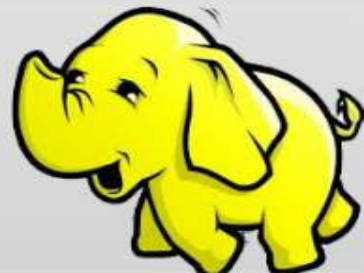
Some Hadoop Milestones

- **2008 - Hadoop Wins Terabyte Sort Benchmark** (sorted 1 terabyte of data in 209 seconds, compared to previous record of 297 seconds)
- 2009 - Avro and Chukwa became new members of Hadoop Framework family
- 2010 - Hadoop's Hbase, Hive and Pig subprojects completed, adding more computational power to Hadoop framework
- **2011 - ZooKeeper Completed**
- **2013 - Hadoop 1.1.2 and Hadoop 2.0.3 alpha.**
 - Ambari, Cassandra, Mahout have been added

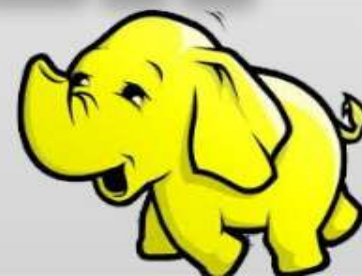
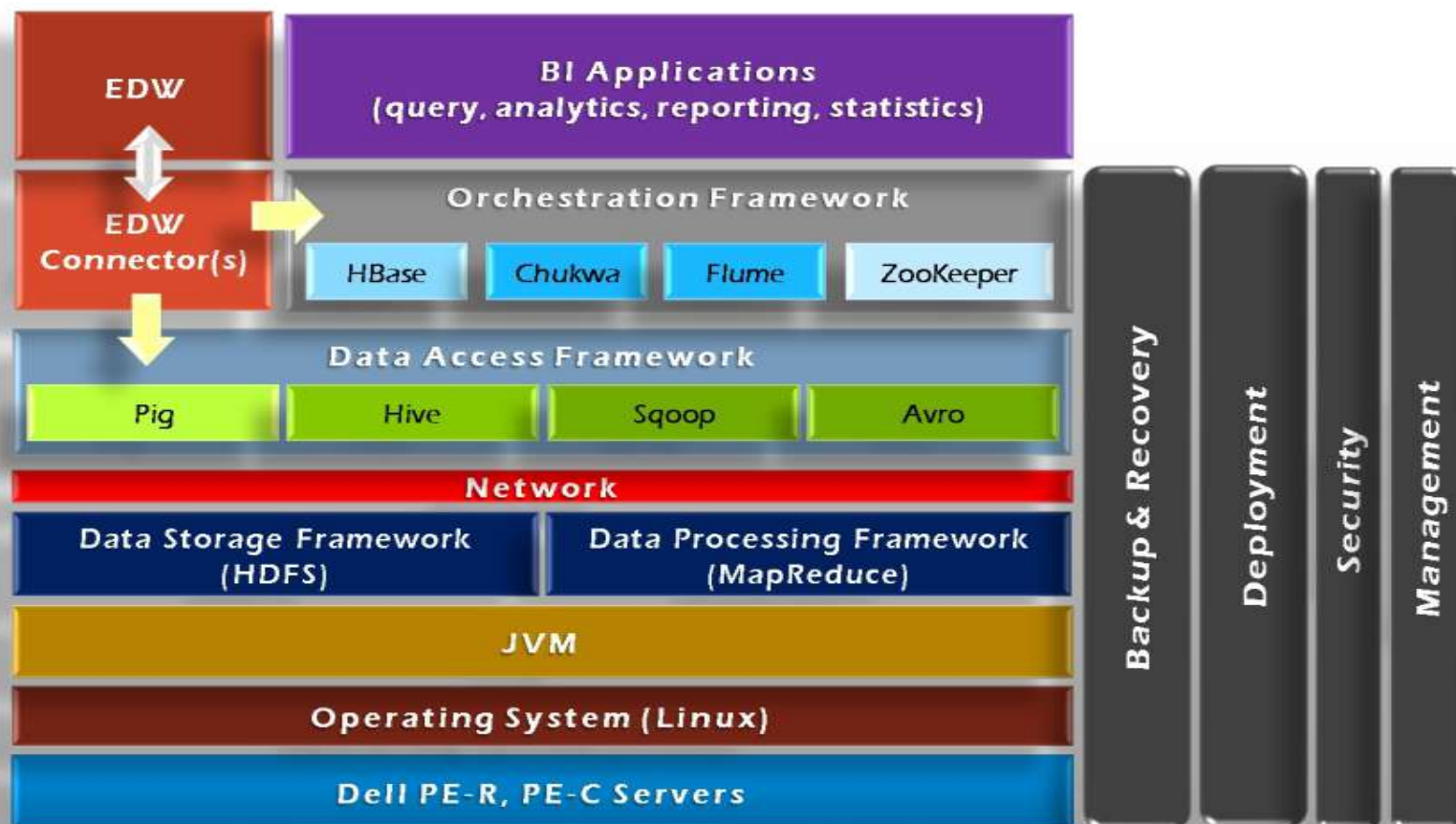


