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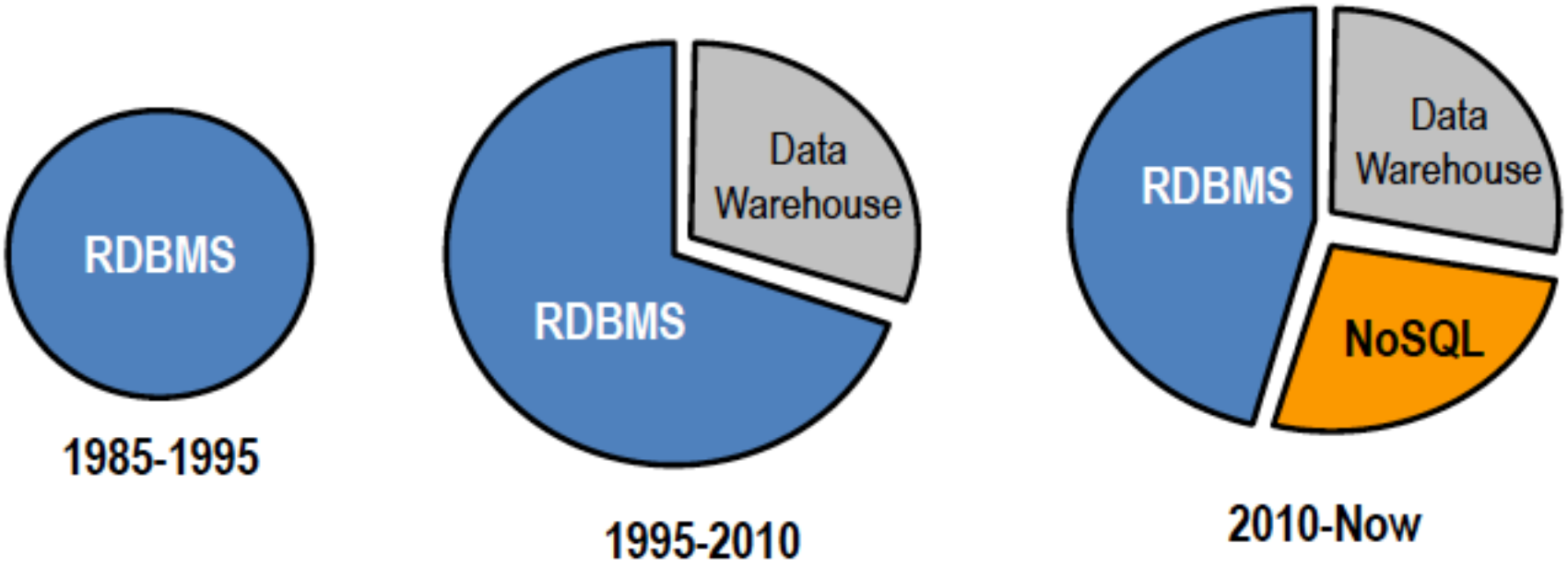
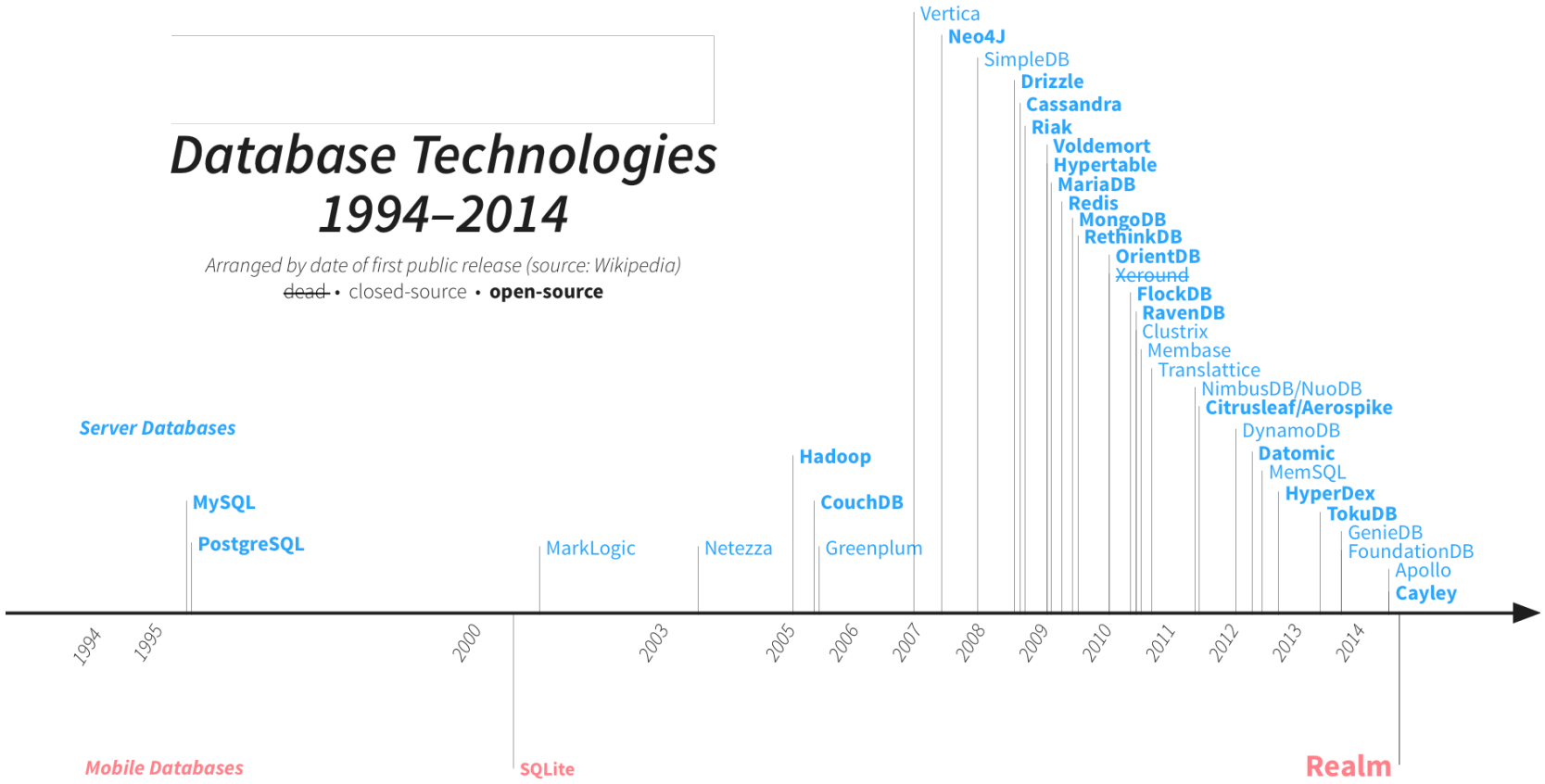
Chapter 4

