Introduction of Big Data Tools

2016.4.6

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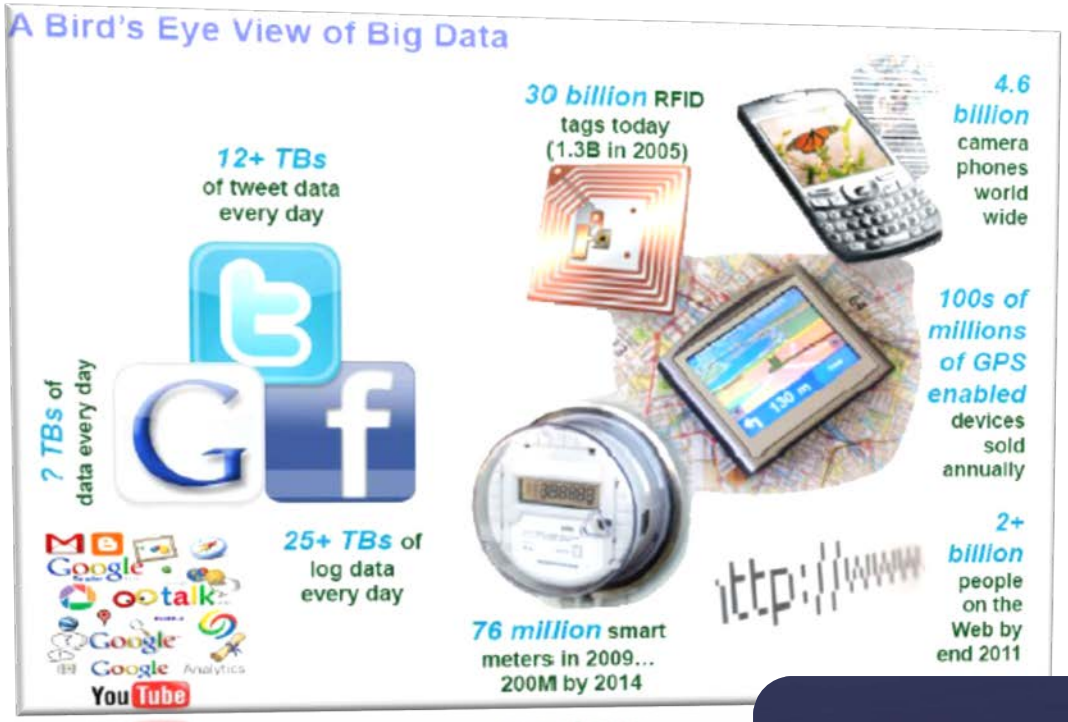
What is Big Data?

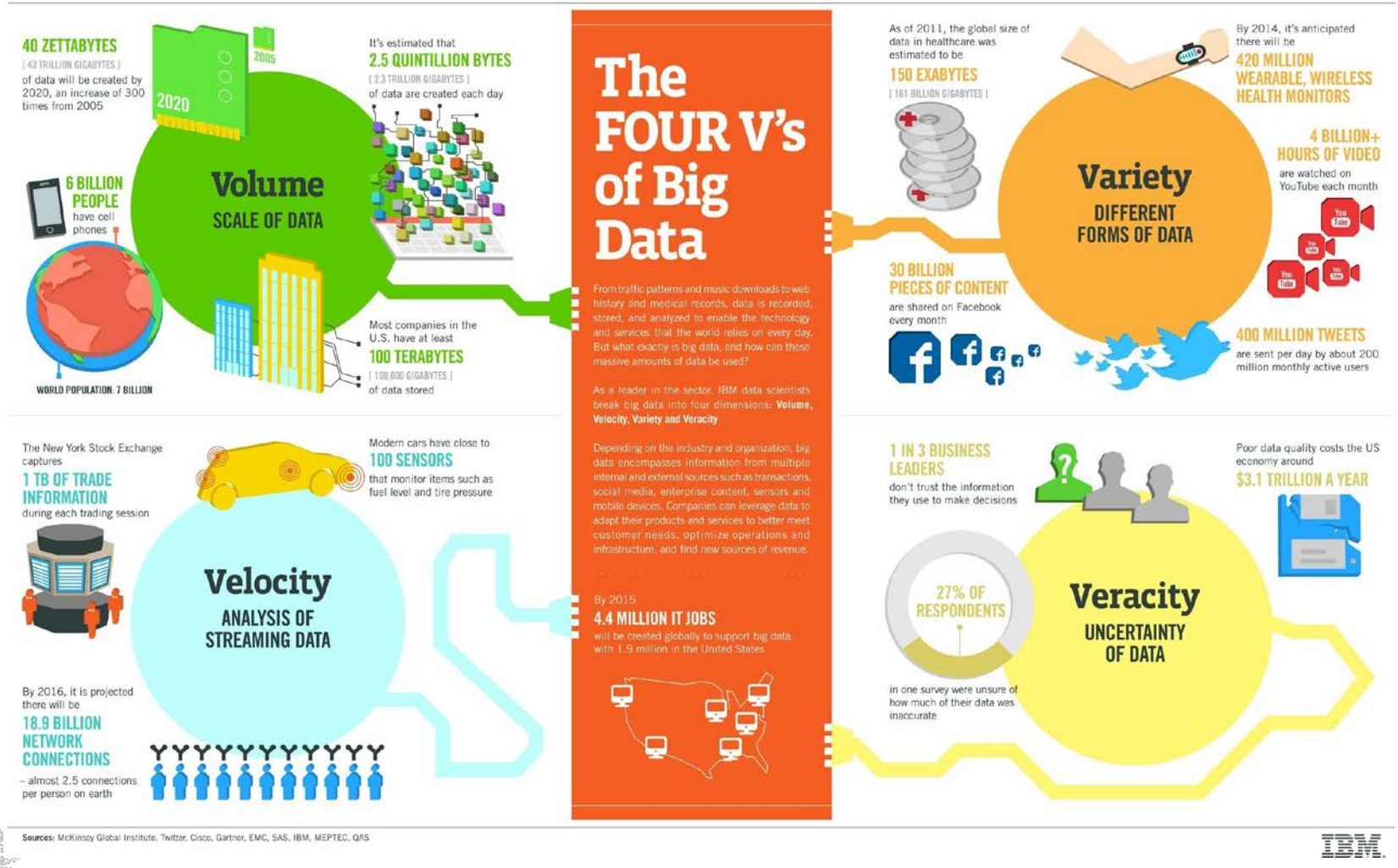
- Wiki: Big data is the term for a collection of data sets so large and complex that it becomes difficult to process using on-hand database management tools or traditional data processing applications.

- IDC: Big data technologies describe a new generation of technologies and architectures, designed to economically extract value from very large volumes of a wide variety of data, by enabling high-velocity capture, discovery, and/or analysis.