What is Hadoop?

- **Hadoop:**
 - an open-source software framework that supports data-intensive distributed applications, licensed under the Apache v2 license.
- **Goals / Requirements:**
 - Abstract and facilitate the storage and processing of large and/or rapidly growing data sets
 - Structured and non-structured data
 - Simple programming models
 - High scalability and availability
 - Use commodity (cheap!) hardware with little redundancy
 - Fault-tolerance
 - Move computation rather than data

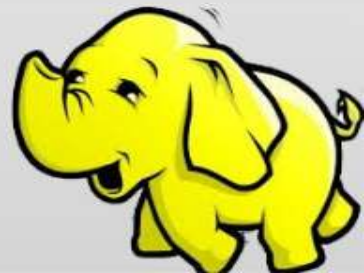


Hadoop Framework Tools

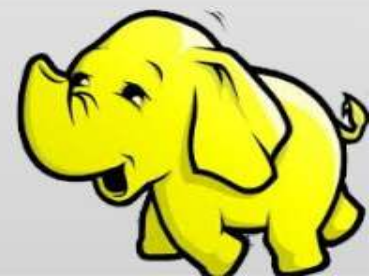
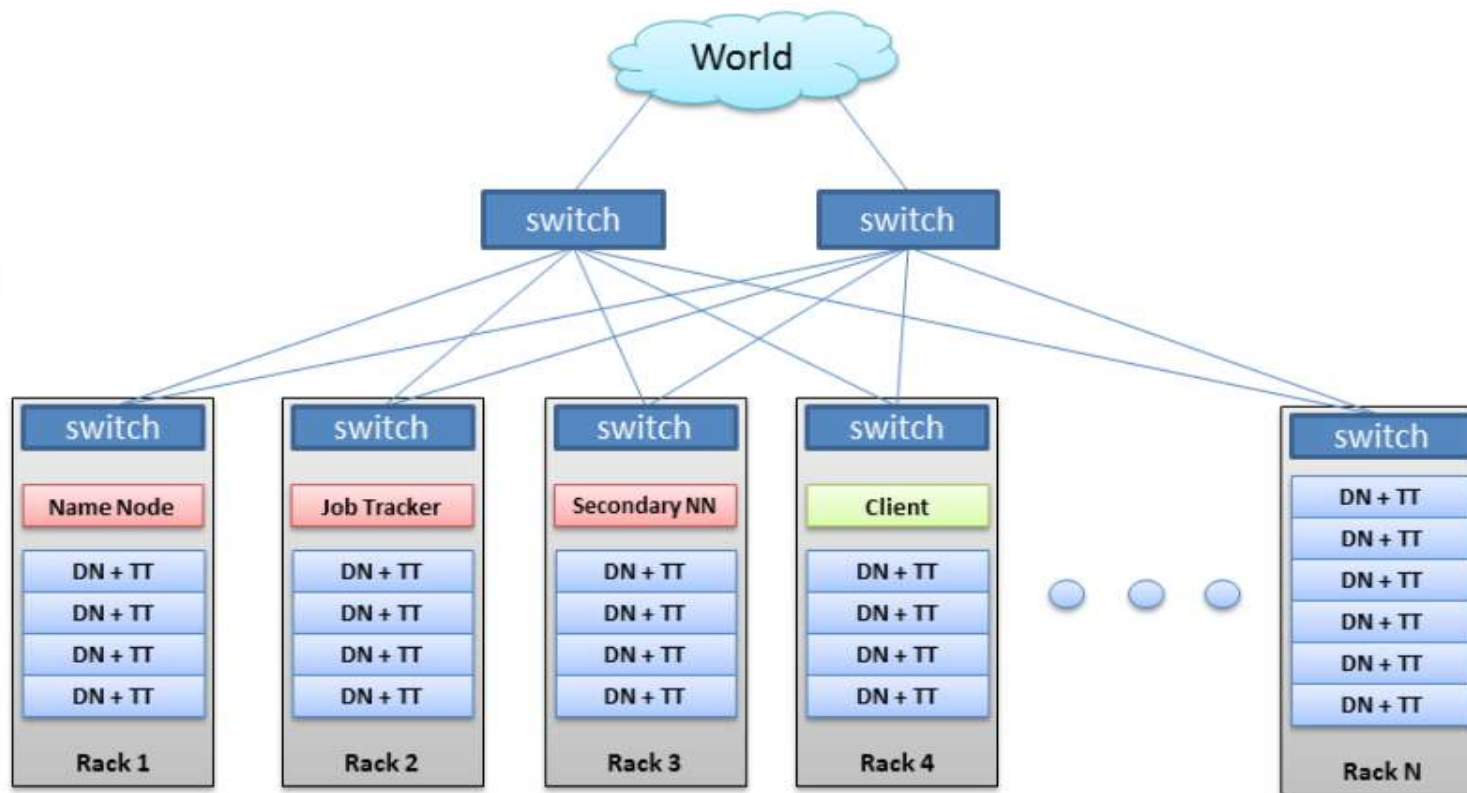