NoSQL - part 1

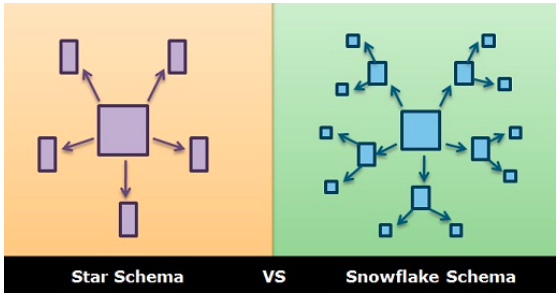
Eras of Databases

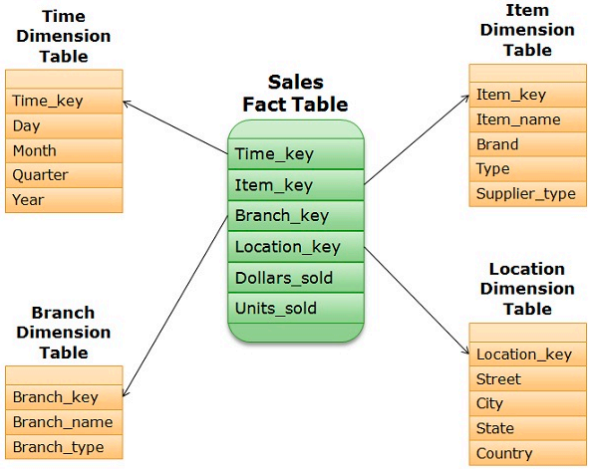


Eras of Databases

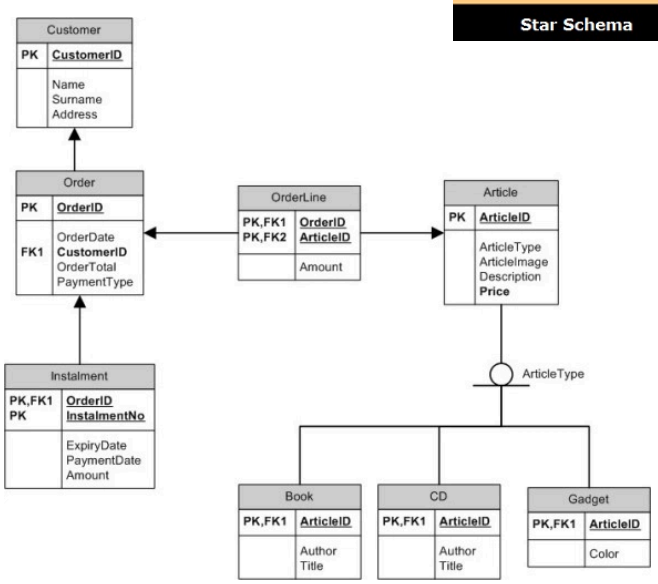


Before NoSQL

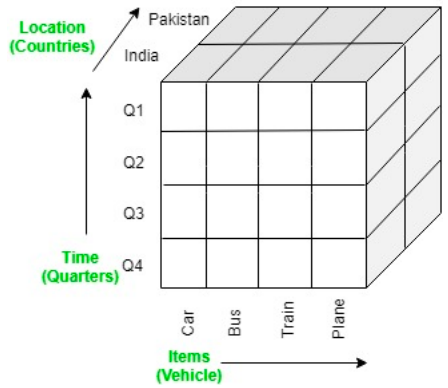




Star schema

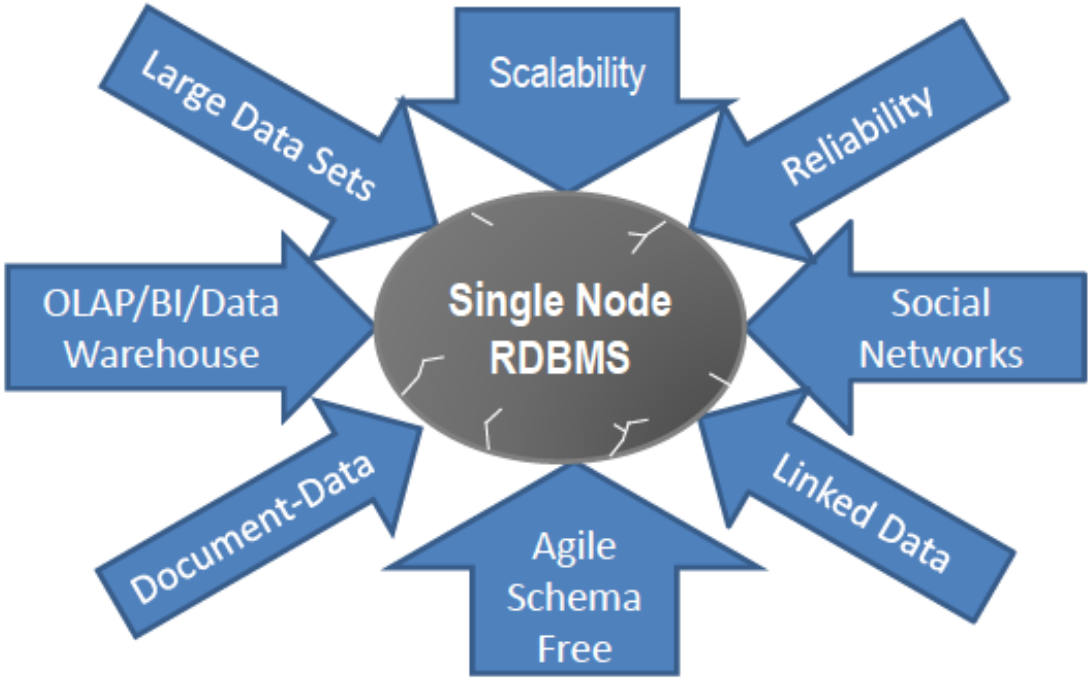


OLTP



OLAP cube

RDBMS: one size fits all needs



ICDE 2005 conference

"One Size Fits All": An Idea Whose Time Has Come and Gone

Authors: Michael Stonebraker StreamBase Systems, Inc.
Ugur Cetintemel Brown University and StreamBase Systems, Inc.

2005 Article

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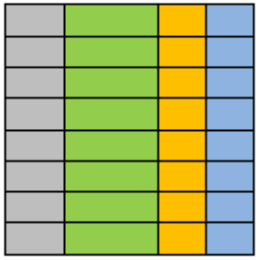
Bibliometrics

· Citation Count: 73
· Downloads (cumulative): 0
· Downloads (12 Months): 0
· Downloads (6 Weeks): 0

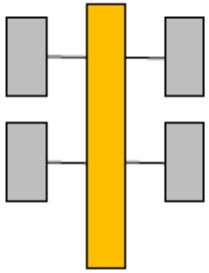
The last 25 years of commercial DBMS development can be summed up in a single phrase: "one size fits all". This phrase refers to the fact that **the traditional DBMS architecture (originally designed and optimized for business data processing) has been used to support many data-centric application**s with widely varying characteristics and requirements. In this paper, we argue that this concept is no longer applicable to the database market, and that the commercial world will fracture into a collection of independent database engines ...

After NoSQL

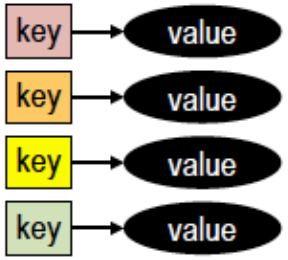
Relational



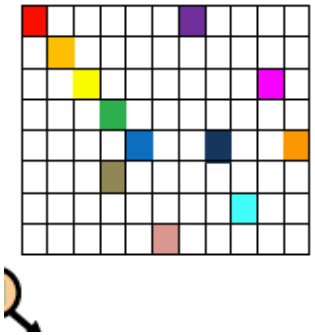
Analytical (OLAP)



