
Distributed Big Data Frameworks

A Panorama



This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 809965.



BIG DATA & AI LANDSCAPE 2018

INFRASTRUCTURE

HADOOP ON-PREMISE
cloudera **Hortonworks**
MAAPR **Pivotal**
IBM InfoSphere
bluedata **jethro**

HADOOP IN THE CLOUD
aws **Microsoft Azure**
Google Cloud **IBM Intelligent**
TREASURE DATA **Google** **altiscale**
CAZENA **CenturyLink**

STREAMING / IN-MEMORY
aws **databricks** **stream**
confluent **GridGain** **ORACLE**
dataArtisans **hazelcast**
TERRACOTTA **lx** **NO FAST DATA**
Wallaroo

NoSQL DATABASES
Google Cloud **aws**
ORACLE **Microsoft Azure**
mongoDB **MarkLogic**
REDIS **DATASTAX**
Azango **Couchbase**
redislabs **SCYLLA**

NEWSQL DATABASES
aws **Microsoft Azure**
Cockroach Labs **InfuData**
MEMSQL **YOUTUB**
chudata **splice**
paradigm **TID**

GRAPH DBs
Amazon Neptune
IBM ORACLE
graphistry **Objectivity**

MPP DBs
IBM Data Warehouse Systems
Qobito
Ecotio
Exasol
Dremio

CLOUD EDW
aws **Microsoft Azure**
Pivotal **Snowflake**

DATA TRANSFORMATION
talend **pentaho**
alteryx **TRIFACTA**
talend **Paxata**
StreamSets **UNIFI**

DATA INTEGRATION
SAP Data Services **Informatica**
Microsoft **enigma** **redm**
alooma **sparsity** **ZALENI**
Stitch **import.io**
InfoWorks **ATTUNITY**

DATA GOVERNANCE
IBM **ScalePoint**
Microsoft **Security Cloud**
colibra **WAVEFRONT**
Alcatel **univocal**
IBM **ORACLE**

MGMT / MONITORING
aws **New Relic** **octrino**
rubrik **APPDYNAMICS**
WAVEFRONT
Microsoft **SignalFx** **drum**
Microsoft **univocal**
Microsoft **univocal**

STORAGE
aws **Google Cloud**
Microsoft Azure **IBM**
Microsoft Azure **IBM**
Microsoft Azure **IBM**
Microsoft Azure **IBM**

CLUSTER SVCS
aws **Microsoft Azure**
Microsoft Azure **IBM**
Microsoft Azure **IBM**
Microsoft Azure **IBM**

APP DEV
aws **Microsoft Azure**
Microsoft Azure **IBM**
Microsoft Azure **IBM**
Microsoft Azure **IBM**

CROWD-SOURCING
aws **Microsoft Azure**
Microsoft Azure **IBM**
Microsoft Azure **IBM**
Microsoft Azure **IBM**

HARDWARE
aws **Microsoft Azure**
Microsoft Azure **IBM**
Microsoft Azure **IBM**
Microsoft Azure **IBM**

GPU DBs
aws **Microsoft Azure**
Microsoft Azure **IBM**
Microsoft Azure **IBM**
Microsoft Azure **IBM**

CROSS-INFRASTRUCTURE/ANALYTICS

aws **Google Cloud** **Microsoft** **IBM** **SAP** **Microsoft** **ORACLE** **NetApp** **syncsort** **MAAPR** **cloudera**

ANALYTICS

DATA ANALYST PLATFORMS
Microsoft **pentaho** **alteryx**
guavus **AYASDI**
ATTIVIO **Datameer** **Quid** **Incora**
Interana **ClearStory** **Origami**
ENDOR **MODE** **Bottlenose** **switchboard**

DATA SCIENCE PLATFORMS
IBM **KNIME** **dataiku**
DOMINO **rapidminer**
CONTINUUM **ALGORITHMIA**
DATAWAY **ANGORE** **SAS**

BI PLATFORMS
Microsoft **aws**
Microsoft **aws**
Microsoft **aws**
Microsoft **aws**

VISUALIZATION
tableau **SAP**
Google Cloud **celonis**
Qlik **Perceptics**
Qlik **Perceptics**
Qlik **Perceptics**

MACHINE LEARNING
aws **Microsoft Azure**
Google Cloud **H2O**
Google Cloud **H2O**
Google Cloud **H2O**

COMPUTER VISION
Amazon Rekognition
Amazon Rekognition
Amazon Rekognition
Amazon Rekognition

HORIZONTAL AI
IBM Watson **Cortana** **FaceFirst**
IBM Watson **Cortana** **FaceFirst**
IBM Watson **Cortana** **FaceFirst**
IBM Watson **Cortana** **FaceFirst**

SPEECH & NLP
aws **Microsoft Azure**
Google Cloud **H2O**
Google Cloud **H2O**
Google Cloud **H2O**

SEARCH
aws **Microsoft Azure**
Google Cloud **celonis**
Qlik **Perceptics**
Qlik **Perceptics**
Qlik **Perceptics**

LOG ANALYTICS
aws **Microsoft Azure**
Google Cloud **H2O**
Google Cloud **H2O**
Google Cloud **H2O**