Hadoop's Architecture

- Distributed, with some centralization
- Main nodes of cluster are where most of the computational power and storage of the system lies
- Main nodes run TaskTracker to accept and reply to MapReduce tasks, and also DataNode to store needed blocks closely as possible
- Central control node runs NameNode to keep track of HDFS directories & files, and JobTracker to dispatch compute tasks to TaskTracker
- Written in Java, also supports Python and Ruby

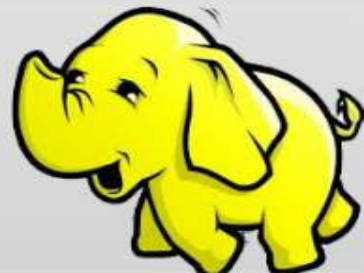


Hadoop's Architecture



Hadoop's Architecture

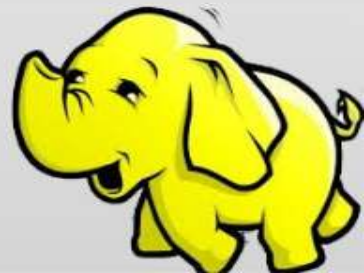
- Hadoop Distributed Filesystem
- Tailored to needs of MapReduce
- Targeted towards many reads of filestreams
- Writes are more costly
- High degree of data replication (3x by default)
- No need for RAID on normal nodes
- Large blocksize (64MB)
- Location awareness of DataNodes in network



Hadoop's Architecture

NameNode:

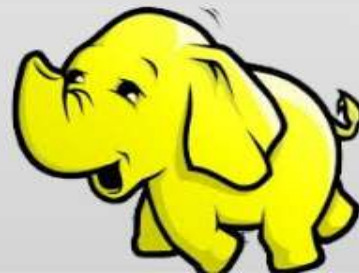
- Stores metadata for the files, like the directory structure of a typical FS.
- The server holding the NameNode instance is quite crucial, as there is only one.
- Transaction log for file deletes/adds, etc. Does not use transactions for whole blocks or file-streams, only metadata.
- Handles creation of more replica blocks when necessary after a DataNode failure



