

NoSQL & NewSQL

~~SQL~~

Overview

- NoSQL
- Transactions
- NewSQL

NoSQL

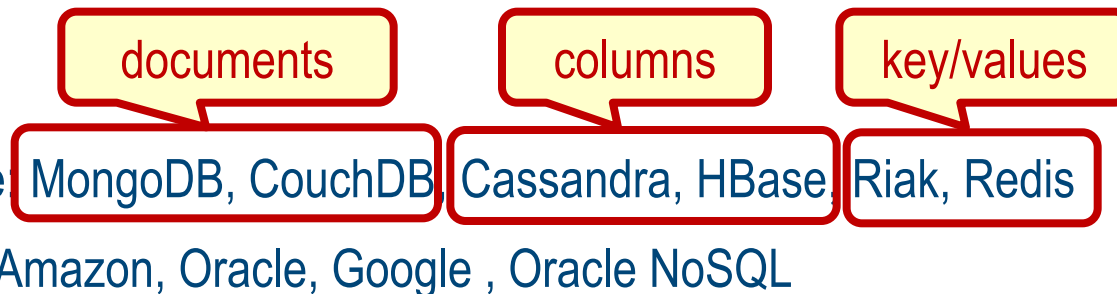
Performance Comparison

- On > 50 GB data:
- MySQL
 - Writes 300 ms avg
 - Reads 350 ms avg
- Cassandra
 - Writes 0.12 ms avg
 - Reads 15 ms avg

We Don't Want No SQL !

- NoSQL movement: SQL considered slow → only access by id („lookup“)
 - Deliberately abandoning relational world: „too complex“, „not scalable“
 - No clear definition, wide range of systems
 - Values considered black boxes (documents, images, ...)
 - simple operations (ex: key/value storage), horizontal scalability for those
 - ACID → CAP, „eventual consistency“

■ Systems



- See also: <http://glennas.wordpress.com/2011/03/11/introduction-to-nosql-john-nunemaker-presentation-from-june-2010/>

NoSQL

- Previous „young radicals“ approaches subsumed under „NoSQL“
- = we want „no SQL“
- Well..., „not only SQL“
 - After all, a QL is quite handy
 - So, QLs coming into play again (and 2-phase commits = ACID!)
- Ex: MongoDB: „tuple“ = JSON structure

```
db.inventory.find(  
  { type: 'food',  
    $or: [ { qty: { $gt: 100 } }, { price: { $lt: 9.95 } } ]  
  } )
```

Another View: Structural Variety in Big Data

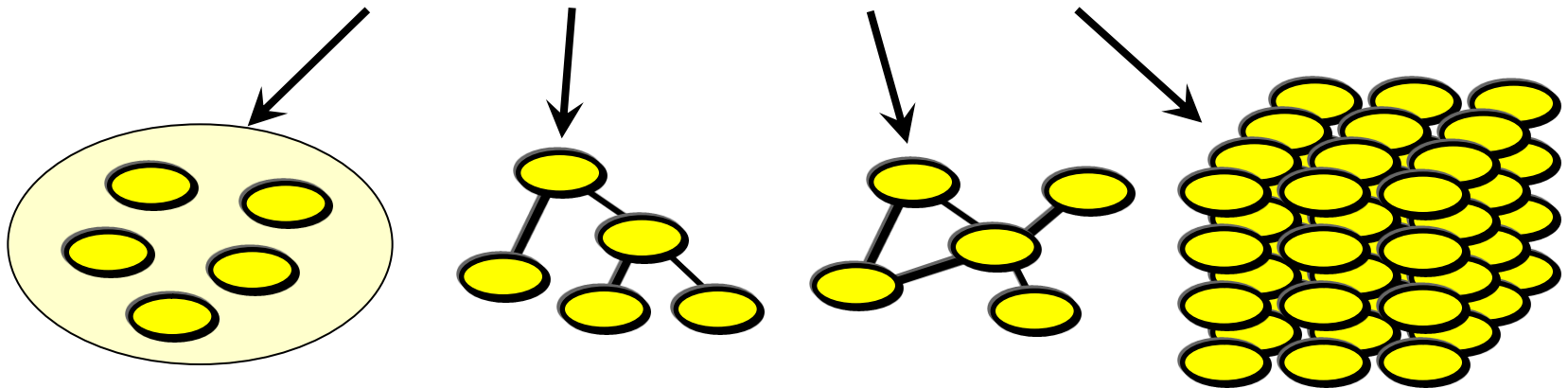
- Stock trading: 1-D sequences (i.e., **arrays**)
- Social networks: large, homogeneous **graphs**
- Ontologies: small, heterogeneous **graphs**
- Climate modelling: 4D/5D **arrays**
- Satellite imagery: 2D/3D **arrays** (+irregularity)
- Genome: long string **arrays**
- Particle physics: **sets** of events
- Bio taxonomies: **hierarchies** (such as XML)
- Documents: key/value stores = **sets** of unique identifiers + whatever
- etc.