SOCIAL ANALYTICS
aws **Microsoft Azure**
Google Cloud **H2O**
Google Cloud **H2O**
Google Cloud **H2O**

WEB / MOBILE / COMMERCE ANALYTICS
aws **Microsoft Azure**
Google Cloud **H2O**
Google Cloud **H2O**
Google Cloud **H2O**

APPLICATIONS - ENTERPRISE

SALES
Microsoft **CHORUS**
INSIDESALES.COM
conversica **salesforce**
clarifai **avisio** **tact.ai**
fuse **machines** **TRIDPOPS**

MARKETING - B2B
RADIUS **App Annie**
EVEREST **Lattice**
INTENT **sense**
tubular **Datafus**
ENGAGIO **mrp**

MARKETING - B2C
Zeta **bloomreach** **SendGrid**
BlueVoyager **PERSADO** **Optix**
ACTIONIQ **SALTTHRU** **BLUECORE**
QUANTIFIN **Impacire** **Amplero**
amperity **TESSALAI** **Simion** **Stifite**

CUSTOMER SERVICE
MEDALLIA **zendesk**
CLARABridge
Gainsight **NO DATA**
DigitalGenius **ahni**
automat **frame** **AI**
miga **INTERCOM** **CaseDesk**

HUMAN CAPITAL
Humana **entelo**
hiQ **ROSTER**
hiretual **RECRUITMENT**
Woodward **Stella**
mya **synectics**

LEGAL
RAVEL **Seal**
JUDICATA **FEBRIVA**
RESEARCH **RESEARCH**
RESEARCH **RESEARCH**

FINANCE
anaplan
ZUORA
SHARMA
WADSWORTH
butter **Kassisto**

ENTERPRISE PRODUCTIVITY
slack
ORACLE
luminate **DIFFBOT**
clara **talara**
butler **Kassisto**

BACK OFFICE AUTOMATION
UiPath
blueprints
Apptio
Apptio **Workfusion**

SECURITY
TANUAM **CYCLANCE** **zscaler**
StackPath **illumin** **CODE AI**
DARBACK **ANOMALY** **Trustm** **AVETRA**
blueprints **DATAVISOR** **sift science**
SECURITY **SECURITY** **SECURITY**
SECURITY **SECURITY** **SECURITY**

APPLICATIONS - INDUSTRY

ADVERTISING
AppSense **critico** **XAd**
ORACLE **OpenX** **Adaptive**
distillery **Adaptive**
Adaptive **Adaptive**

EDUCATION
edX **FutureLearn**
edX **FutureLearn**
edX **FutureLearn**
edX **FutureLearn**

GOVERNMENT
mark43 **GovSight**
GovSight **GovSight**
GovSight **GovSight**
GovSight **GovSight**

REAL ESTATE
Redfin **Opener**
Opener **Opener**
Opener **Opener**
Opener **Opener**

FINANCE - INVESTING
KENSHIC **Datamatrix**
Datamatrix **Datamatrix**
Datamatrix **Datamatrix**
Datamatrix **Datamatrix**

FINANCE - LENDING
MOJO **JIANPUAI**
Kreditech **AVANT**
INSIGHT **100Credit**
100Credit **100Credit**

INSURANCE
Intacta **Lemonade**
Lemonade **Lemonade**
Lemonade **Lemonade**
Lemonade **Lemonade**

HEALTHCARE
Ratiron **Clover** **YARUS** **HealthTap**
Metabeta **Gingerio** **Glow** **babylon**
3DMed **zebra** **PADA** **ovis**
TEMPUS **zebra** **AIcura**
precision **prognosis** **enite** **prognosis**

LIFE SCIENCES
Verily **Verily**
Verily **Verily**
Verily **Verily**
Verily **Verily**

TRANSPORTATION
UBER **TESLA**
UBER **TESLA**
UBER **TESLA**
UBER **TESLA**

AGRICULTURE
FARMERS **Granular**
Granular **Granular**
Granular **Granular**
Granular **Granular**

COMMERCE
Instacart **STITCH**
STITCH **STITCH**
STITCH **STITCH**
STITCH **STITCH**

INDUSTRIAL
AVEVA **SIEMENS**
SIEMENS **SIEMENS**
SIEMENS **SIEMENS**
SIEMENS **SIEMENS**

OPEN SOURCE

FRAMEWORK
TensorFlow **PyTorch**
TensorFlow **PyTorch**
TensorFlow **PyTorch**
TensorFlow **PyTorch**

QUERY / DATA FLOW
Spark **SQL**
Spark **SQL**
Spark **SQL**
Spark **SQL**

DATA ACCESS
nifi **mongoDB**
nifi **mongoDB**
nifi **mongoDB**
nifi **mongoDB**

COORDINATION
talend
talend
talend
talend

STREAMING
Spark **Flink**
Spark **Flink**
Spark **Flink**
Spark **Flink**

STAT TOOLS
Scalab **Scalab**
Scalab **Scalab**
Scalab **Scalab**
Scalab **Scalab**

AI / MACHINE LEARNING / DEEP LEARNING
TensorFlow **theano**
TensorFlow **theano**
TensorFlow **theano**
TensorFlow **theano**