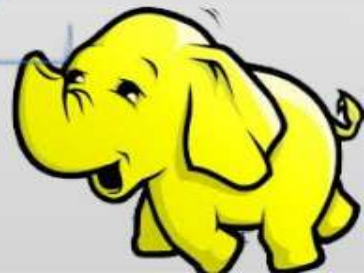
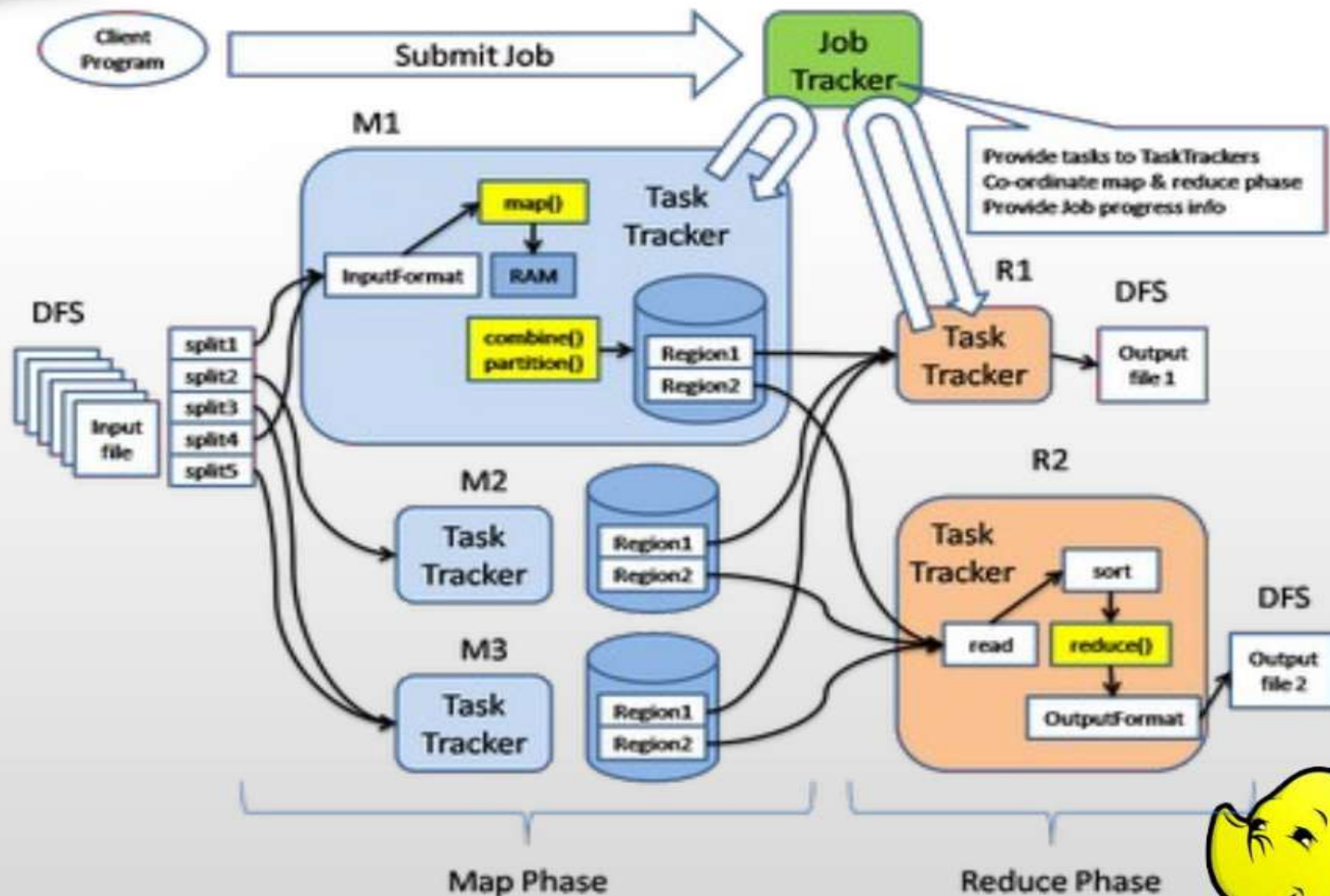
Hadoop's Architecture

DataNode:

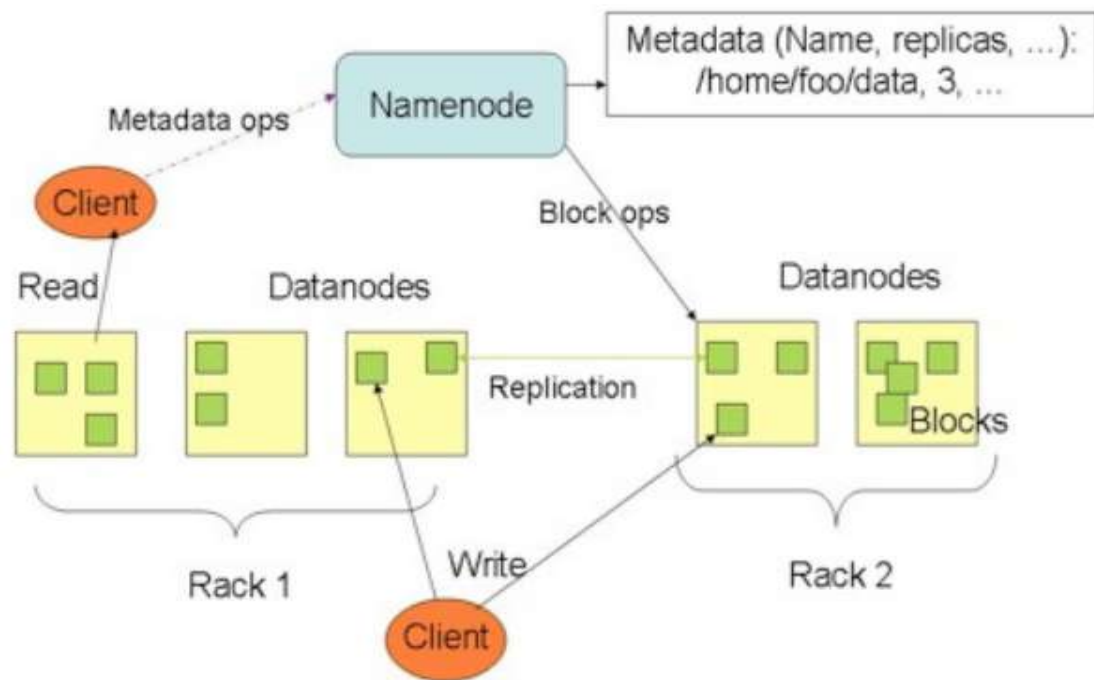
- Stores the actual data in HDFS
- Can run on any underlying filesystem (ext3/4, NTFS, etc)
- Notifies NameNode of what blocks it has
- NameNode replicates blocks 2x in local rack, 1x elsewhere



Hadoop's Architecture: MapReduce Engine



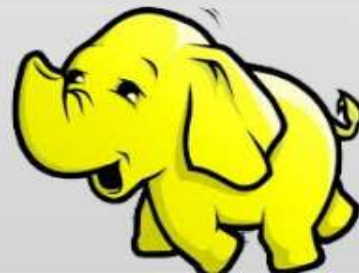
```
<!-- Package WordPress
-->
<!-- Package Default Theme
-->
?>
<!DOCTYPE html PUBLIC "-//W3C//DTD
html 4.01//EN" "http://www.w3.
head profile="http://
meta http-equiv="C
<title><?php wp
<link rel="
<link rel="
<sty
```



Hadoop's Architecture

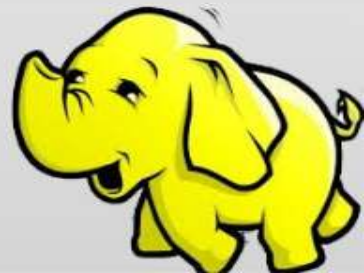
MapReduce Engine:

- JobTracker & TaskTracker
- JobTracker splits up data into smaller tasks("Map") and sends it to the TaskTracker process in each node
- TaskTracker reports back to the JobTracker node and reports on job progress, sends data ("Reduce") or requests new jobs



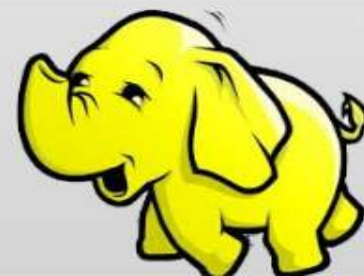
Hadoop's Architecture

- None of these components are necessarily limited to using HDFS
- Many other distributed file-systems with quite different architectures work
- Many other software packages besides Hadoop's MapReduce platform make use of HDFS



Hadoop in the Wild

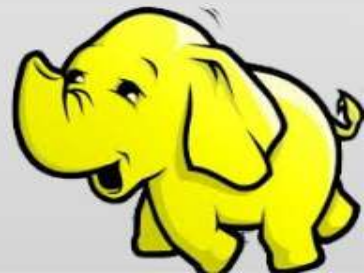
- Hadoop is in use at most organizations that handle big data:
 - Yahoo!
 - Facebook
 - Amazon
 - Netflix
 - Etc...
- Some examples of scale:
 - Yahoo!'s Search Webmap runs on 10,000 core Linux cluster and powers Yahoo! Web search
 - FB's Hadoop cluster hosts 100+ PB of data (July, 2012) & growing at 1/2 PB/day (Nov, 2012)