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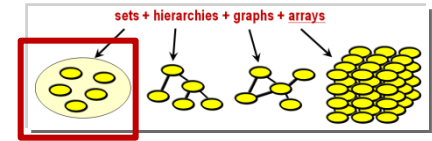
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Structural Variety in [Big] Data

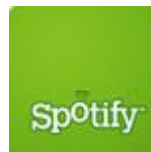
sets + hierarchies + graphs + arrays



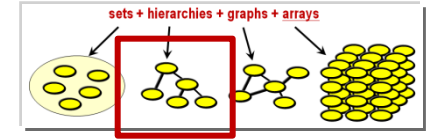
Ex 1: Key/Value Store



- Conceptual model: key/value store = **set of key+value**
 - Operations: *Put(key,value)*, *value = Get(key)*
 - → large, distributed **hash table**
- Needed for:
 - twitter.com: tweet id -> information about tweet
 - kayak.com: Flight number -> information about flight, e.g., availability
 - amazon.com: item number -> information about it
- Ex: Cassandra (Facebook; open source)
 - Myriads of users, like:



Ex 2: Document Stores

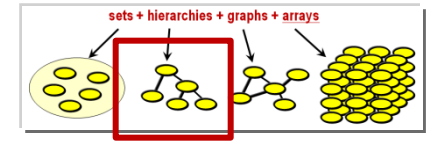


- Like key/value, but value is a **complex document**
 - Data model: set of nested records
- Added: **Search** functionality within document
 - Full-text search: Lucene/Solr, ElasticSearch, ...
- Application: content-oriented applications
 - Facebook, Amazon, ...
- Ex: MongoDB, CouchDB

```
db.inventory.find( { $or: [ { status: "A" }, { qty: { $lt: 30 } } ] } )
```

```
SELECT * FROM inventory WHERE status = "A" AND qty < 30
```

Ex 3: Hierarchical Data



```
<?xml version="1.0" encoding="UTF-8"?>

<bookstore>

<book category="COOKING">
  <title lang="en">Everyday Italian</title>
  <author>Giada De Laurentiis</author>
  <year>2005</year>
  <price>30.00</price>
</book>

<book category="CHILDREN">
  <title lang="en">Harry Potter</title>
  <author>J K. Rowling</author>
  <year>2005</year>
  <price>29.99</price>
</book>

<book category="WEB">
  <title lang="en">XQuery Kick Start</title>
  <author>James McGovern</author>
  <author>Per Bothner</author>
  <author>Kurt Cagle</author>
  <author>James Linn</author>
  <author>Vaidyanathan Nagarajan</author>
  <year>2003</year>
  <price>49.99</price>
</book>

<book category="WEB">
  <title lang="en">Learning XML</title>
  <author>Erik T. Ray</author>
  <year>2003</year>
  <price>39.95</price>
</book>

</bookstore>
```

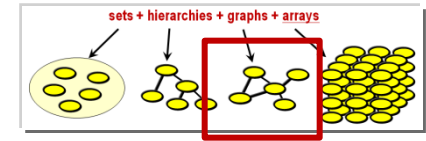
- Disclaimer: long before NoSQL!

`doc("books.xml") /bookstore/book/title`

`doc("books.xml") /bookstore/book[price<30]`

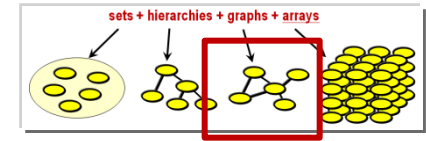
- Later more, time permitting!

Ex 4: Graph Store

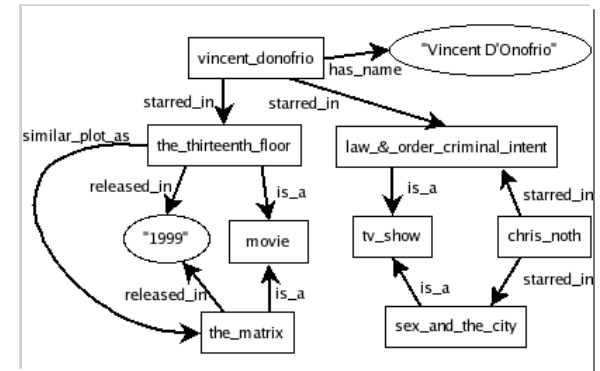


- Conceptual model: Labeled, directed, attributed graph
- Why not relational DB? can model graphs!
 - but “endpoints of an edge” already requires join
 - No support for global ops like transitive hull
- Main cases:
 - Small, heterogeneous graphs
 - Large, homogeneous graphs