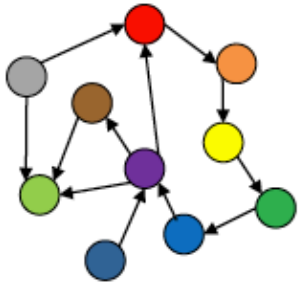
Key-Value



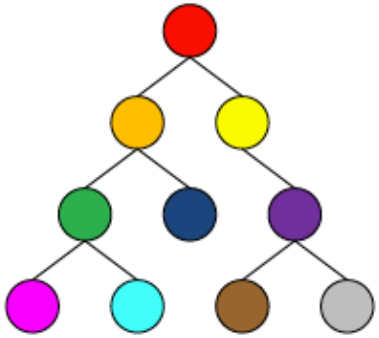
Column-Family



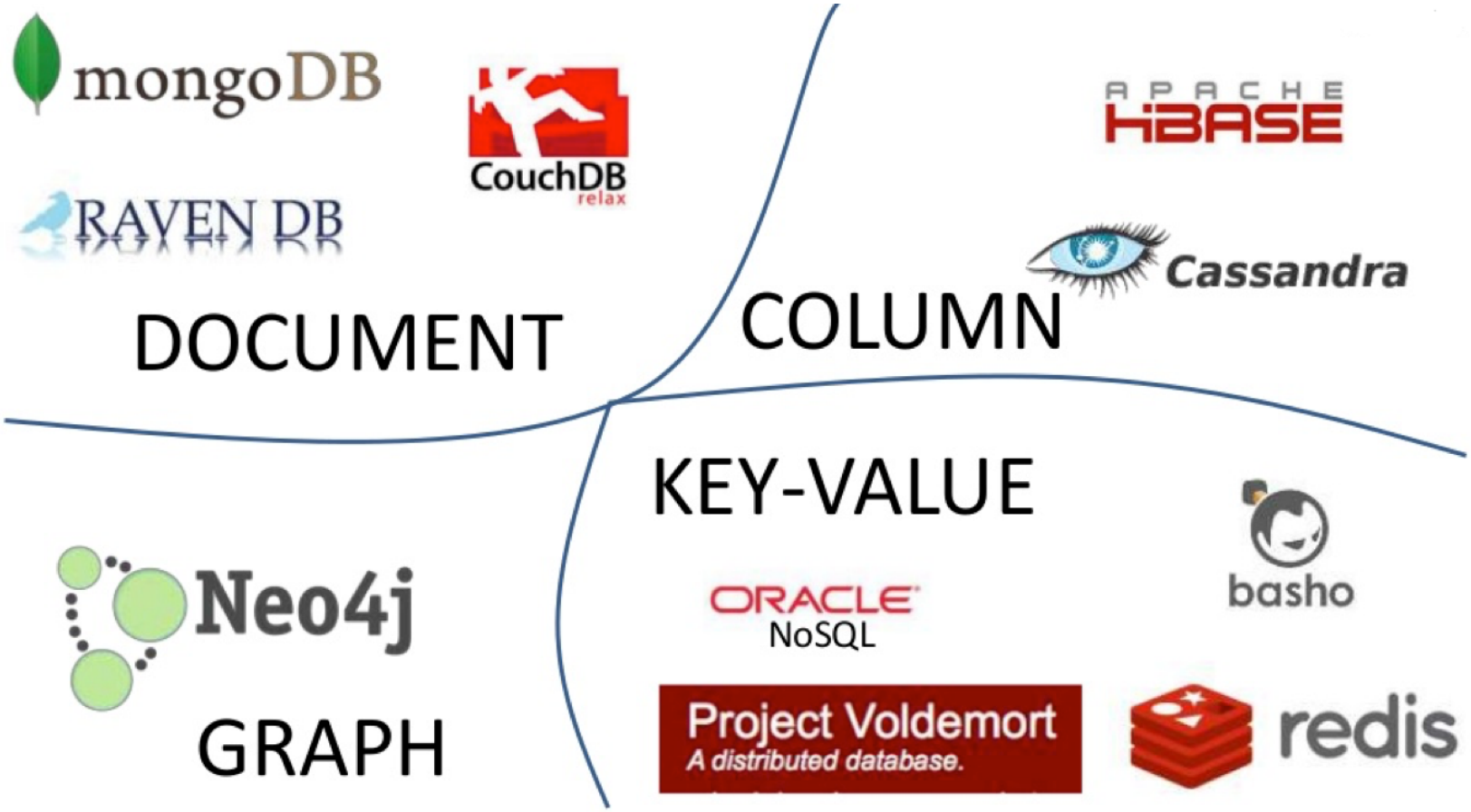
Graph



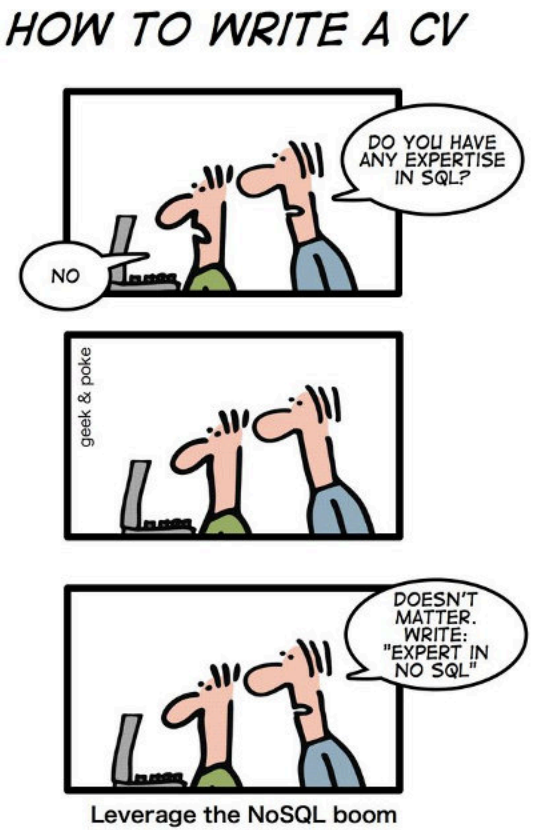
Document



NoSQL landscape



How to write a CV



Why NoSQL

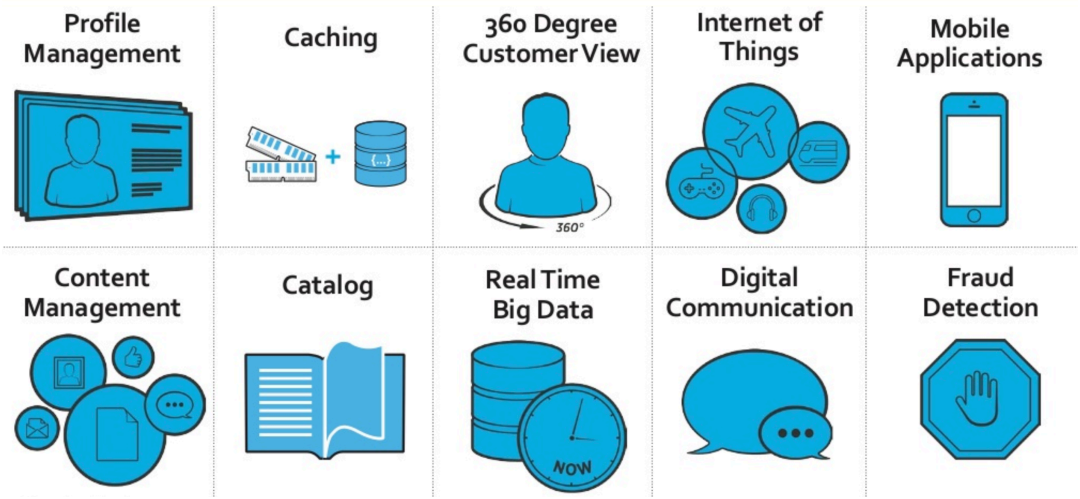
- Web applications have different needs
  - Horizontal scalability – lowers cost
  - Geographically distributed
  - Elasticity
  - Schema less, flexible schema for semi-structured data
  - Easier for developers
  - Heterogeneous data storage
  - High Availability/Disaster Recovery
- Web applications do not always need
  - Transaction
  - Strong consistency
  - Complex queries