Hadoop in the Wild

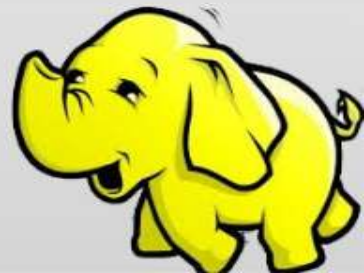
Three main applications of Hadoop:

- Advertisement (Mining user behavior to generate recommendations)
- Searches (group related documents)
- Security (search for uncommon patterns)



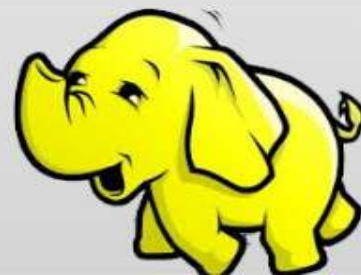
Hadoop in the Wild

- Non-realtime large dataset computing:
 - NY Times was dynamically generating PDFs of articles from 1851-1922
 - Wanted to pre-generate & statically serve articles to improve performance
 - Using Hadoop + MapReduce running on EC2 / S3, converted 4TB of TIFFs into 11 million PDF articles in 24 hrs



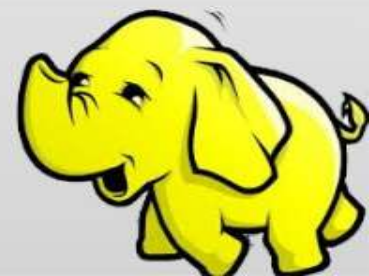
Hadoop in the Wild: Facebook Messages

- Design requirements:
 - Integrate display of email, SMS and chat messages between pairs and groups of users
 - Strong control over who users receive messages from
 - Suited for production use between 500 million people immediately after launch
 - Stringent latency & uptime requirements



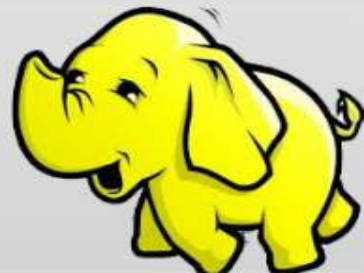
Hadoop in the Wild

- System requirements
 - High write throughput
 - Cheap, elastic storage
 - Low latency
 - High consistency (within a single data center good enough)
 - Disk-efficient sequential and random read performance



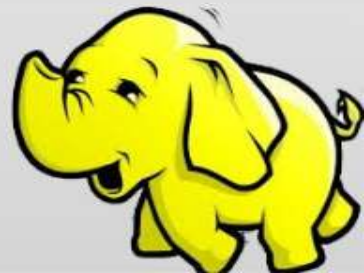
Hadoop in the Wild

- Classic alternatives
 - These requirements typically met using large MySQL cluster & caching tiers using Memcached
 - Content on HDFS could be loaded into MySQL or Memcached if needed by web tier
- Problems with previous solutions
 - MySQL has low random write throughput... BIG problem for messaging!
 - Difficult to scale MySQL clusters rapidly while maintaining performance
 - MySQL clusters have high management overhead, require more expensive hardware



Hadoop in the Wild

- Facebook's solution
 - Hadoop + HBase as foundations
 - Improve & adapt HDFS and HBase to scale to FB's workload and operational considerations
 - Major concern was availability: NameNode is SPOF & failover times are at least 20 minutes
 - Proprietary "AvatarNode": eliminates SPOF, makes HDFS safe to deploy even with 24/7 uptime requirement
 - Performance improvements for realtime workload: RPC timeout. Rather fail fast and try a different DataNode



```
<?php  
//  
 * Wordpress WordPress  
 * WordpressTheme Default Theme  
 //  
?>  
<!DOCTYPE html PUBLIC "-//W3C/  
html xmlns="http://www.w3.  
  
charset profile="http://  
meta http-equiv="Con  
title"<?php wp  
  
link rel=""  
link rel"  
city"
```

- Word Count
 - `hadoop jar hadoop-0.20.2-examples.jar wordcount <input dir> <output dir>`
- Hive
 - `hive -f pagerank.hive`