Ex 4a: RDF & SPARQL



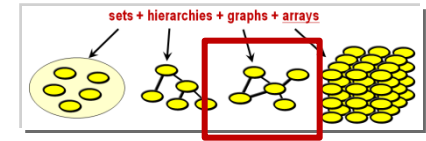
- Situation: **Small, heterogeneous** graphs
- Use cases: ontologies, knowledge graphs, Semantic Web
- Model:
 - Data model: graphs as triples
 - RDF (Resource Data Framework)
 - Query model: patterns on triples
 - SPARQL (see later, time permitting)



```

PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name ?mbox
WHERE
{
    ?x foaf:name ?name .
    ?x foaf:mbox ?mbox
}
  
```

Ex 4b: Graph Databases

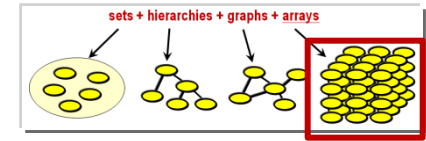


- Situation: **Large, homogeneous** graphs
- Use cases: Social Networks
- Common queries:
 - *My friends*
 - *who has no / many followers*
 - *closed communities*
 - *new agglomerations,*
 - *new themes, ...*
- Sample system: Neo4j with QL Cypher



```
MATCH (:Person {name: 'Jennifer'})-[:WORKS_FOR]->(company:Company)
RETURN company.name
```

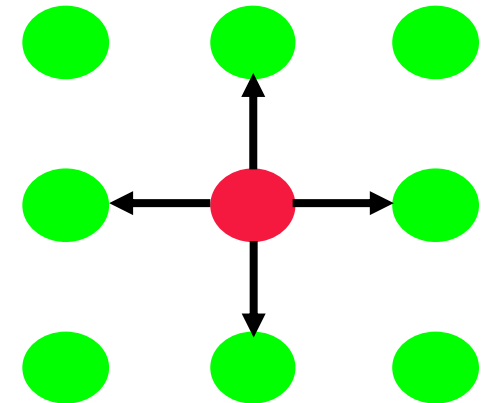
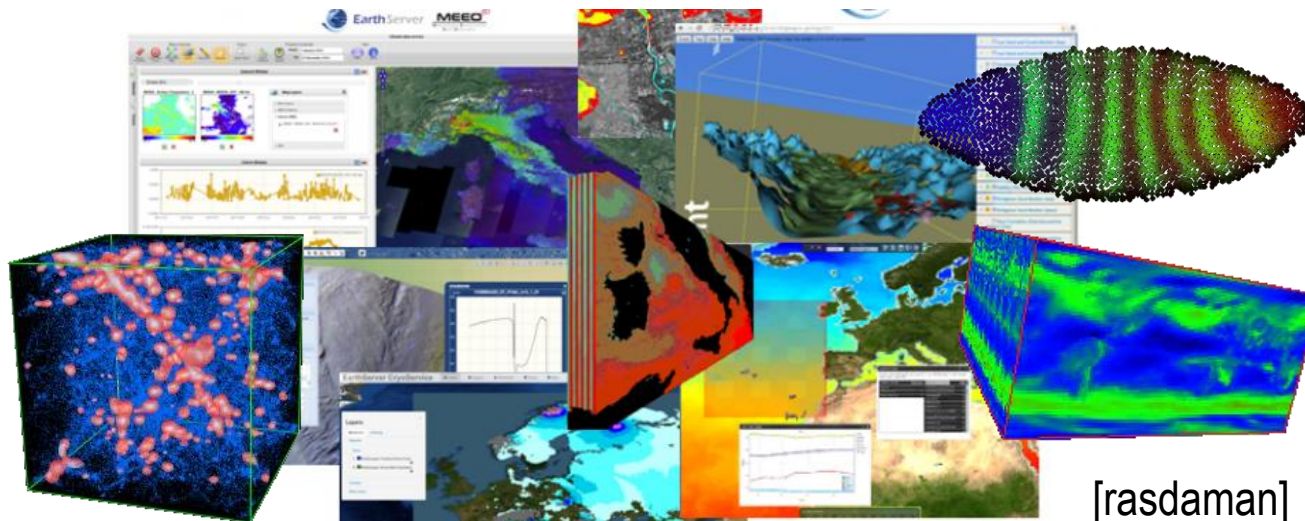
Ex 5: Array Analytics