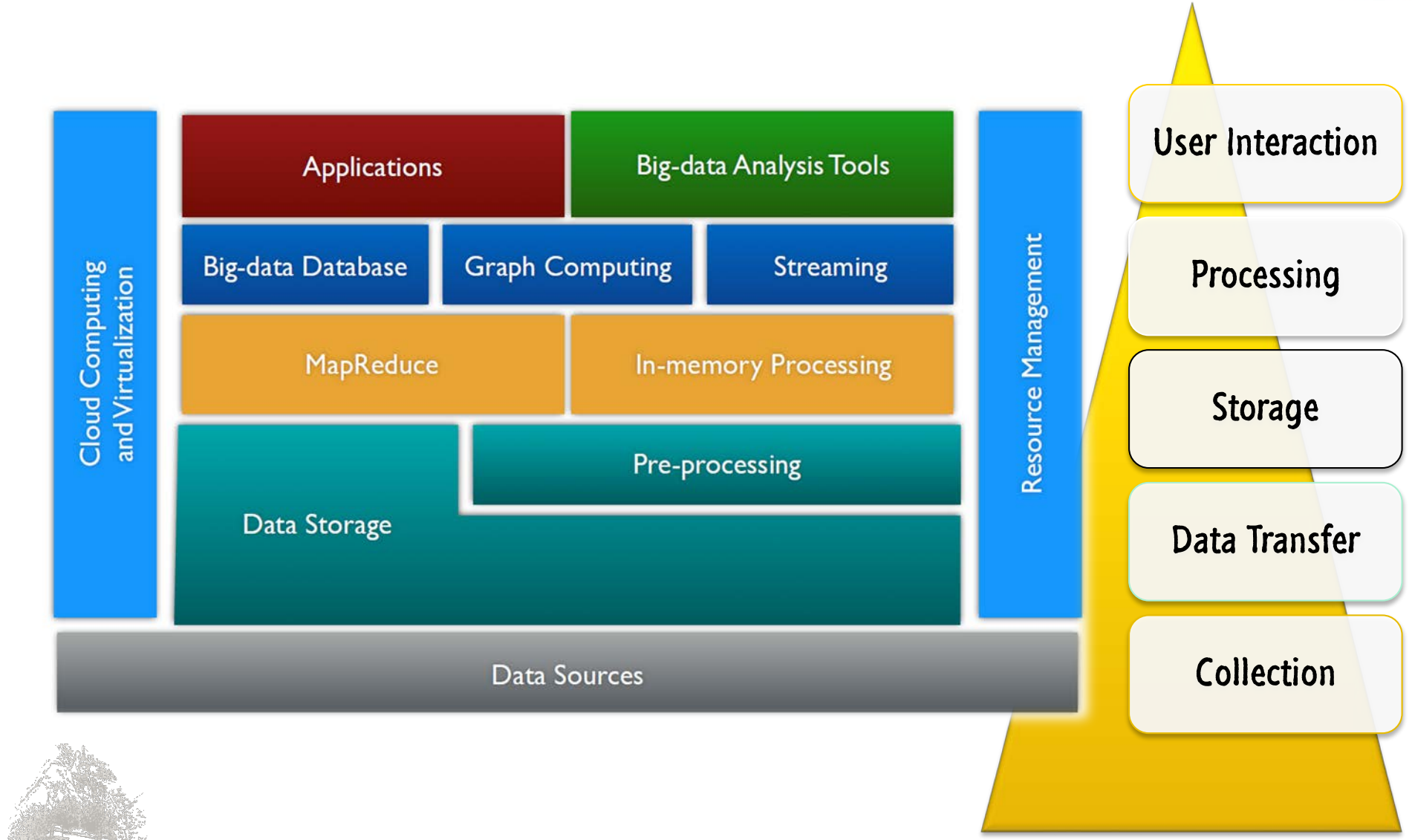
What is Big Data?



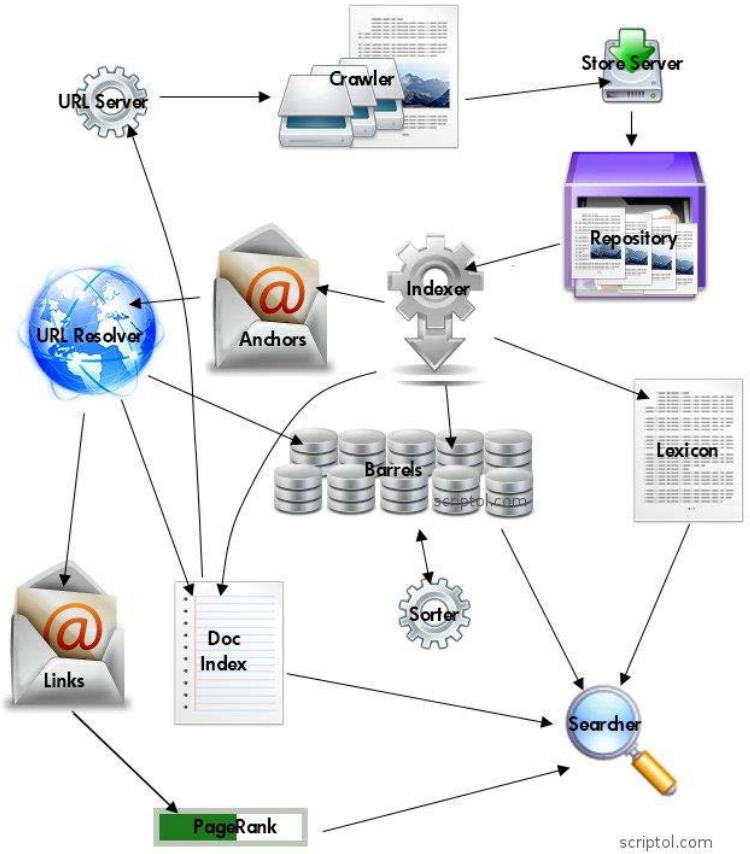
Four V's of Big Data



Framework of Big Data Systems

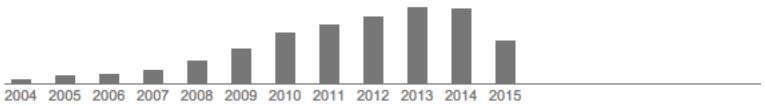


Distributed File System



The Google file system [PDF] frc

Authors	Sanjay Ghemawat, Howard Gobioff, Shun-Tak Leung
Publication date	2003/10/19
Conference	ACM SIGOPS operating systems review
Volume	37
Issue	5
Pages	29-43
Publisher	ACM
Description	ABSTRACT We have designed and implemented the Google File System, a scalable distributed file system for large distributed data-intensive applications. It provides fault tolerance while running on inexpensive commodity hardware, and it delivers high aggregate performance to a large number of clients. While sharing many of the same goals as previous distributed file systems, our design has been driven by observations of our application workloads and technological environment, both current and anticipated, that reflect a ...
Total citations	Cited by 5427