SEARCH
elasticsearch **Solr**
elasticsearch **Solr**
elasticsearch **Solr**
elasticsearch **Solr**

LOGGING & MONITORING
elasticsearch **kibana**
elasticsearch **kibana**
elasticsearch **kibana**
elasticsearch **kibana**

VISUALIZATION
BeakerX
BeakerX
BeakerX
BeakerX

COLLABORATION
polymer **polymer**
polymer **polymer**
polymer **polymer**
polymer **polymer**

SECURITY
Apache Ranger **KNOX**
Apache Ranger **KNOX**
Apache Ranger **KNOX**
Apache Ranger **KNOX**

DATA SOURCES & APIs

HEALTH
Apple **VALIDIC**
Apple **VALIDIC**
Apple **VALIDIC**
Apple **VALIDIC**

IOT
GE Digital **thingworx**
GE Digital **thingworx**
GE Digital **thingworx**
GE Digital **thingworx**

FINANCIAL & ECONOMIC DATA
Bloomberg **THOMSON REUTERS**
Bloomberg **THOMSON REUTERS**
Bloomberg **THOMSON REUTERS**
Bloomberg **THOMSON REUTERS**

AIR / SPACE / SEA
Orbital Insight **planet**
Orbital Insight **planet**
Orbital Insight **planet**
Orbital Insight **planet**

PEOPLE / ENTITIES
axiom **experian**
axiom **experian**
axiom **experian**
axiom **experian**

LOCATION INTELLIGENCE
FOURSQUARE **mapbox**
FOURSQUARE **mapbox**
FOURSQUARE **mapbox**
FOURSQUARE **mapbox**

OTHER
qualtrics **DATA GOV**
qualtrics **DATA GOV**
qualtrics **DATA GOV**
qualtrics **DATA GOV**

DATA SERVICES
Palantir **ORACLE**
Palantir **ORACLE**
Palantir **ORACLE**
Palantir **ORACLE**

INCUBATORS & SCHOOLS
Pluralistic **alvanize**
Pluralistic **alvanize**
Pluralistic **alvanize**
Pluralistic **alvanize**

RESEARCH
OpenAI **facebook research**
OpenAI **facebook research**
OpenAI **facebook research**
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THANK YOU !



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Database Paradigms

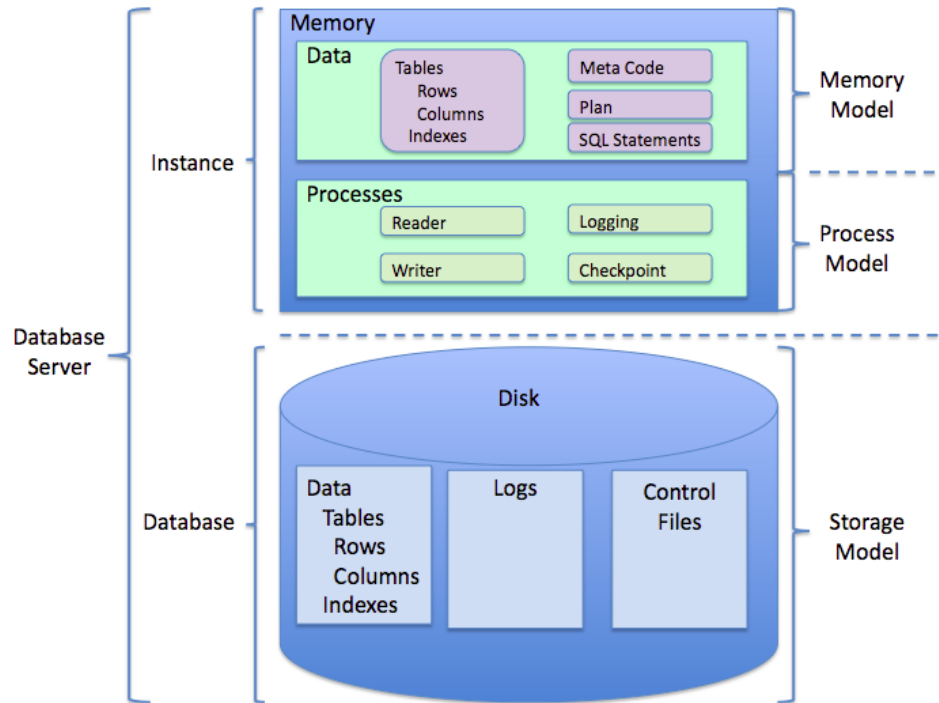
Database Paradigms

- **Relational (RDBMS) — The SQL world...!**

Relational (a quick reminder)

- ACID set of properties *i.e.* atomicity, consistency, isolation and durability.
- SQL is the canonical query language
- MySQL, PostgreSQL, Oracle, ...