SQL vs NoSQL

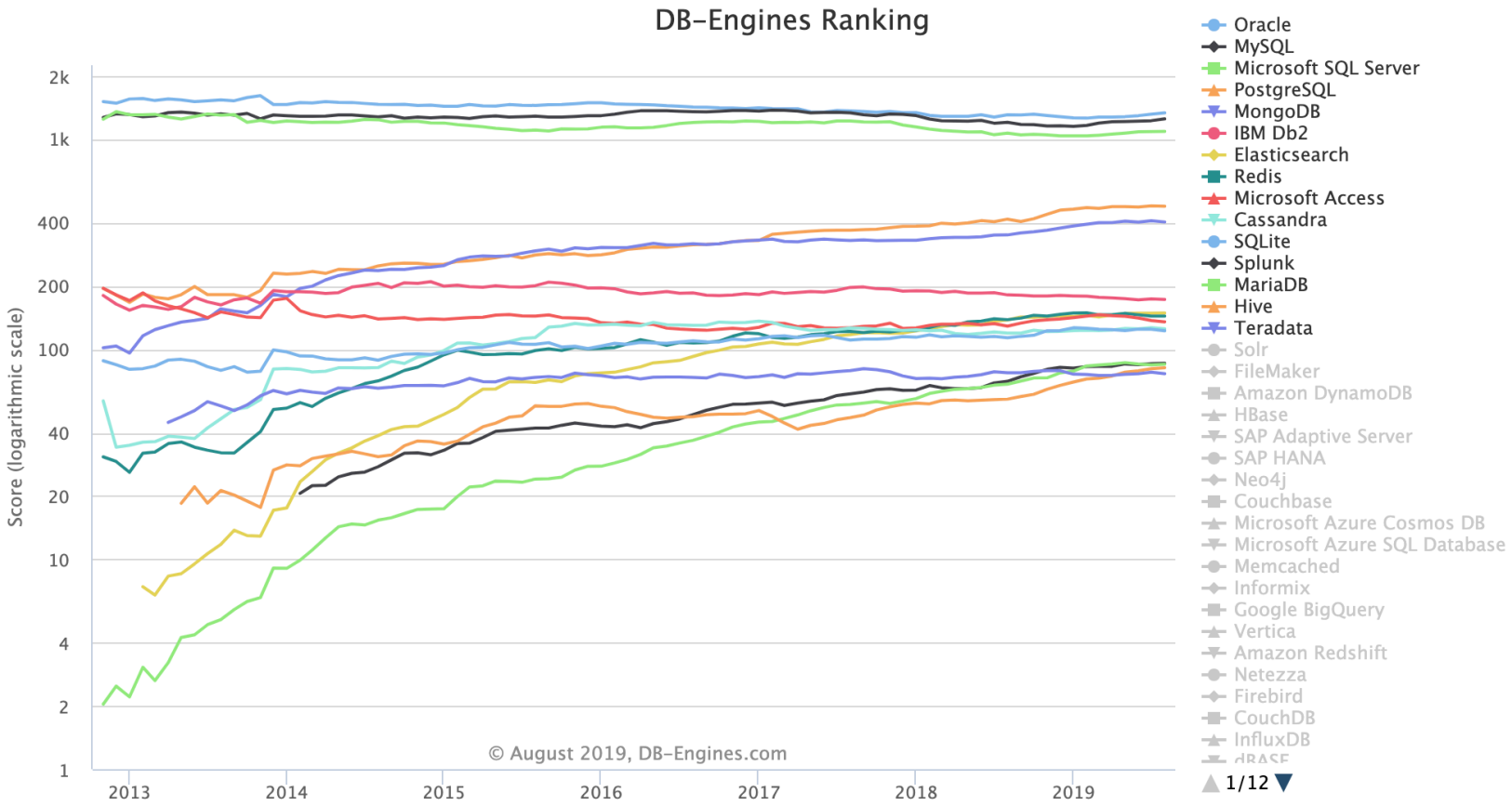
SQL	NoSQL
Gigabytes to Terabytes	Petabytes(1kTB) to Exabytes(1kPB) to Zetabytes(1kEB)
Centralized	Distributed
Structured	Semi structured and Unstructured
Structured Query Language	No declarative query language
Stable Data Model	Schema less
Complex Relationships	Less complex relationships
ACID Property	Eventual Consistency
Transaction is priority	High Availability, High Scalability
Joins Tables	Embedded structures

NoSQL use cases

- Massive data volume at scale (Big volume)
  - Google, Amazon, Yahoo, Facebook – 10-100K servers
- Extreme query workload (Big velocity)
- High availability
- Flexible, schema evolution

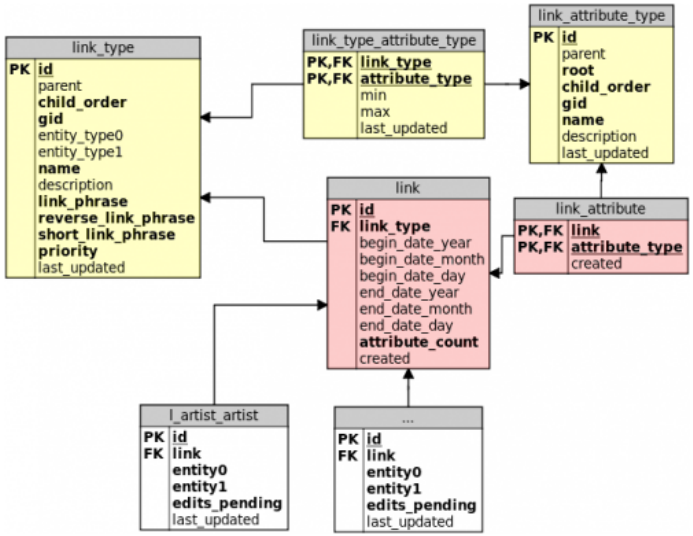


DB engines ranking according to their popularity (2019)



Relational data model revisited

- Data is usually stored in row by row manner (row store)
- Standardized query language (SQL)
- Data model defined **before** you add data
- Joins merge data from multiple tables
  - Results are tables
- **Pros:** Mature ACID transactions with fine-grain security controls, widely used
- **Cons:** Requires up front data modeling, does not scale well

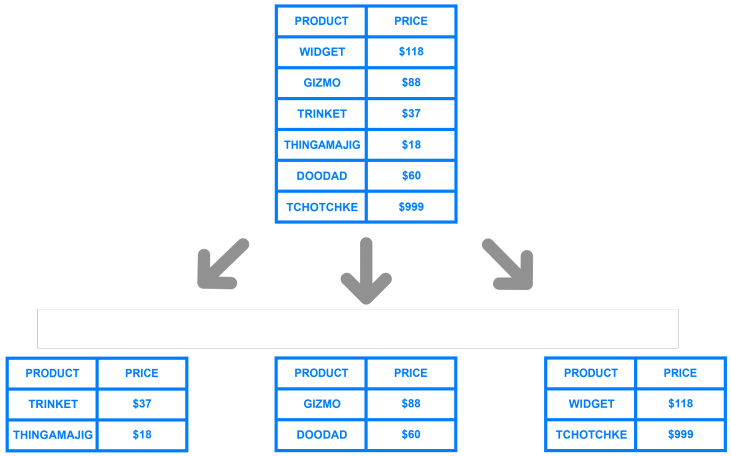


Oracle, MySQL, PostgreSQL, Microsoft SQL Server, IBM DB/2

Key/value data model

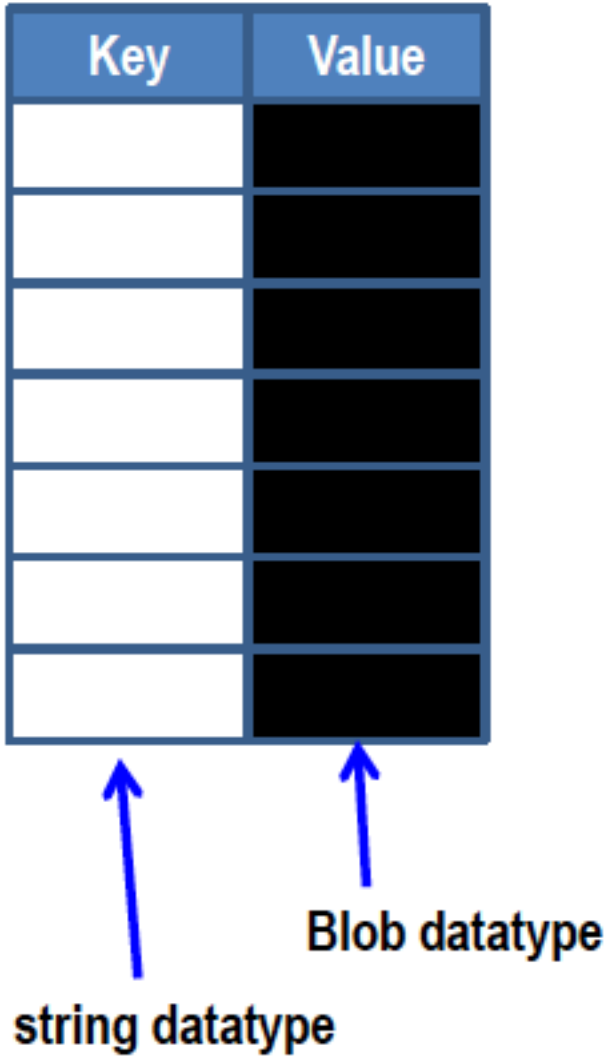
- Simple key/value interface
  - GET, PUT, DELETE
- Value can contain any kind of data
- Super fast and easy to scale (no joins)
- Examples
  - Berkley DB, Memcache, DynamoDB, Redis, Riak