Hadoop Distributed File System

Storage Functions

- Write
- Read
- Append
- Delete
- Modify

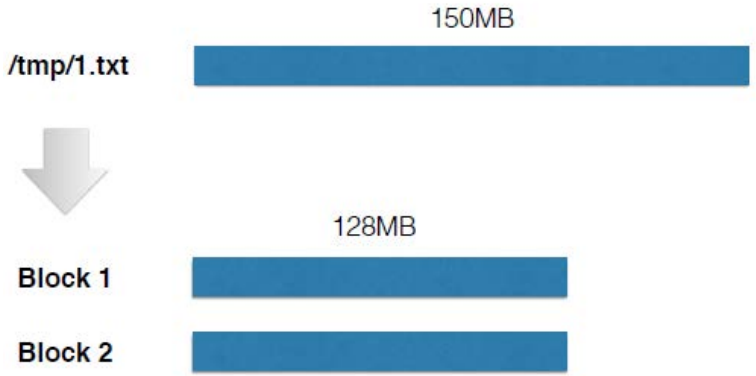
Requirements

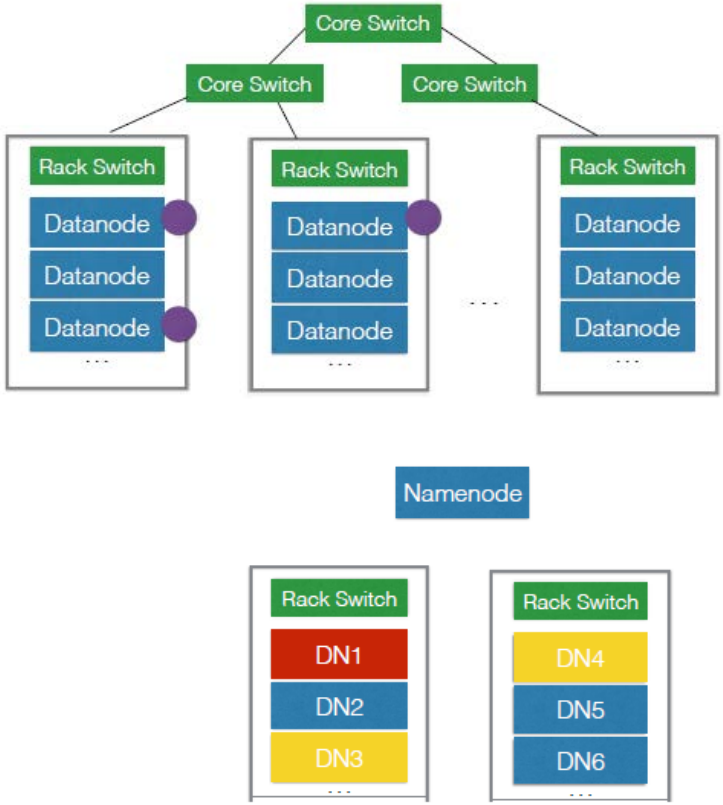
- Large-Scale Data
- Parallel Processing
- Write Once, Read Many
- Streaming I/O
- Fault Tolerance

Hadoop Distributed File System

Design Features

- Large Chunks
- Metadata in Namenode (Single Master)
- Replication
- Rack Awareness
- Pipelined Write





Hadoop Distributed File System

Benefits

- Simple design with single master
- Fault tolerance
- Custom designed

Limitations

- Only viable in a specific environment
- Limited security

MapReduce

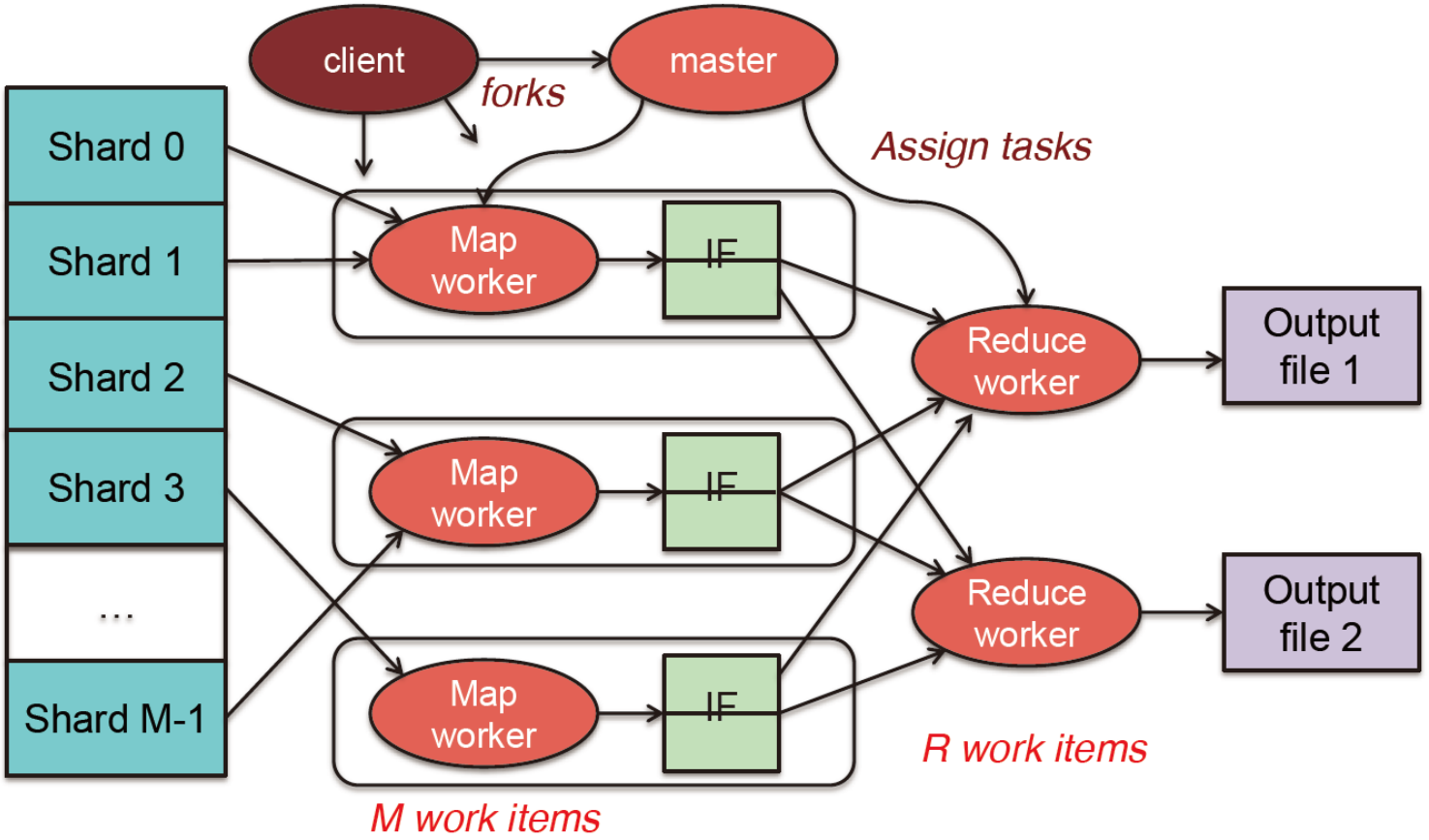
Large-scale Data Processing

- Iterate over a large number of records
- Extract something of interest from each
- Shuffle and sort intermediate results
- Aggregate intermediate results
- Generate final output