Relational (a quick reminder)



https://en.wikipedia.org/wiki/Relational_database#/media/File:RDBMS_structure.png



Database Paradigms

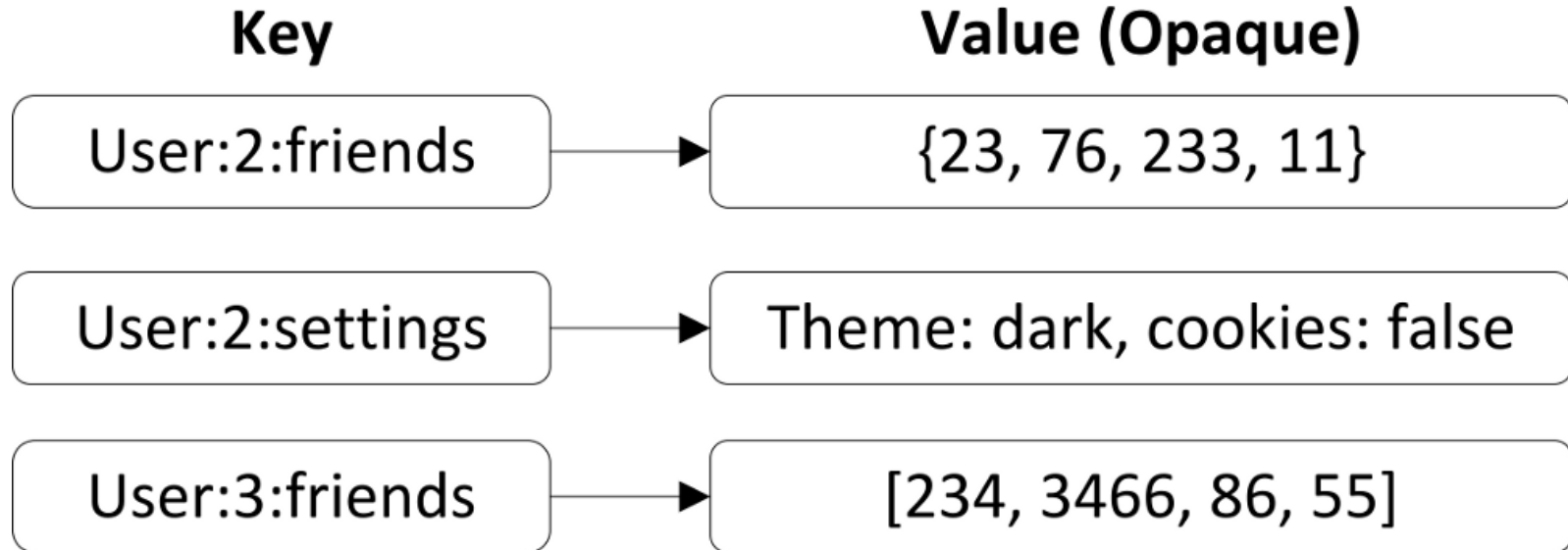
- Relational (RDBMS) — The SQL world...!
- NoSQL
 - **Key-Value stores**

Key-Value stores

- Paradigm → One key = One value
 - Without duplicate
 - Usually sorted
- Key is like a hash
- Value is seen as a binary object
- Examples:
 - Amazon Dynamo
 - MemcacheDB
 - Apache Accumulo



Key-Value stores



Database Paradigms

- Relational (RDBMS) — The SQL world...!
- NoSQL
 - Key-Value stores
 - **Document databases**

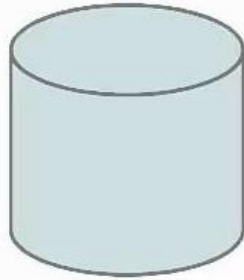
Document databases

- Key-Value store, but the value is structured and *understood* by the DB.
- Querying data is possible (by other means than just a key).
- Examples:
 - Amazon SimpleDB
 - CouchDB
 - Riak
 - **MongoDB**

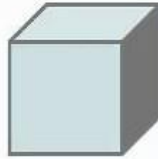


Document databases

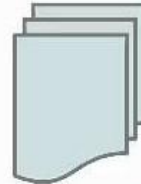
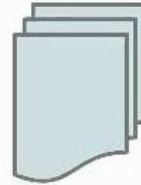
Documents are gathered together in collections within the database.



Database



Collections



Documents



Database Paradigms

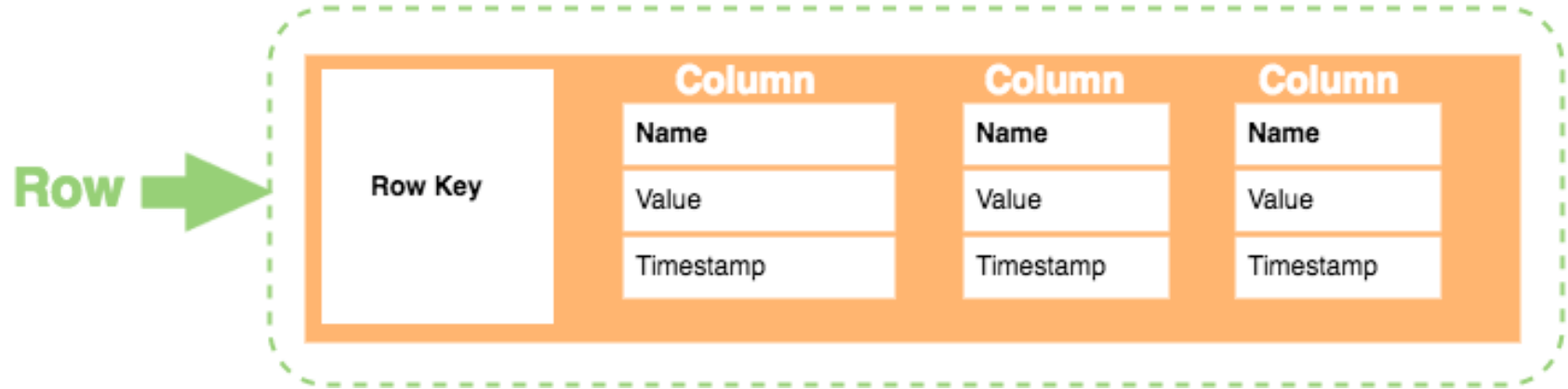
- Relational (RDBMS) — The SQL world...!
- NoSQL
 - Key-Value stores
 - Document databases
 - **Wide Column stores (*e.g.* BigTable and its variations)**