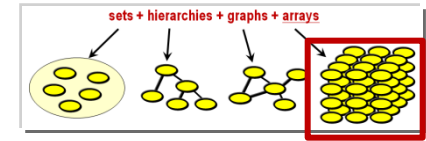
- **Array Analytics** :=
Efficient analysis on multi-dimensional arrays of a size several orders of magnitude above the evaluation engine's main memory

sensor, image [timeseries],
simulation, statistics data

- Essential property: n -D Cartesian neighborhood



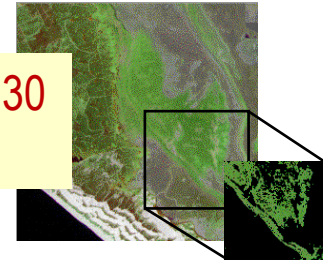
Ex 5: Array Databases



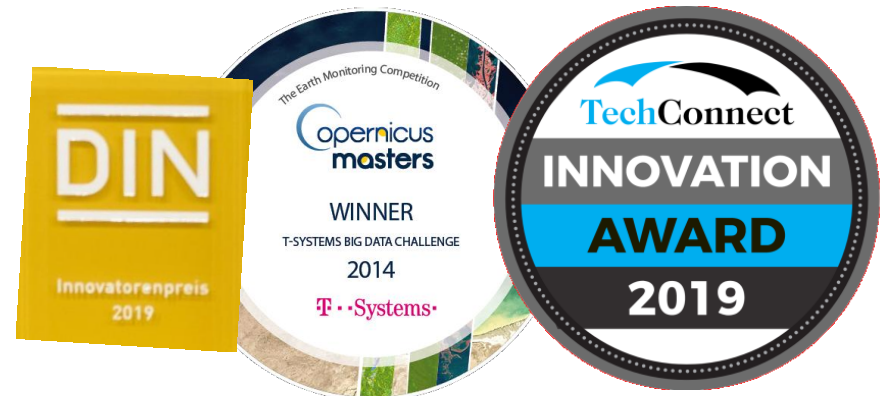
- Ex: **rasdaman** = **Array DBMS**

- Data model: n-D arrays as attributes
- Query model: Tensor Algebra
- Demo at <http://standards.rasdaman.org>

```
select img.raster[x0:x1,y0:y1] > 130
from LandsatArchive as img
```



- Multi-core, distributed, platform for EarthServer (<https://earthserver.xyz>)
- Relational? „Array DBMSs can be 200x RDBMS“ [Cudre-Maroux]



Transactions

No More ACID

- RDBMS provide ACID...locally
- Close to impossible to achieve in distributed situations
- Instead: **BASE**
 - Basically Available Soft-state Eventual Consistency
 - Prefers availability over consistency
- Ex: Cassandra

Outlook: ACID vs BASE

- **BASE** = Basically Available Soft-state Eventual Consistency
 - availability over consistency, relaxing ACID
 - ACID model promotes consistency over availability, BASE promotes availability over consistency
- Comparison:
 - Traditional RDBMSs: Strong consistency over availability under a partition
 - Cassandra: Eventual (weak) consistency, availability, partition-tolerance
- **CAP Theorem** [proposed: Eric Brewer; proven: Gilbert & Lynch]:
In a distributed system you can satisfy at most 2 out of the 3 guarantees
 - **Consistency**: all nodes have same data at any time
 - **Availability**: system allows operations all the time
 - **Partition-tolerance**: system continues to work in spite of network partitions

Discussion: ACID vs BASE

- Justin Sheely: “eventual consistency in well-designed systems does not lead to inconsistency”
- Daniel Abadi: “If your database only guarantees eventual consistency, you have to make sure your application is well-designed to resolve all consistency conflicts. [...] Application code has to be smart enough to deal with any possible kind of conflict, and resolve them correctly”
 - Sometimes simple policies like “last update wins” sufficient
 - other apps far more complicated, can lead to errors and security flaws
 - Ex: ATM heist with 60s window
 - DB with stronger guarantees greatly simplifies application design

CAP Theorem

- Proposed by Eric Brewer, UCB; subsequently proved by Gilbert & Lynch
- In a distributed system you can satisfy at most 2 out of the 3 guarantees
 - **Consistency**: all nodes have same data at any time
 - **Availability**: system allows operations all the time
 - **Partition-tolerance**: system continues to work in spite of network partitions
- Traditional RDBMSs
 - Strong consistency over availability under a partition
- Cassandra
 - Eventual (weak) consistency, Availability, Partition-tolerance