key	value
firstName	Bugs
lastName	Bunny
location	Earth

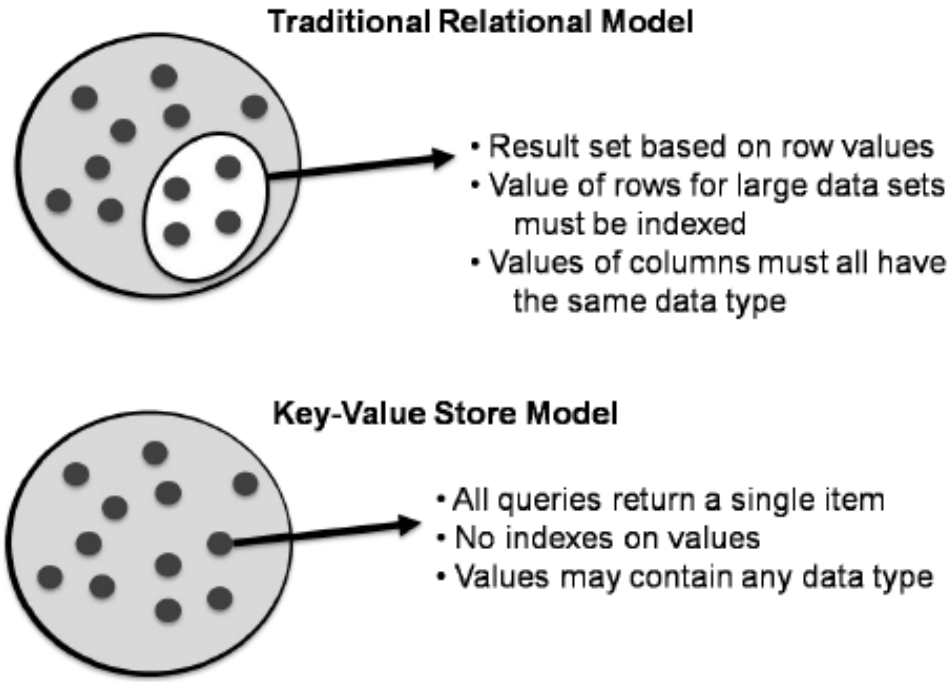


Key/value vs. table

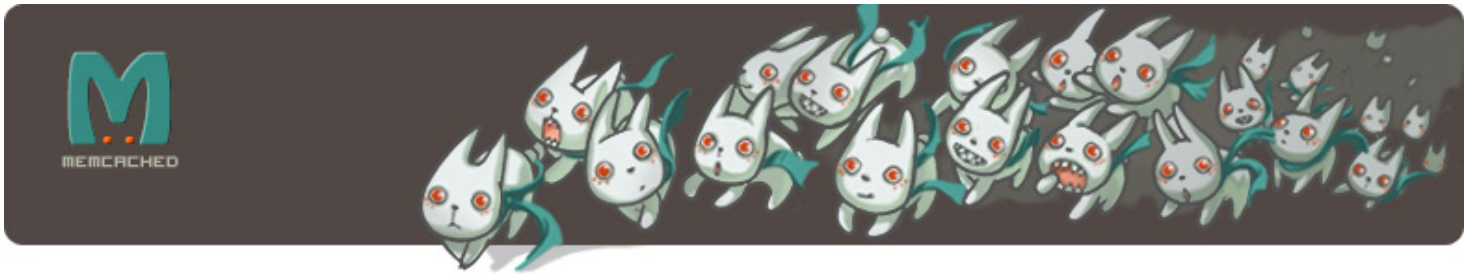
- A table with two columns and a simple interface
  - Add a key-value
  - For this key, give me the value
  - Delete a key



Key/value vs. Relational data model



Memcached



- Open source in-memory key-value caching system
- Make effective use of RAM on many distributed web servers
- Designed to speed up dynamic web applications by alleviating database load
  - Simple interface for highly distributed RAM caches
  - 30ms read times typical
- Designed for quick deployment, ease of development
- APIs in many languages

Redis

- Open source in-memory key-value store with optional durability
- Focus on high speed reads and writes of common data structures to RAM
- Allows simple lists, sets and hashes to be stored within the value and manipulated
- Many features that developers like expiration, transactions, pub/sub, partitioning

Amazon DynamoDB

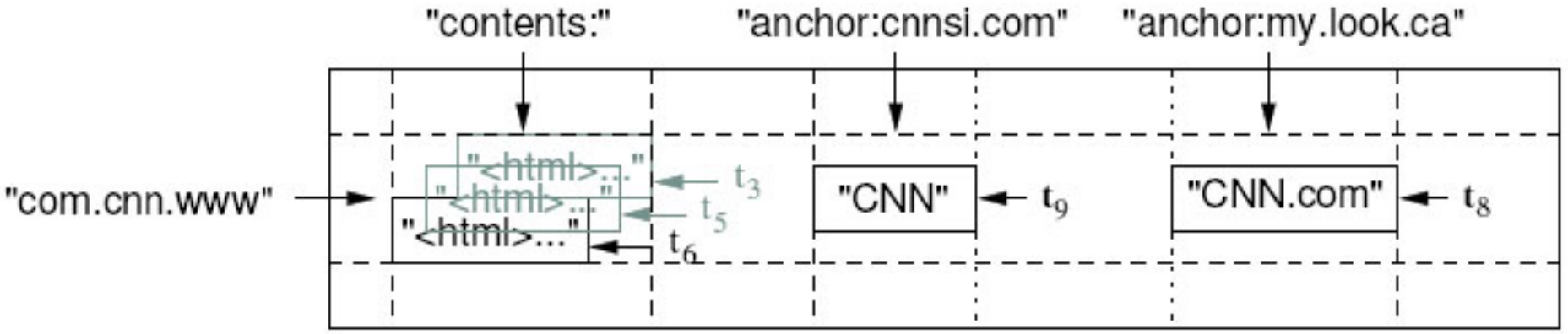
- Scalable key-value store
- Fastest growing product in Amazon's history
- Focus on throughput on storage and predictable read and write times
- Strong integration with S3 and Elastic MapReduce

Riak

- Open source distributed key-value store with support and commercial versions by Basho
- A "Dynamo-inspired" database
- Focus on availability, fault-tolerance, operational simplicity and scalability
- Support for replication and auto-sharding and rebalancing on failures
- Support for MapReduce, fulltext search and secondary indexes of value tags
- Written in ERLANG

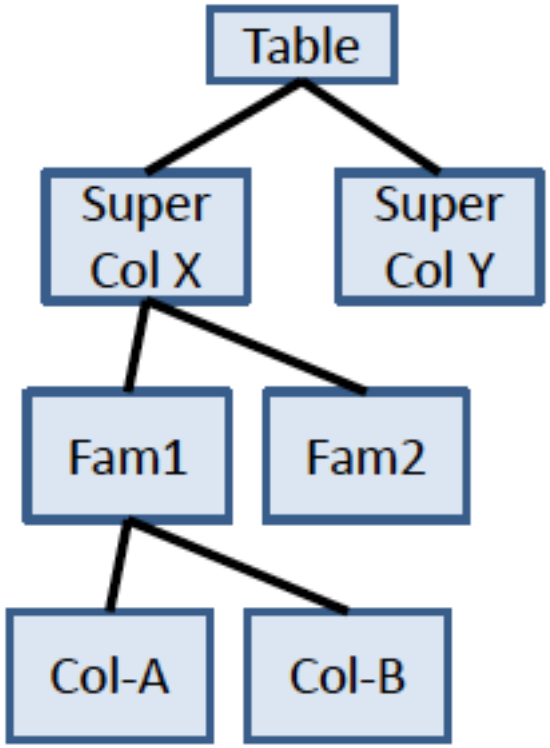
Column family store

- Dynamic schema, column-oriented data model
- Sparse, distributed persistent multi-dimensional sorted map
- (row, column (family), timestamp) -> cell contents



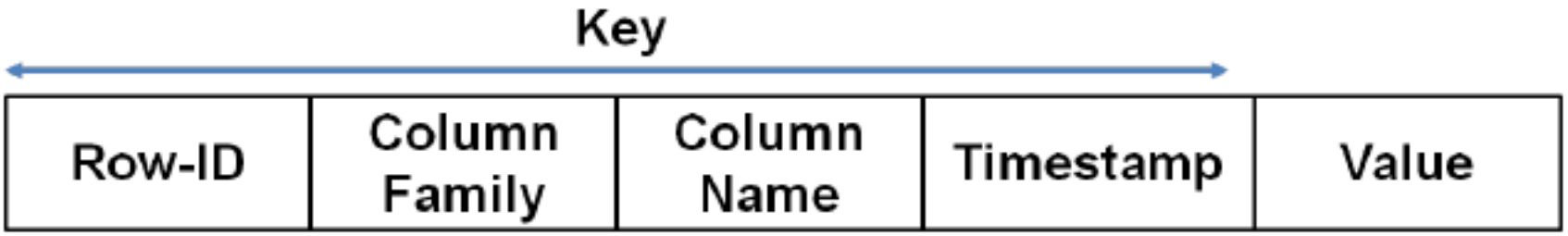
Column families

- Group columns into "Column families"
- Group column families into "Super-Columns"
- Be able to query all columns with a family or super family
- Similar data grouped together to improve speed