Wide Column stores

- Often referred as BigTables systems
- “Sparse, distributed mutli-dimensional sorted map”
- Examples:
 - Google BigTable
 - Cassandra (Facebook)
 - HBase



Wide Column stores



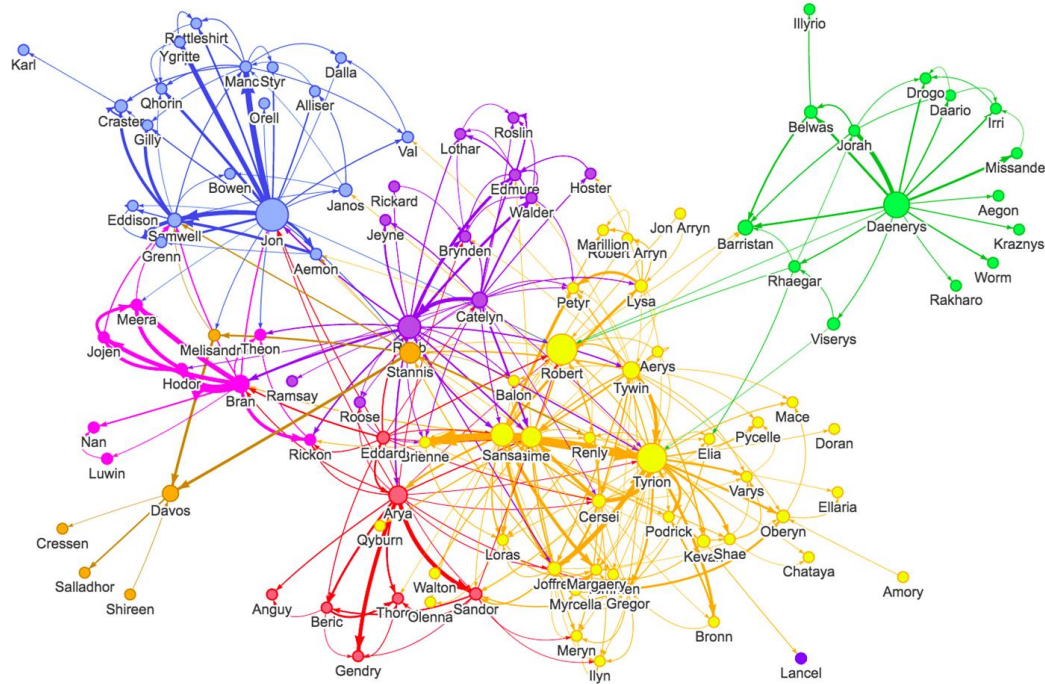
Database Paradigms

- Relational (RDBMS) — The SQL world...!
- NoSQL
 - Key-Value stores
 - Document databases
 - Wide Column stores (*e.g.* BigTable and its variations)
 - **Graph databases**
- Other ones...

Graph databases

- Multi-relational graph
- Put emphasis on links between data pieces
- Examples:
 - Neo4j
 - InfoGrid
 - Triplestores...

Graph databases



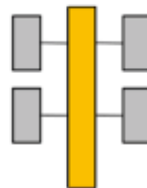
Database Paradigms (Visually)

SQL Database

Relational

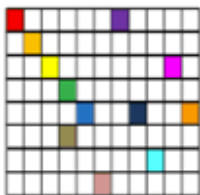


Analytical (OLAP)



NoSQL Database

Column-Family



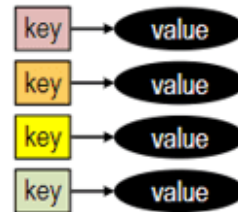
Graph



Document



Key-Value



Selected Storage Systems

MongoDB



- Document database (NoSQL)
 - scalability and flexibility
 - querying and indexing
- Stores data in
 - JSON-like documents
 - schema free database
- Open-Source



What is MongoDB great for?