NewSQL

NewSQL: *The Empire Strikes Back*

- Michael Stonebraker: „*no one size fits all*“
- NoSQL: sacrificing functionality for performance – no QL, only key access
 - Single round trip fast, complex real-world problems slow
- Swinging back from NoSQL:
declarative QLs considered good (again), but SQL often inadequate
- Definition 1: NewSQL = SQL with **enhanced performance** architectures
- Definition 2: NewSQL = SQL enhanced with, eg, **new data types**
 - Some call this NoSQL

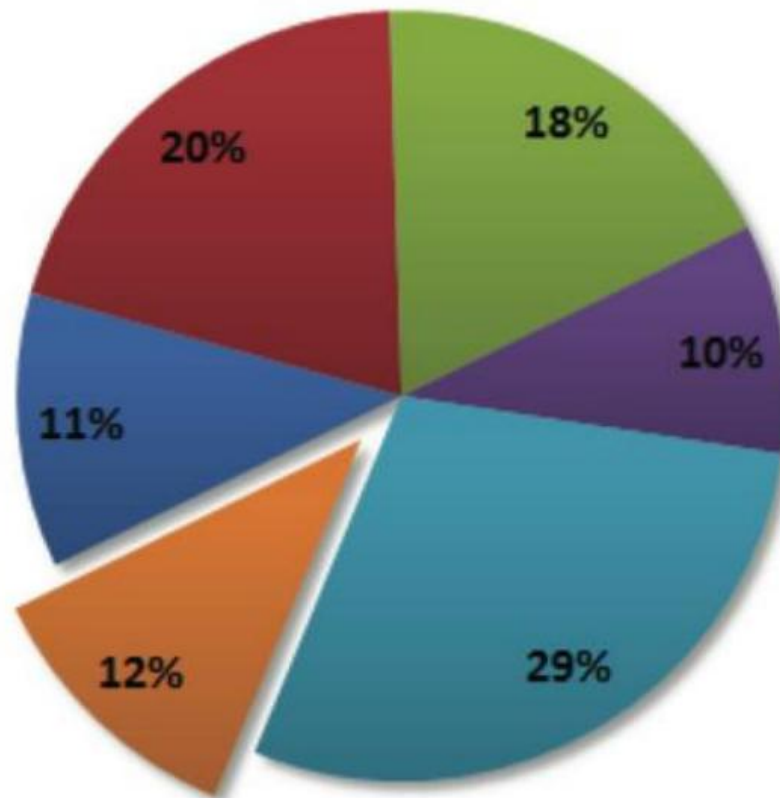
What Makes an RDBMS Slow?

General Purpose RDBMS Processing Profile

OLTP Through the Looking Glass, and What We Found There

Stavros Harizopoulos, Daniel Abadi, Samuel Madden, and Michael Stonebraker
ACM SIGMOD 2008.

- Index Management
- Logging
- Locking
- Latching
- Buffer Management
- Useful Work

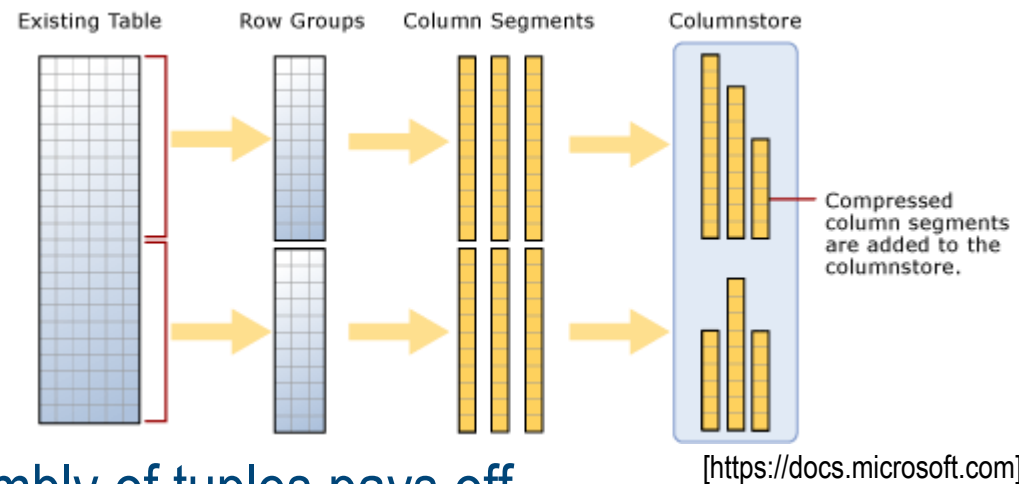


Column-Store Databases

- Observation: fetching long tuples overhead when few attributes needed
- Brute-force decomposition: one value (plus key)

- Ex: Id+SNLRH → Id+S, Id+N, Id+L, Id+R, Id+H

- Column-oriented storage:
each binary table separate file



- With clever architecture, reassembly of tuples pays off
 - system keys, contiguous, not materialized, compression, MMIO, ...