Column family data model vs. relational

- Sparse matrix, preserve table structure
  - One row could have millions of columns but can be very sparse
- Hybrid row/column stores
- Number of columns is extendible
  - New columns to be inserted without doing an "alter table"



Bigtable

- ACM TOCS 2008
- Fault-tolerant, persistent
- Scalable
  - Thousands of servers
  - Terabytes of in-memory data
  - Petabyte of disk-based data
  - Millions of reads/writes per second, efficient scans
- Self-managing
  - Servers can be added/removed dynamically
  - Servers adjust to load imbalance

Bigtable: A Distributed Storage System for Structured Data

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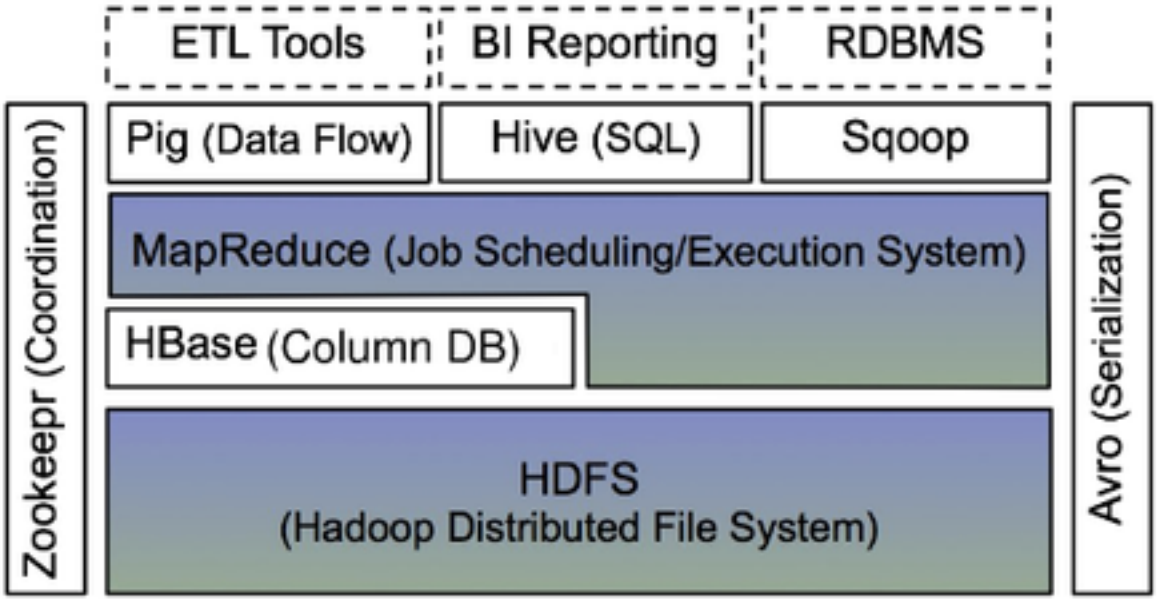
Apache Hbase

- Open-source Bigtable, written in JAVA
- Part of Apache Hadoop project

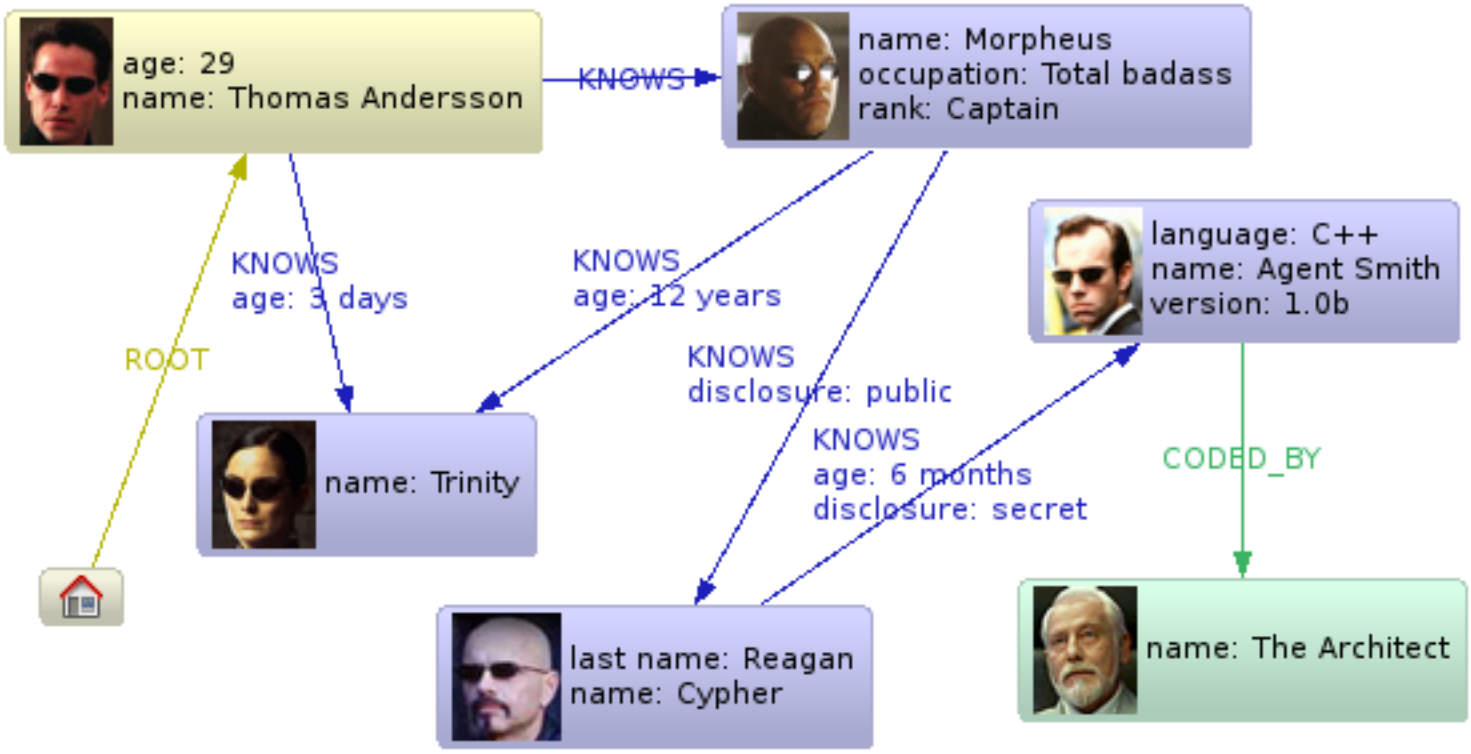


Apache Cassandra

- Apache open source column family database
- Supported by DataStax
- Peer-to-peer distribution model
- Strong reputation for linear scale out (millions of writes/second)
- Written in Java and works well with HDFS and MapReduce

Graph data model

- Core abstractions: Nodes, Relationships, Properties on both

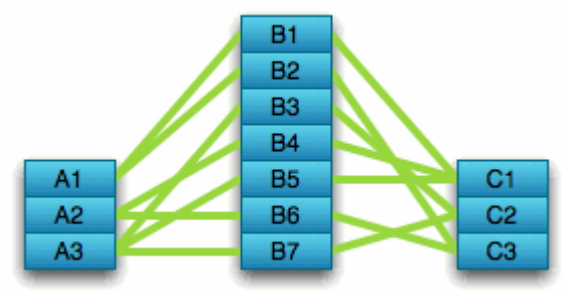


Graph database store

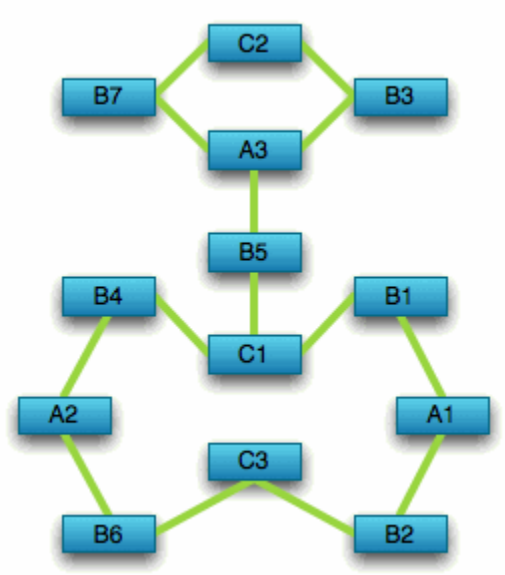
- A database stored data in an explicitly graph structure
- Each node knows its adjacent nodes
- Queries are really graph traversals