- RDBMS replacement for Web Applications
- Semi-structured Content Management
- Real-time Analytics & High-Speed Logging
- Caching and Scalability

Apache Hive



- Apache Hive is a data warehouse
 - Developed by Facebook
 - On top of Apache Hadoop
- Provides
 - Data summarization
 - Query
 - Analysis
- Open-Source
- Gives an SQL-like interface

Apache Hive - Some Facts



Most Queries Per Hour

100,000 Queries Per Hour
(Yahoo Japan)

Analytics Performance

100 Million rows/s Per Node
(with Hive LLAP)

Largest Hive Warehouse

300+ PB Raw Storage
(Facebook)

Largest Cluster

4,500+ Nodes
(Yahoo)



Apache Hive - Limitations



- **Not** design for online transaction processing
- **Not** suited for real-time queries
- **Not** made for low-latency query
- Certain standard SQL functions do not exist
 - NOT IN
 - NOT LIKE
 - NOT EQUAL

Apache Cassandra



- Facebook inbox search feature
- millisecond read and write times
- Designed for linear, incremental scalability on top of commodity hardware.
- Open-Source since 2008

Cassandra - Strenghts



- Linear scale performance when adding node
- Peer-to-peer architecture instead of master-slave
- Fault tolerant in case of node failure
- High performance
- Schema-free/Schema-less

Cassandra - Limitations



Use cases where it is better to avoid using Cassandra

- If there are too many joins required
- To store configuration data
- During compaction, things slow down
- Aggregation Operator support is limited
- Can update or delete data but not designed for

Distributed Stream Processing

Apache Kafka



- Distributed event streaming platform
- Able to handle up to trillions of events a day
- Initially conceived as a messaging queue
- Open-sourced by LinkedIn in 2011
- Useful for:
 - Stream processing
 - Website activity tracking
 - Metrics collection and monitoring
 - Log aggregation

Apache Kafka



Three key capabilities

- Publish and Subscribe
 - Stream of records
- Process
 - Streams of records as they occur
- Store
 - Streams of records in fault tolerant manner

Search, Indexing, visualization

ElasticSearch



- Distributed and highly available search engine
 - Indexes are sharded (replicas)
 - read/search on any replica shards
- Multi-tenant
 - Support for more than one index
- Various set of APIs
- Document oriented
- Reliable
- Near real time search

- Data into ElasticSearch
 - Receive data in form of JSON documents
 - Ingest data using Logstash
 - Connectors to other data stores
- Stores and add searchable reference to the document
- All data is indexed by default
- Every field has a dedicated inverted index
- All of inverted indexes can be used in a query

Visualization

- Browser-based analytics and search dashboard for Elasticsearch
 - search
 - view
 - interactwith the data stored in Elasticsearch indices
- Visualize data
 - Charts
 - Tables
 - Maps



- Display changes in real time
- Discover
 - Explore data using selected index patterns
- Visualize
 - Create visualizations of data based on
 - ElasticSearch queries, Search saved from Discover
 - Stored as dashboards
- Dashboard
 - collection of visualizations and searches

Processing Frameworks

Analytic Frameworks

- Batch-only
 - Apache Hadoop MapReduce
- Stream and In-Memory Computing
 - Apache Spark
 - Apache Flink