MapReduce Provides

- Automatic parallelization & distribution
- Fault-tolerance
- Status and monitoring tools
- A clean abstraction for programmers

MapReduce


client
forks
master
Assign tasks
Shard 0
Shard 1
Shard 2
Shard 3
...
Shard M-1
Map worker
IF
Map worker
IF
Map worker
IF
Reduce worker
Reduce worker
Output file 1
Output file 2
R work items
M work items

MapReduce

Example

It will be seen that this mere painstaking burrower and grub-worm of a poor devil of a Sub-Sub appears to have gone through the long Vaticans and street-stalls of the earth, picking up whatever random allusions to whales he could anyways find in any book whatsoever, sacred or profane. Therefore you must not, in every case at least, take the higgledy-piggledy whale statements, however authentic, in these extracts, for veritable gospel cetology. Far from it. As touching the ancient authors generally, as well as the poets here appearing, these extracts are solely valuable or entertaining, as affording a glancing bird's eye view of what has been promiscuously said, thought, fancied, and sung of Leviathan, by many nations and generations, including our own.

MAP

it 1
will 1
be 1
seen 1
that 1
this 1
mere 1
painstaking 1
burrower 1
and 1
grub-worm 1
of 1
a 1
poor 1
devil 1
of 1
a 1
sub-sub 1
appears 1
to 1
have 1
gone 1

REDUCE

…
a 1
a 1
aback 1
aback 1
abaft 1
abaft 1
abandon 1
abandon 1
abandon 1
abandoned 1
abandoned 1
abandoned 1
abandoned 1
abandoned 1
abandoned 1
abandonedly 1
abandonment 1
abandonment 1
abased 1
abased 1

a 4736
aback 2
abaft 2
abandon 3
abandoned 7
abandonedly 1
abandonment 2
abased 2
abasement 1
abashed 2
abate 1
abated 3
abatement 1
abating 2
abbreviate 1
abbreviation 1
abeam 1
abed 2
abednego 1
abel 1
abhorred 3
abhorrence 1

MapReduce

Benefits

- Transparent
- Fault tolerance
- Scalable
- Load Balanced

Limitations

- Scheduling Control
- Coding Complexity
- Hard Disk I/O

Data Parallel Computing on General Directed Acyclic Graphs

- Dryad (Microsoft)
- Tez (Apache)

Applications based on MR

Apache Pig

- High Level Programming Language

Apache Hive

- SQL Operation on HDFS

Apache Flume

- Transfer Continuous Log or Event Data

Apache Sqoop

- Transfer Data from RDBMS

ETL

- Extract
- Transform
- Load

Other Data Warehouse Tools

- Spark SQL/Shark (Based on Spark)
- Dremel (Google)
- Drill (Apache)
- Impala (Cloudera)

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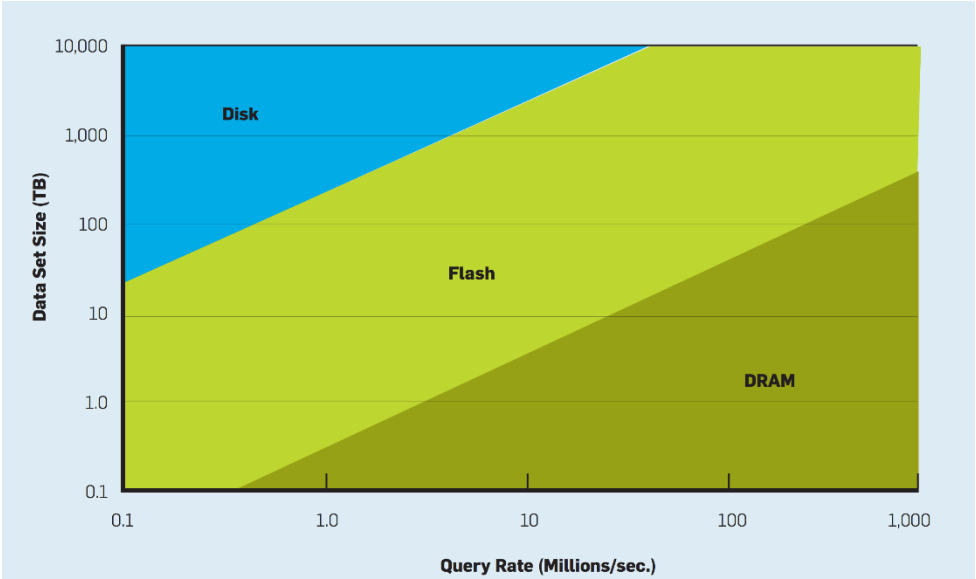
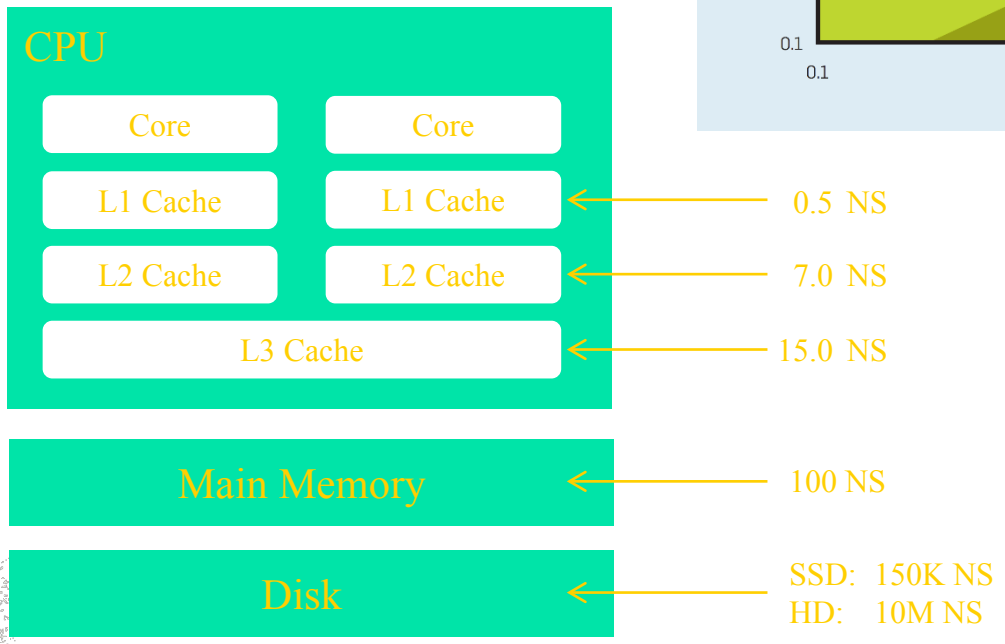
In-Memory Processing

- Speed
- Capacity & Cost
- Fault Tolerance





In-Memory Processing

How To Share Memory?