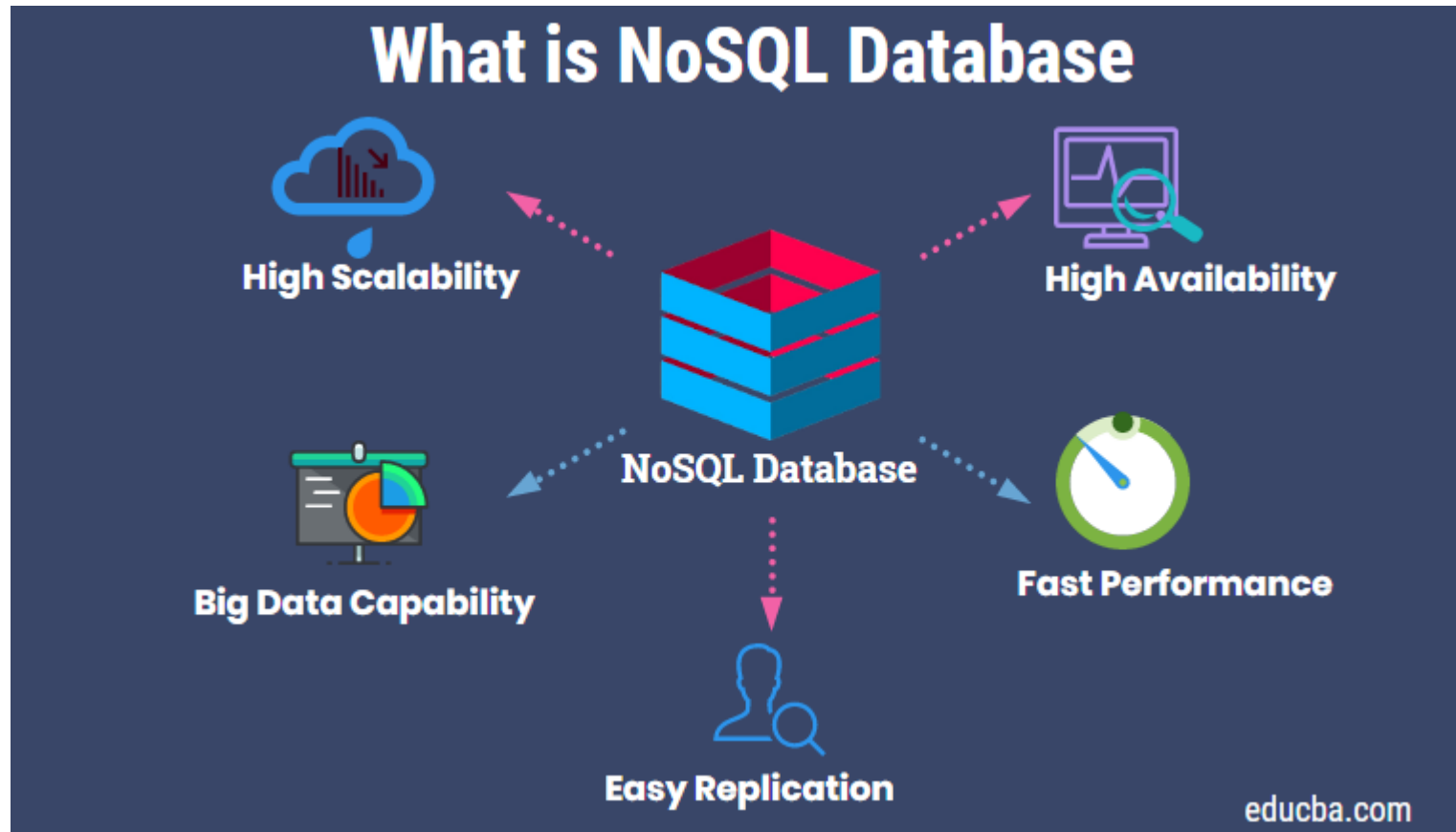
- Sample systems: MonetDB, Vertica, SAP HANA

Main-Memory Databases

- RAM faster than disk → load data into RAM, process there
 - Multi-TB RAM
 - CPU, GPU, ...
- Largely giving up ACID's Durability → different approaches
 - Snapshots, transaction logging, non-volatile RAM (battery!), replication, ...
- Sample systems:
 - ArangoDB, HSQLDB, MonetDB, SAP HANA, VoltDB, Oracle TimesTen, ...