Compared to Relational Databases

Optimized for aggregation



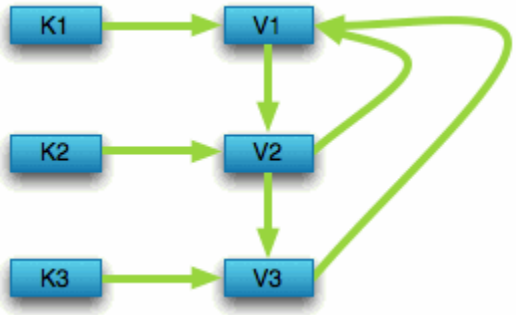
Optimized for connections



Compared to Key Value Stores

Optimized for simple look-ups

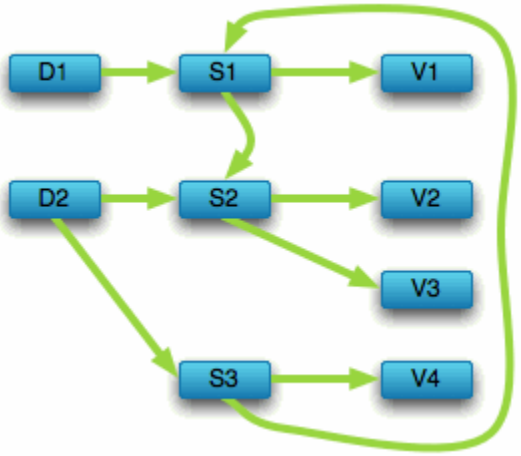
Optimized for traversing connected data



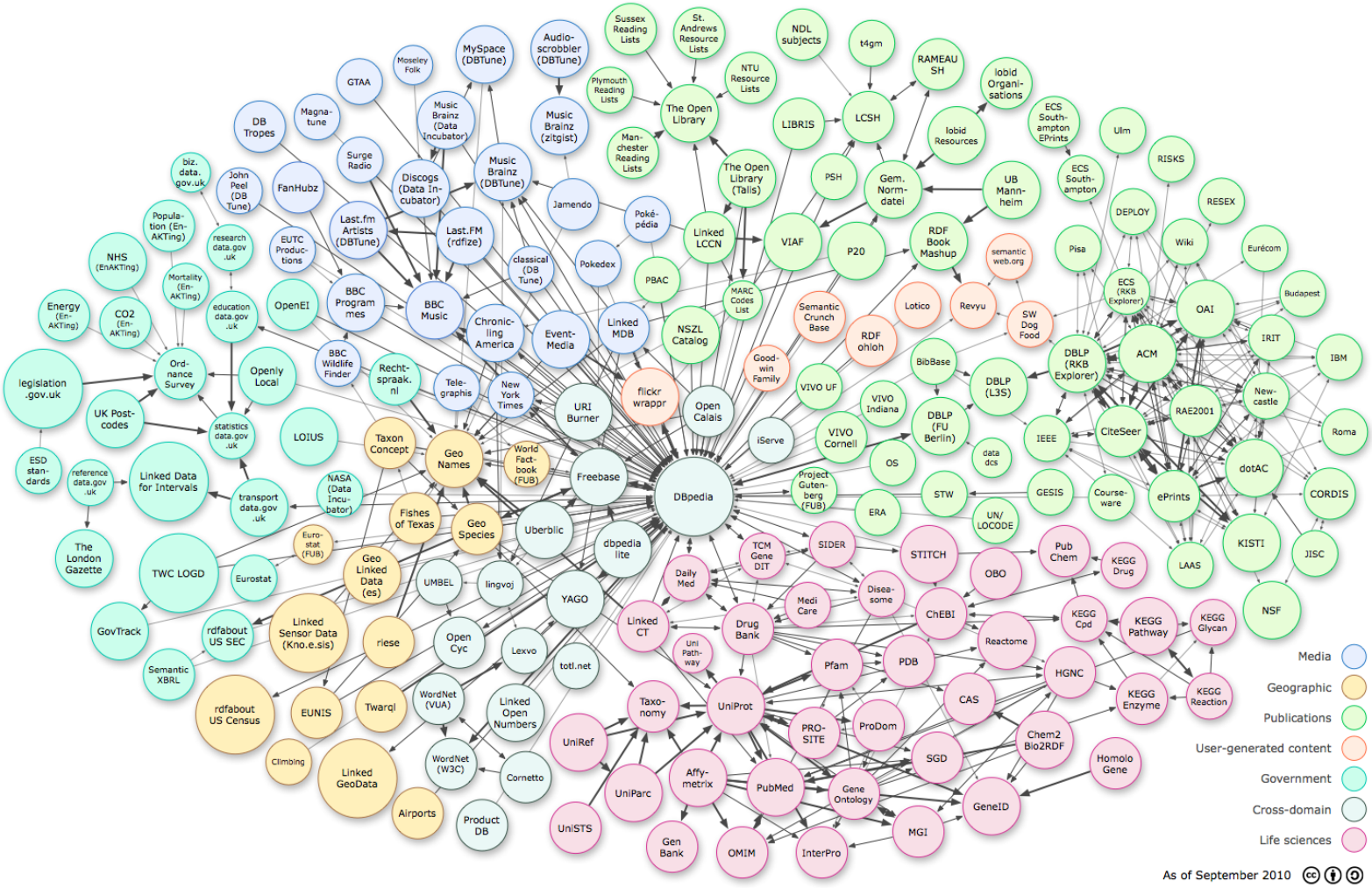
Compared to Document Stores

Optimized for “trees” of data

Optimized for seeing the forest and the trees, and the branches, and the trunks



Linking open data



Neo4j

- Graph database designed to be easy to use by Java developers
- Disk-based (not just RAM)
- Full ACID
- High Availability (with Enterprise Edition)
- 32 Billion Nodes, 32 Billion Relationships, 64 Billion Properties
- Embedded java library
- REST API

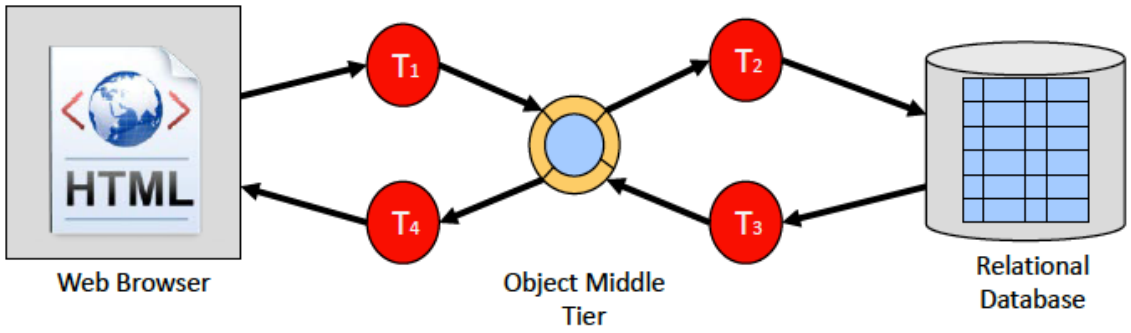
Document store

- Documents, not value, not tables
- JSON or XML formats
- Document is identified by ID
- Allow indexing on properties

```
{
  person: {
    first_name: "Peter",
    last_name: "Peterson",
    addresses: [
      {street: "123 Peter St"},
      {street: "504 Not Peter St"}
    ],
  }
}
```