- DSM (Distributed Shared Memory)
- Distributed Key-Value Stores

High Cost for Fault Tolerance!

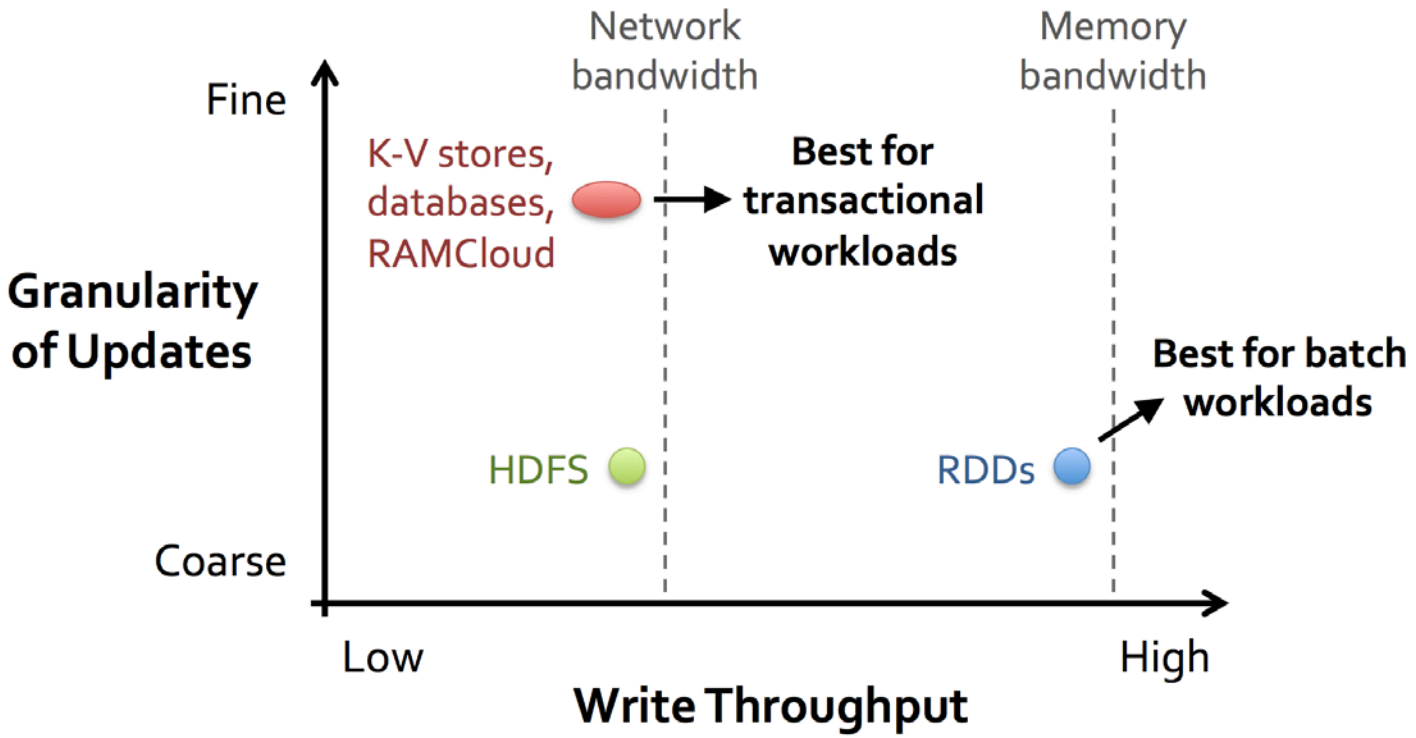
Spark

RDDs (Resilient Distributed Datasets)