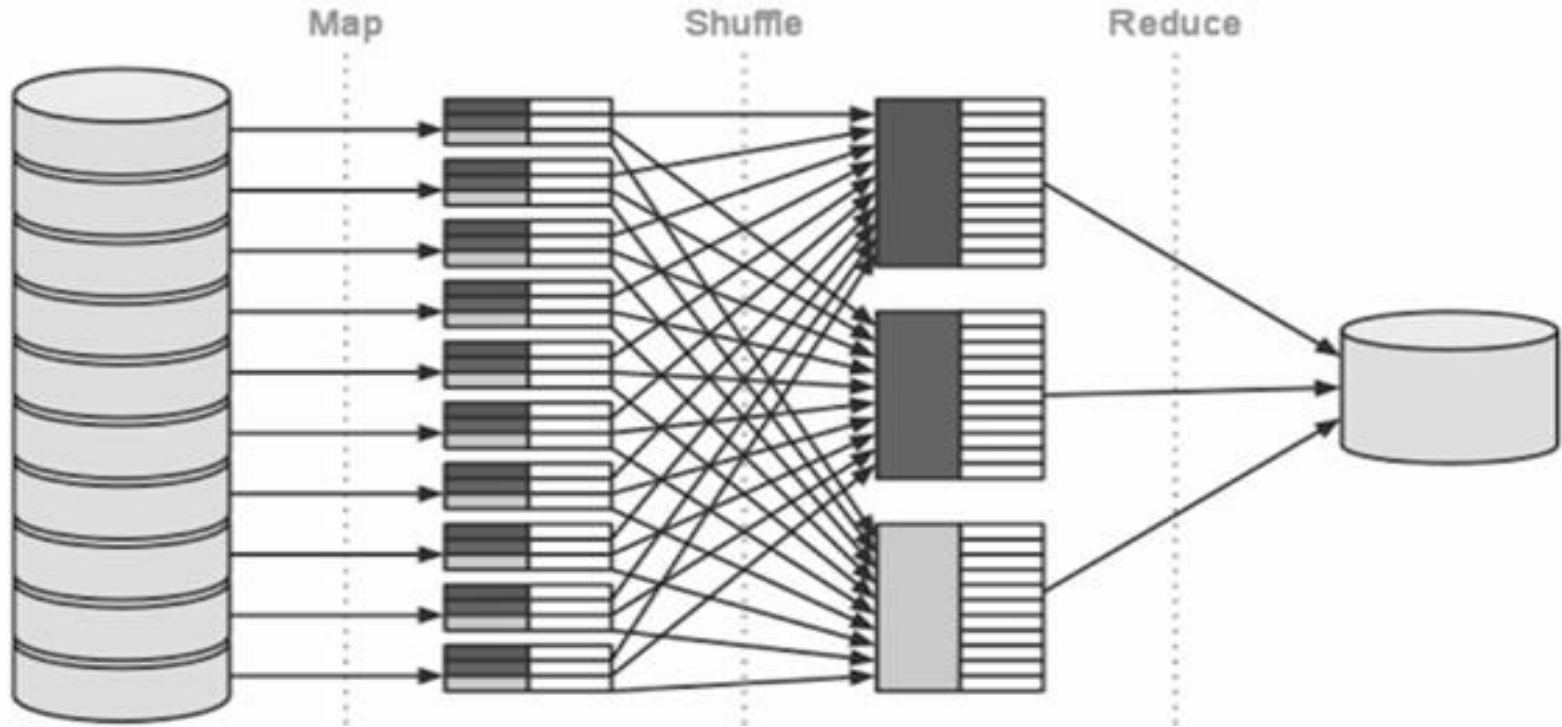


Hadoop MapReduce



- Distributed framework to process vast amounts of data (multi-terabyte data-sets)
 - Cluster of commodity hardware
 - Reliable
 - Fault tolerant
- MapReduce job
 - Divides the large data into independent chunks
 - Processed by Map-tasks in parallel
 - Sorted output is passed to the reduce-tasks
 - Typically both input and output are stored in filesystem (HDFS)

MapReduce Engine



Map reduce

- First popular data flow model
- In the Map-Reduce model, the user provides two functions (map and reduce)
 - Map() must output key-value pairs
 - Input to the reduce is partitioned by key across machines (shuffled)
 - reduce() output the aggregated values



Processing of Map tasks

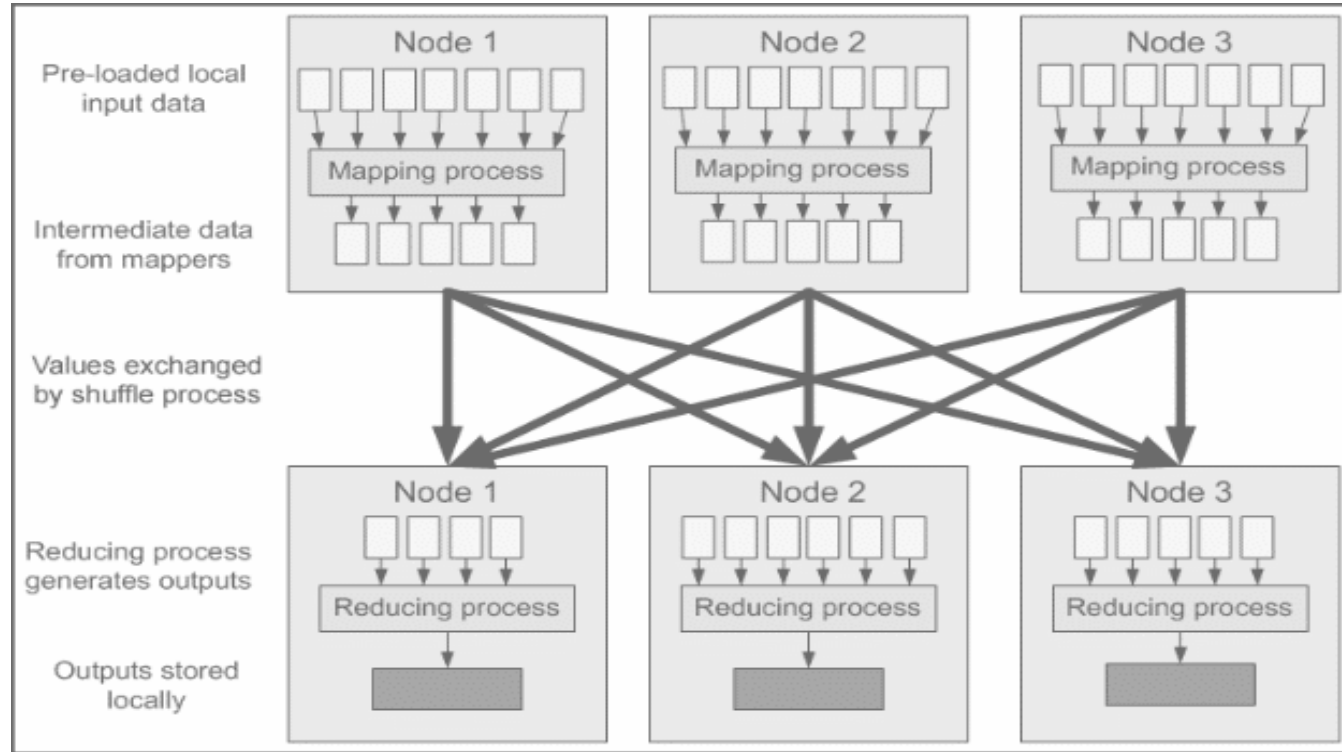
- Given a file divided into multiple parts (splits).
- Each record (line) is processed by a Map function,
 - written by the user,
 - takes an input key/value pair
 - produces a set of intermediate key/value pairs.
 - e.g. (doc—id, doc-content)
- Draws an analogy to SQL group-by clause