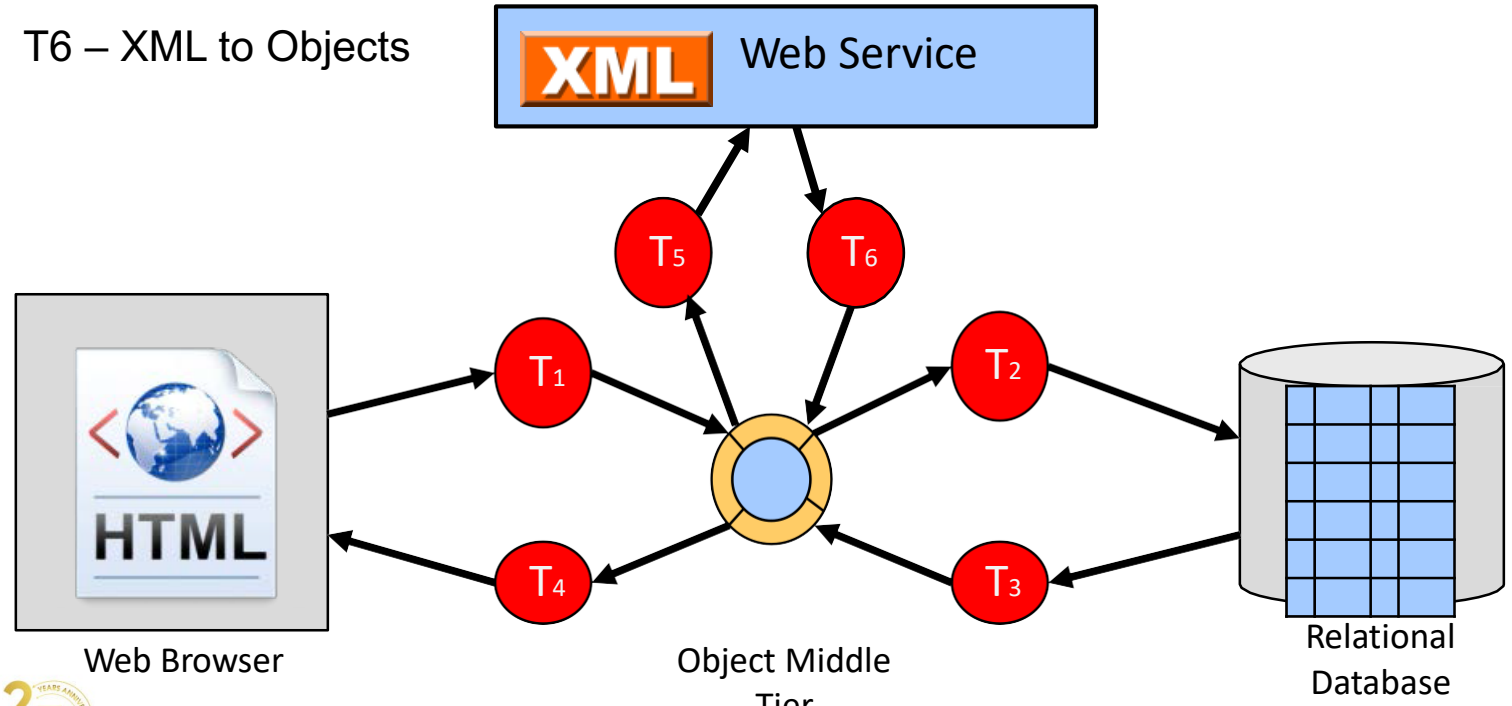
Relational data mapping

- T1–HTML into Objects
- T2–Objects into SQL Tables
- T3–Tables into Objects
- T4–Objects into HTML



Web Service in the middle

- T1 – HTML into Java Objects
- T2 – Java Objects into SQL Tables
- T3 – Tables into Objects
- T4 – Objects into HTML
- T5 – Objects to XML
- T6 – XML to Objects

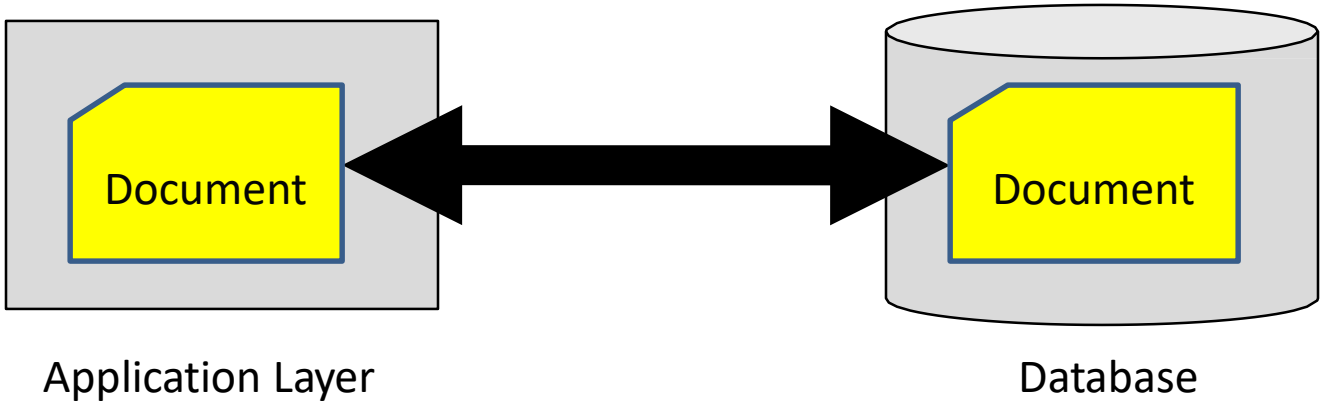


Discussion

- Object-relational mapping has become one of the most complex components of building applications today
  - Java Hibernate Framework
  - JPA
- To avoid complexity is to keep your architecture very simple

Document mapping

- Documents in the database
- Documents in the application
- No object middle tier
- No "shredding"
- No reassembly
- Simple!

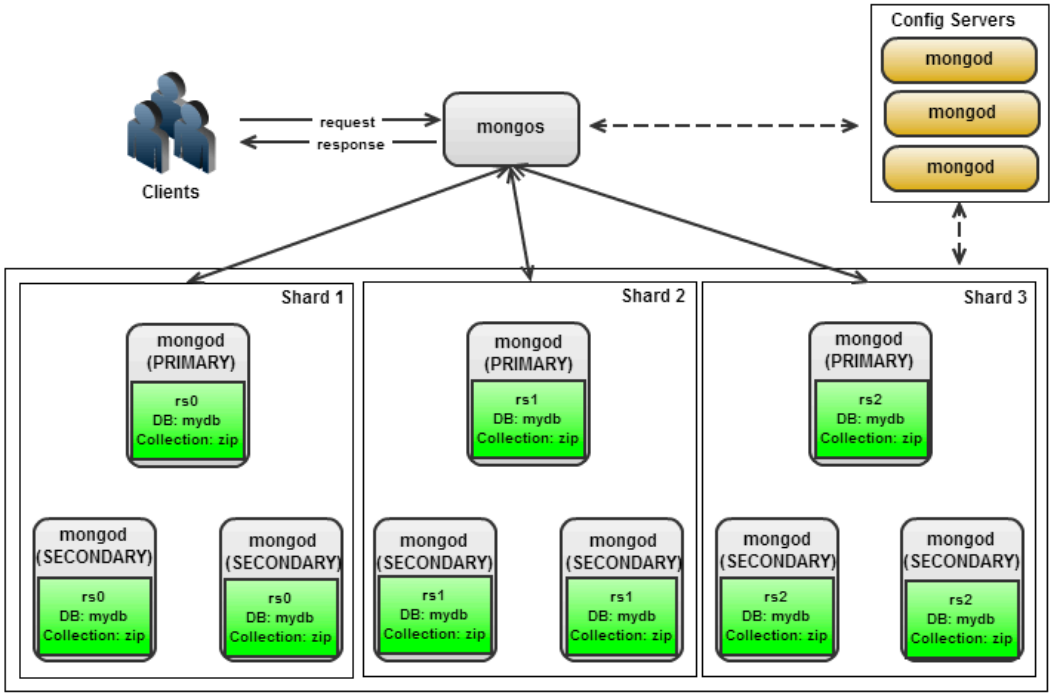


MongoDB

- Open Source JSON data store created by 10gen
- Master-slave scale out model
- Strong developer community
- Sharding built-in, automatic
- Implemented in C++ with many APIs (C++, JavaScript, Java, Perl, Python etc.)

MongoDB architecture

- Replica set
  - Copies of the data on each node
  - Data safety
  - High availability
  - Disaster recovery
  - Maintenance
  - Read scaling
- Sharding
  - “Partitions” of the data
  - Horizontal scale



Apache CouchDB

- Apache project
- Open source JSON data store
- Written in ERLANG
- RESTful JSON API
- B-Tree based indexing, shadowing b-tree versioning
- ACID fully supported
- View model
- Data compaction
- Security

References

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