- Parallel Actions Only (Map, Filter, Join, etc.)
- Rebuild by Action Logs

Spark

Tradeoff of Spark

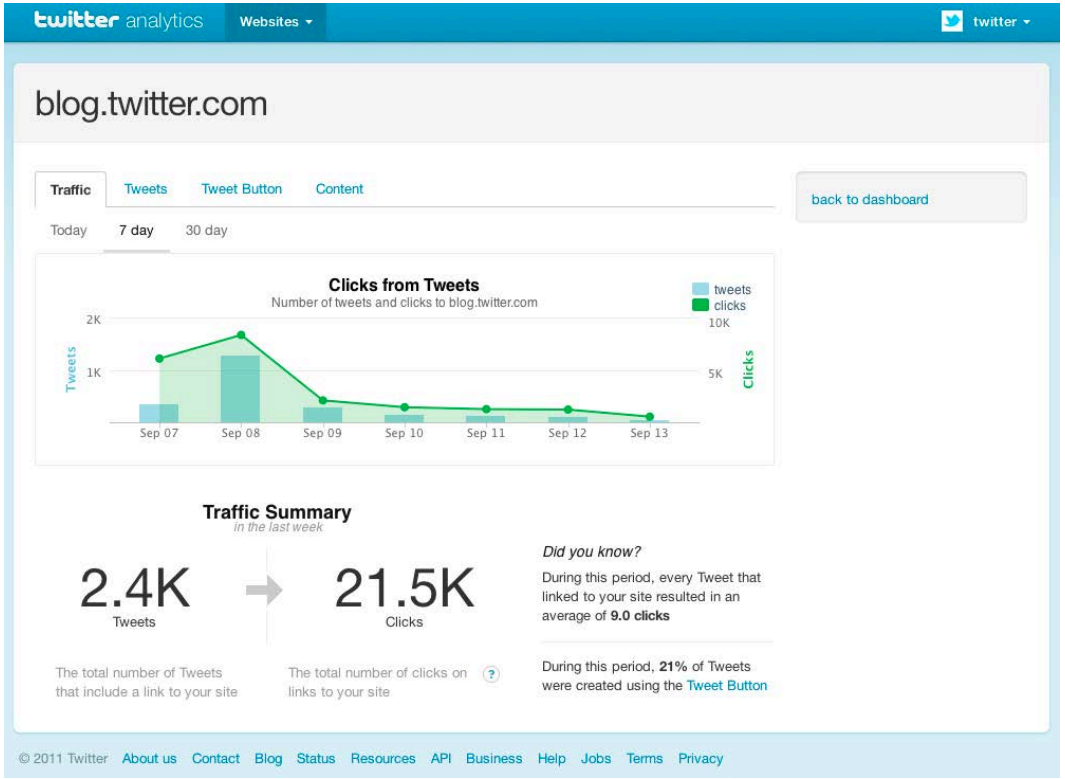


Stream Processing

Streaming Data

- Volume
- Velocity

$$F(X + \Delta X) = F(X) op\ H(\Delta X)$$



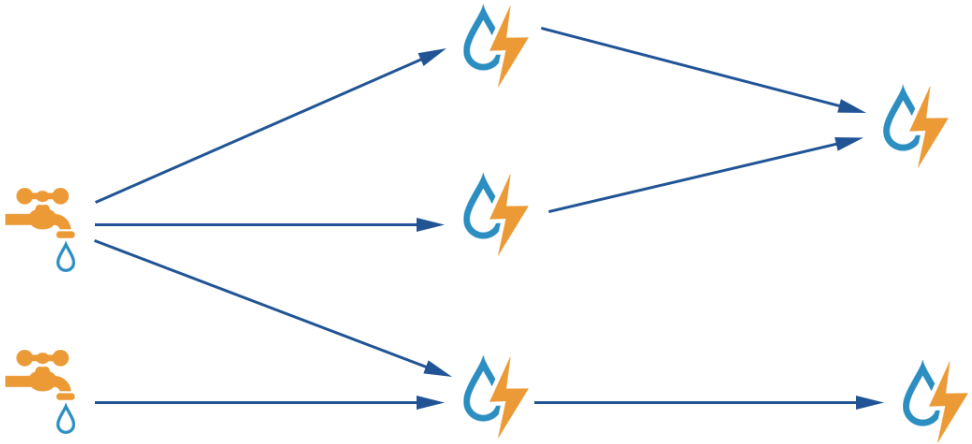
Stream Processing

Requirements of Stream Processing

- Realtime
- Fault Tolerance (Data/System)

APACHE STORM™

- Stream (K-V Tuple)
- Spout
- Bolt
- Topology



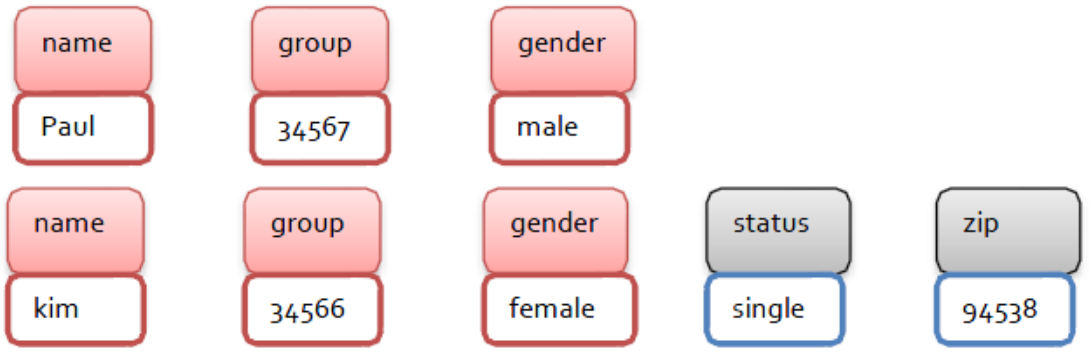
NoSQL Database

RDBMS vs NoSQL

Big Data

- Variety
- Sparse

- Key-Value
- Column-Oriented
- Document-Oriented

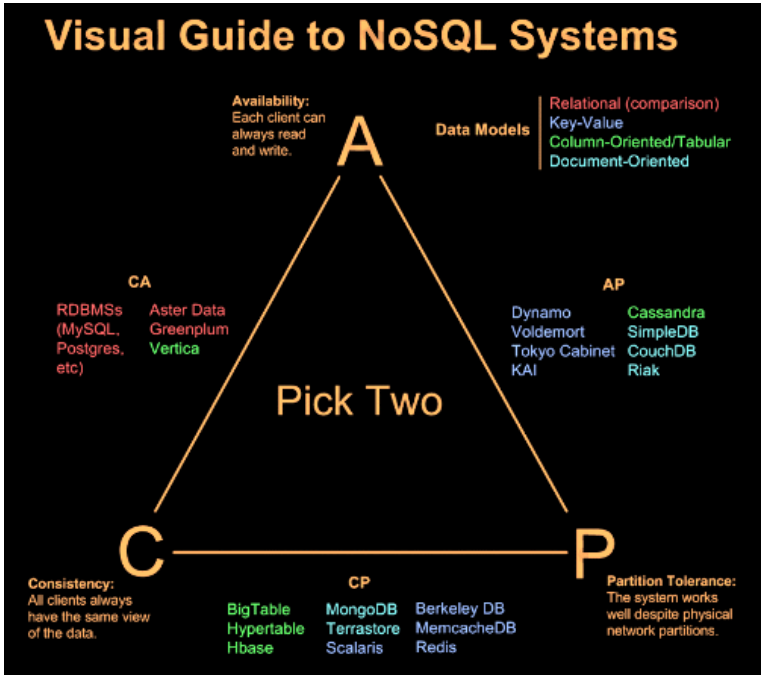


key	name	group	gender	status	zip
356	Paul	34567	male	null	null
54	kim	34566	female	single	94538

NoSQL Database

CAP

- Consistency
- Availability
- Partition Tolerances



RDBMS

- Atomicity
- Consistency
- Isolation
- Durability

NoSQL

- Basically Available
- Soft-state
- Eventually Consistent

NoSQL Database

- HBase
- Cassandra
- MongoDB
- Accumulo
- Redis

…

- Tradeoff between consistency and availability.
- Weak with complex SQL operations.