Processing of Reduce Tasks

Given a set of (key, value) records by map tasks

- The intermediate values are combined into a list based on keys and given to a reducer.
- Each reducer further performs an *aggregate* function (e.g., average) computed over all the rows with the same “key”

Visualizing map and reduce tasks



Example: Word counting in class

”Consider the problem of counting the number of occurrences of each word in a large collection of documents”



Divide a collection of documents among the class

Each person calculates counts of individual words in the documents

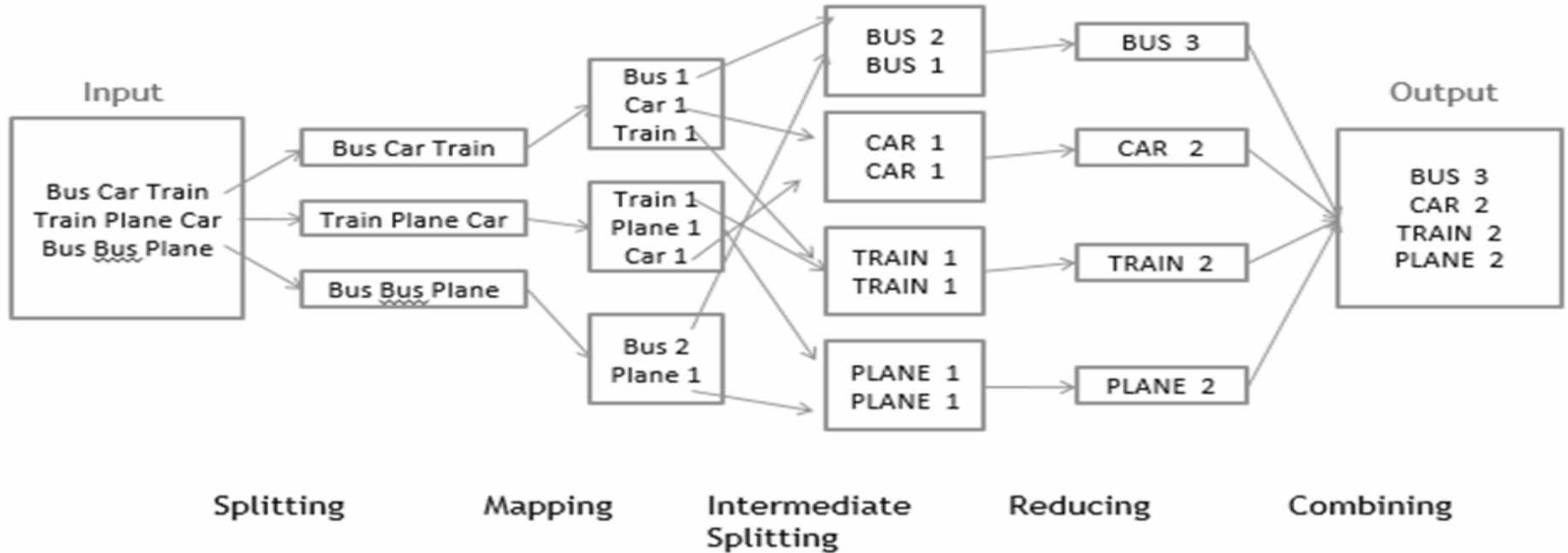
independent

Gather the words and counts

Sum up the counts from all the documents for all the words



Word Count MapReduce



Drawbacks of MapReduce

- Forces data analysis workflow into a map and a reduce phase
 - You might need
 - Join
 - Filter
 - Sample
 - Complex workflows that do not fit into map/Reduce
 - Mapreduce relies on reading data from disk
 - Performance bottleneck
 - Especially for iterative algorithms
 - e.g. Machine Learning

Requirement . .

- A tool, compatible with the existing environment
- Without replacing the stack
 - replace map-reduce only
- Generic
 - Provides a rich API, more functions
- Reduces Disk I/O
 - Faster
 - In-memory computations
- Provides an interactive shell

Apache Flink



- Distributed stream processing engine
- Process bounded and unbounded streams
- Generic deployment
- Scalable
 - Trillions of events
 - Terabytes of states
 - Thousands of cores
- In-Memory performance

Apache Flink APIs

- Data Stream API
 - bounded or unbounded streams of data
- Dataset API
 - bounded data sets
 - Transformations (Filter, map, join)
- Table API
 - SQL-like expression language for relational stream

Apache Flink Layered APIs

High-level Analytics API	SQL / Table API (dynamic tables)	- Conciseness + + Expressiveness -
Stream- & Batch Data Processing	DataStream API (streams, windows)	
Stateful Event- Driven Applications	ProcessFunction (events, state, time)	



Apache Flink Libraries

- Complex Event Processing (CEP)
 - Pattern detection from events
- DataSet API
 - Map, Reduce, join, iterate
- Gelly
 - Scalable Graph processing library

References

<https://flink.apache.org/>



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THANK YOU !



LEARNING, APPLYING, MULTIPLYING BIG DATA ANALYTICS

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