Summary

Assessment: A NoSQL View on NoSQL



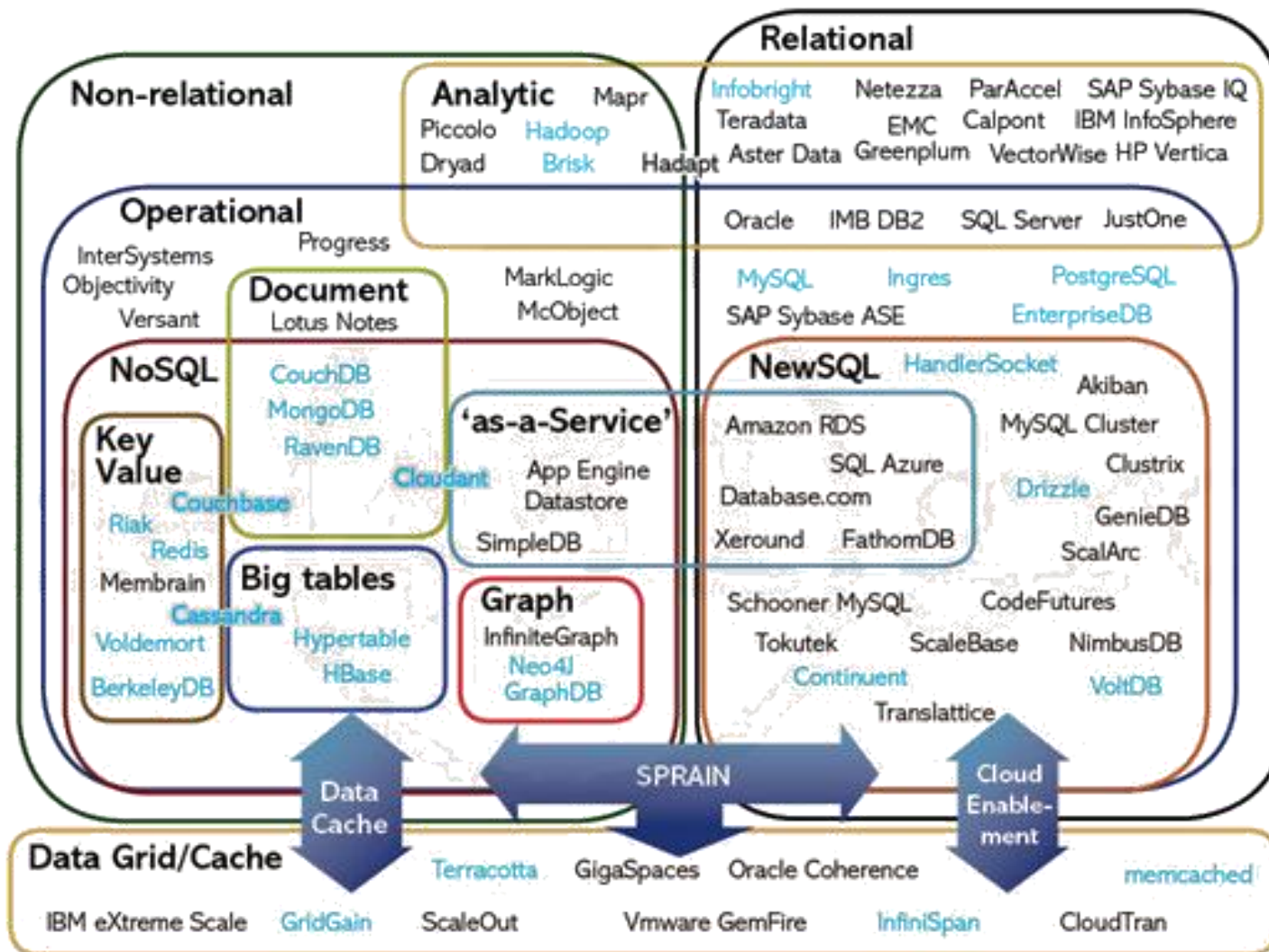
Ex: Common NoSQL Misconception

- “NoSQL virtually can store any kind of data whether it’s structured or unstructured. It can store text, audio, video, graphics or any kind of files.”
- ...no better than a file system.
- Ever heard of BLOBs in RDBMSs?
- NoSQL can answer question...on metadata. Just like any RDBMS.
- No QL support for these data types: cannot ask for
 - „audio containing music in minor?“
 - „someone saying yes my dear?“
 - „hate speech?“