ELK

elastic

Elasticsearch

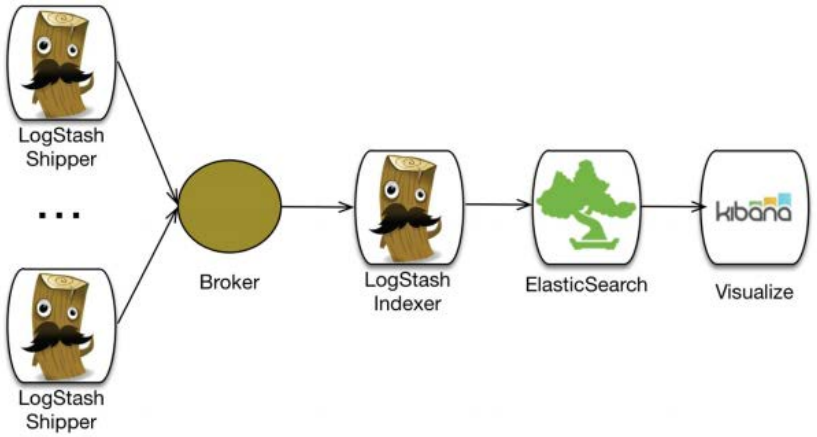
- Real-Time Full-Text Search

Logstash

- Data Collect, Transform and Transport

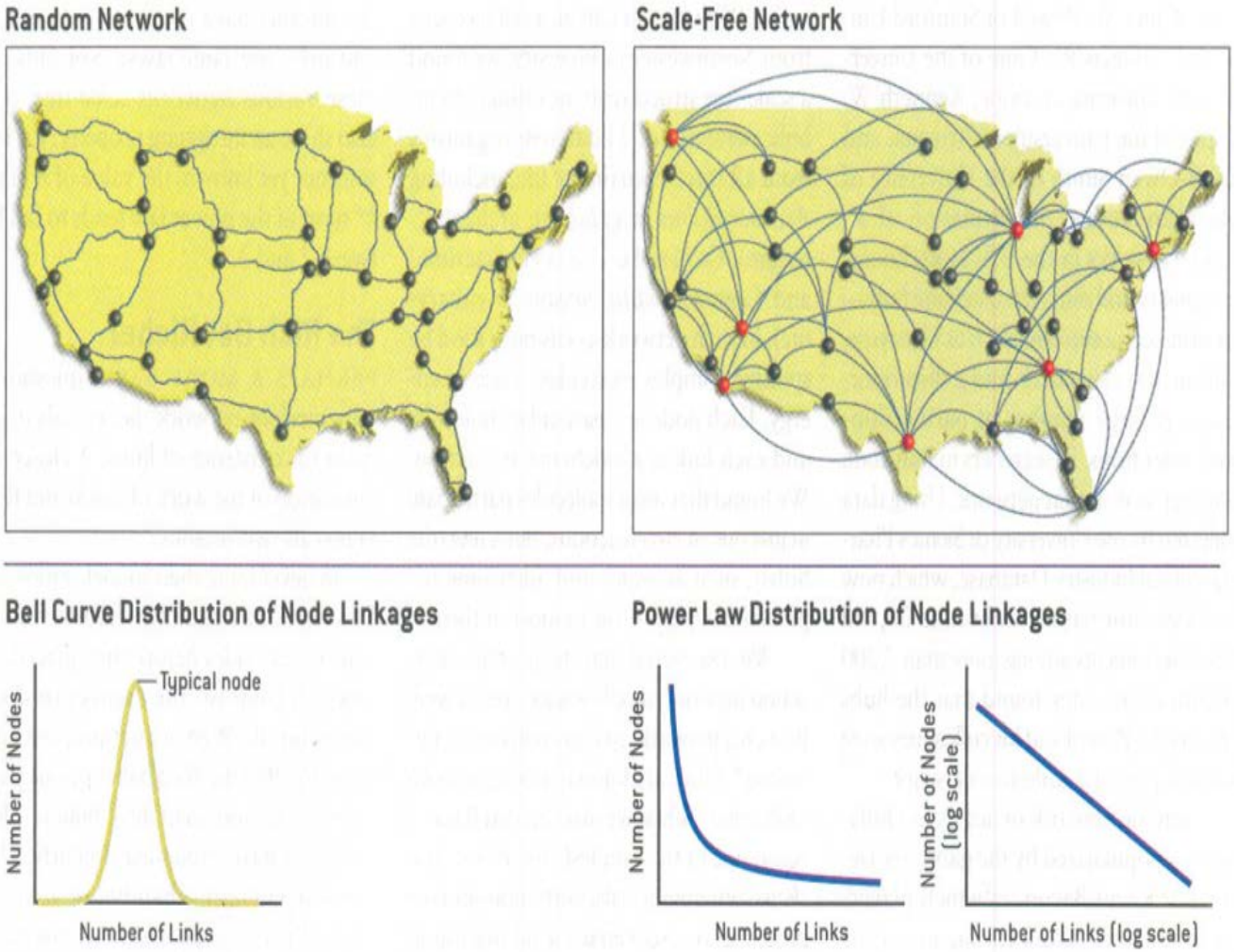
Kibana

- Analysis and Visualization



Graph Database

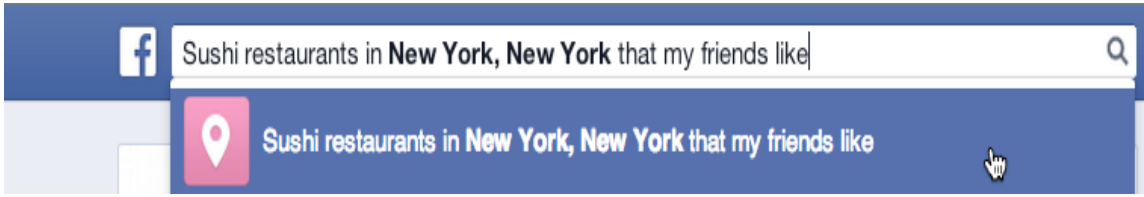
Organic Growth -> Scale Free



Graph Database

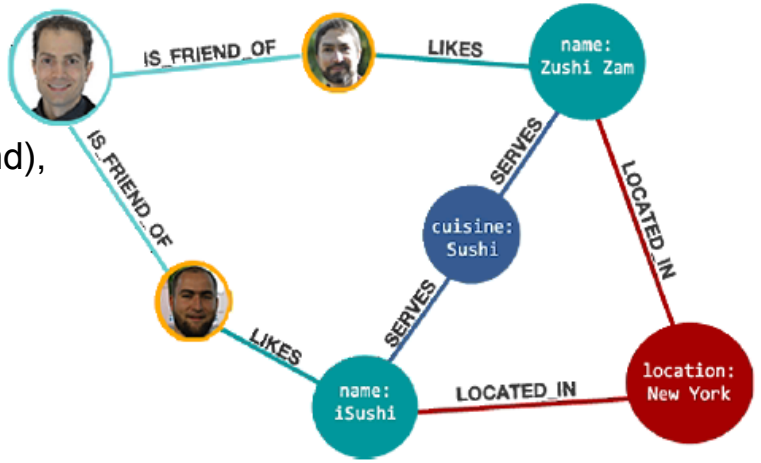
neo4j

Social Recommendation



Graph Query Examples

```
MATCH (person:Person)-[:IS_FRIEND_OF]->(friend),
(friend)-[:LIKES]->(restaurant),
(restaurant)-[:LOCATED_IN]->(loc:Location),
(restaurant)-[:SERVES]->(type:Cuisine)
WHERE person.name = 'Philip'
AND loc.location='New York'
AND type.cuisine='Sushi'
RETURN restaurant.name
```



Graph Analysis

PROJECT PEGASUS

APACHE GIRAPH

GraphLab

- Page Rank
- Triangle Counting
- Connected Components
- Shortest Distance
- Random Walk
- Graph Coarsening
- Graph Coloring
- Minimum Spanning Forest
- Community Detection
- Collaborative Filtering
- Belief Propagation
- Named Entity Recognition

…

Large-Scale Machine Learning

Tasks

–Classification [Predictive]

–Clustering [Descriptive]

–Association Rule Discovery [Descriptive]

–Sequential Pattern Discovery [Descriptive]

–Regression [Predictive]

–Deviation Detection [Predictive]