Top 10 NoSQL Databases in 2022



The Explosion of DBMSs

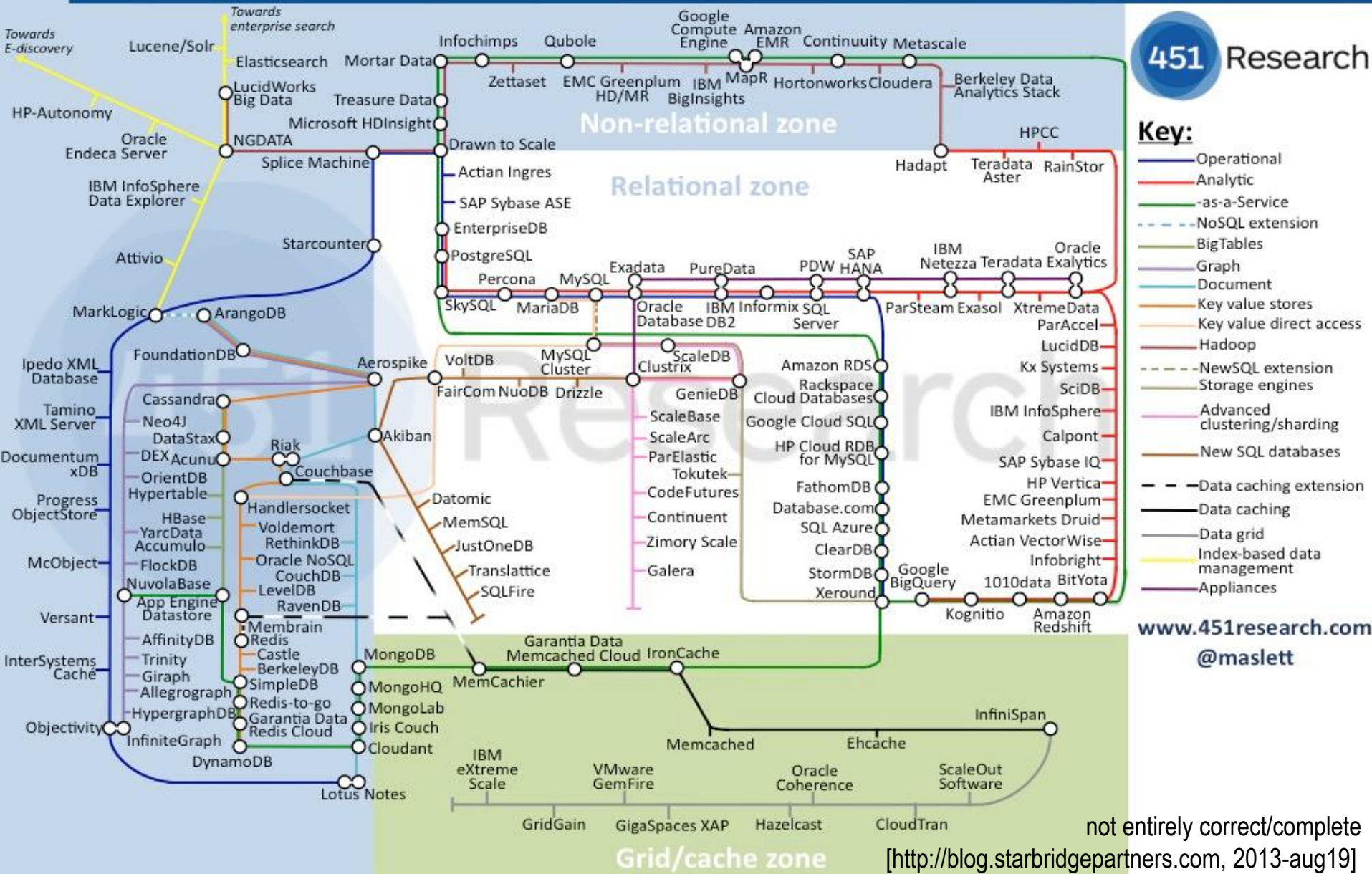


[451 group]

...not
entirely correct

Database Landscape Map – December 2012

451 Research



Summary & Outlook

- Fresh approach to scalable data services: NoSQL, NewSQL
 - Diversity of technology → pick best of breed for specific problem
- The future:
 - Avenue 1: **Modular data frameworks** to coexist - Heterogeneous model coupling barely understood - needs research
 - Avenue 2: concepts **assimilated by relational vendors** - Like fulltext, object-oriented, SPARQL, ... cf „Oracle NoSQL“
 - “SQL-as-a-service”: Amazon RDS, Microsoft SQL Azure, Google Cloud SQL
- Caveat: NoSQL **not interoperable**, „vendor“ lock-in