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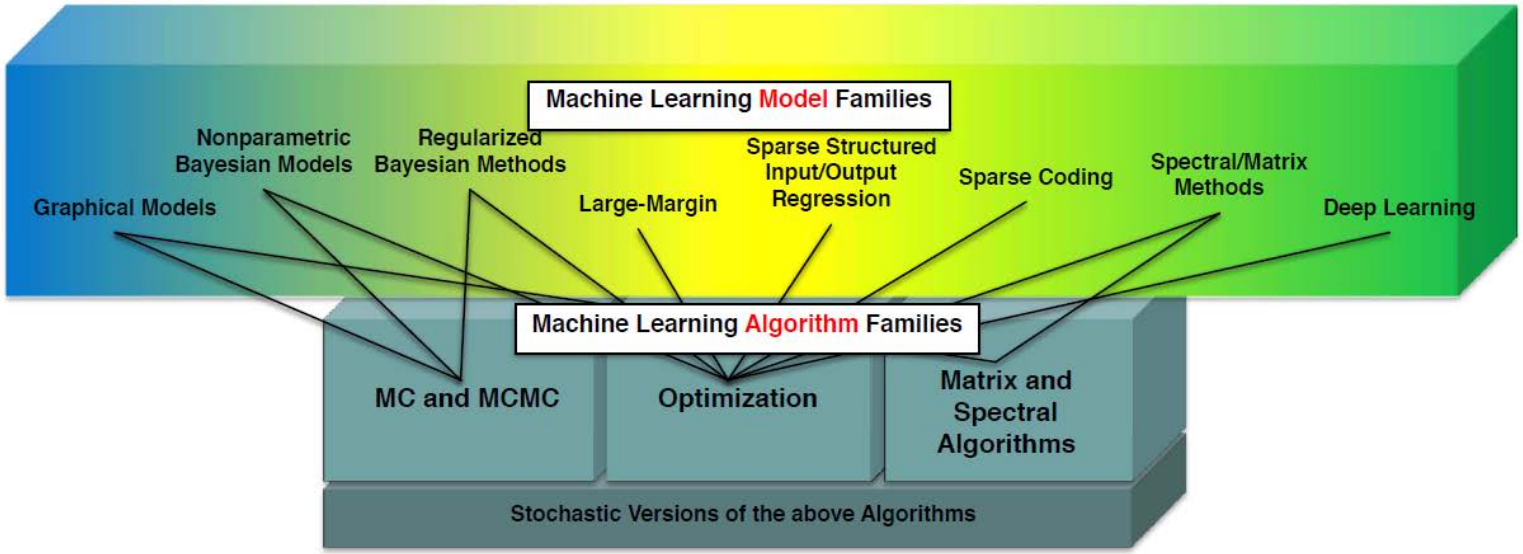

Large-Scale Machine Learning

For Specific Algorithms:

- YahooLDA (Latent Dirichlet Allocation)
- Caffe (Convolutional Neural Network)
- Torch → TensorFlow (Tensor Mathematics)

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General Platform

- Mahout
- Spark MLlib
- DMLC @ CMU
- Petuum @ CMU
- DMTK @ MSRA

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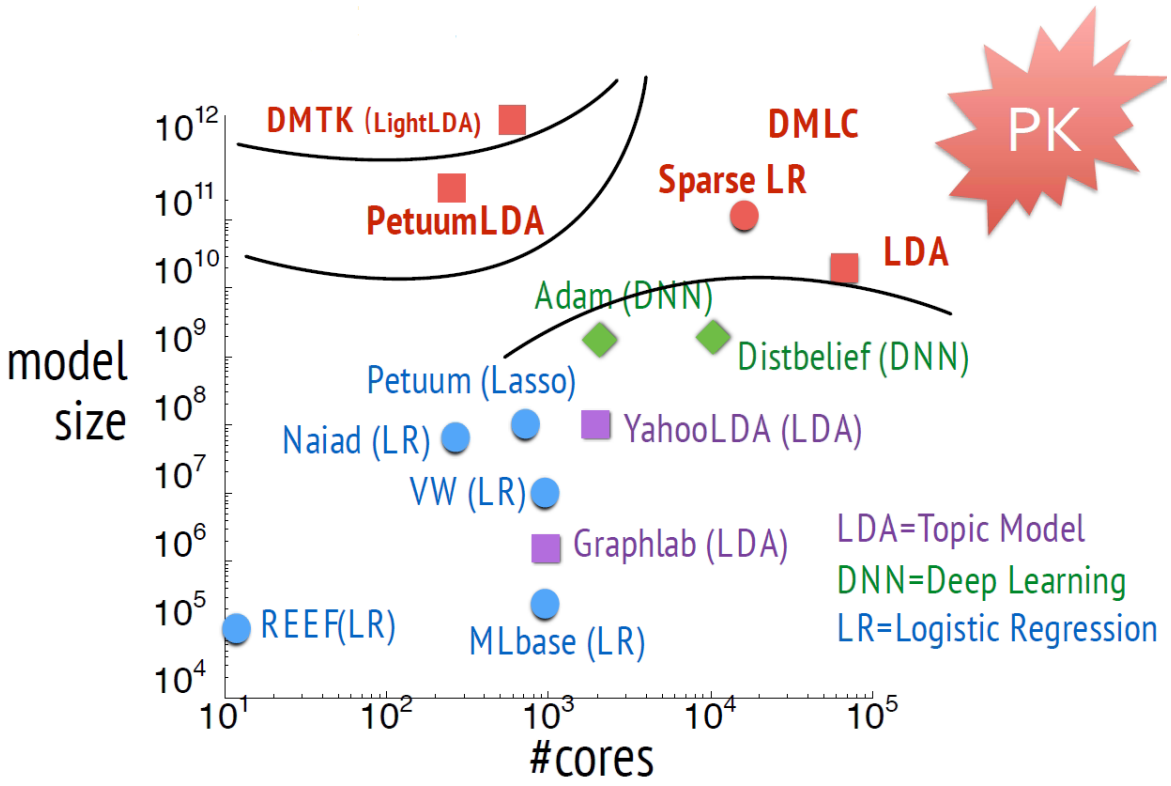

Visualization

- Prefuse
- Google Refine
- Tableau
- R
- Processing
- D3 (JS)
- ColorBrewer

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Google Refine

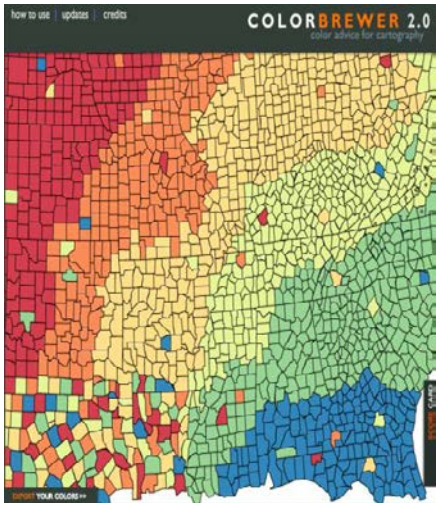
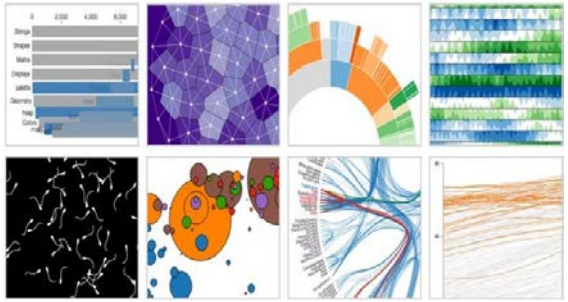


tableau SOFTWARE

Data-Driven Documents



Thank you!

Questions?