Database Systems Evolution

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Outline

- Why do we need storage system
- How they evolved along the time
- Milestone solutions
- Current landscape

Thinking about Data Systems

- Many applications today are **data-intensive**, as opposed to **compute-intensive**.
- Raw CPU power is rarely a limiting factor for these applications
  - bigger problems are usually the **amount** of data, the **complexity** of data, and the **speed** at which it is changing.

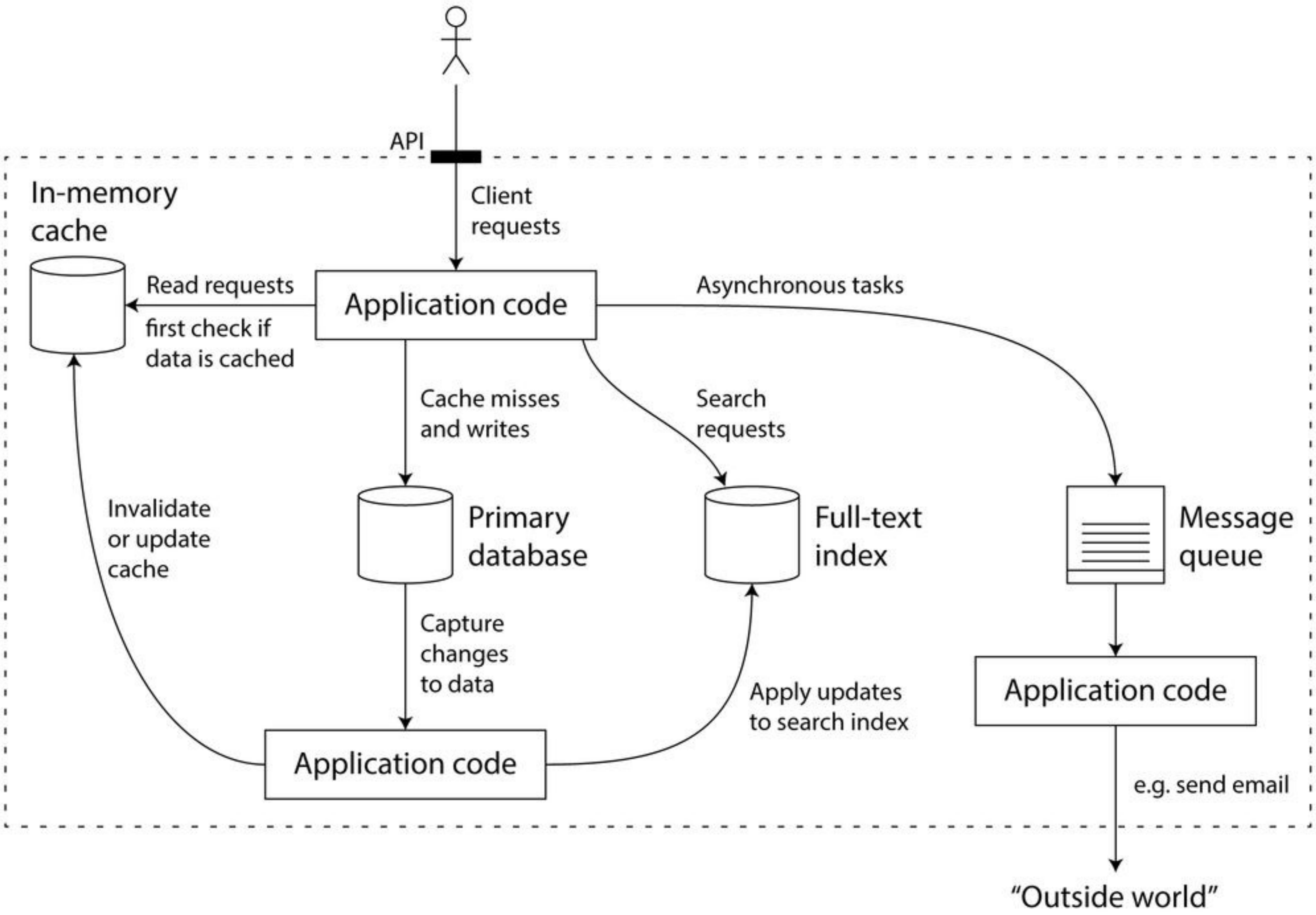
Data systems typically needs to

- Store data so that they, or another application, can find it again later (**databases**).
- Remember the result of an expensive operation, to speed up reads (**caches**).
- Allow users to search data by keyword or filter it in various ways (**search indexes**).
- Send a message to another process, to be handled asynchronously (**message queues**).
- Observe what is happening, and act on events as they occur (**stream processing**).
- Periodically crunch a large amount of accumulated data (**batch processing**).

Thinking about Data Systems

- Increasingly, many applications have wide-ranging requirements
  - Many times, a single tool can no longer meet all of its data processing and storage needs.
- Instead, the work is broken down into tasks that can be performed efficiently on a single tool,
  - the different tools are stitched together using application code.
- For example, we may have an application with:
  - a caching layer (e.g. memcached or similar),
  - a full-text search server (e.g. Elasticsearch or Solr),
  - separated from the main database (e.g. MySQL).

Thinking about Data Systems



Data Systems – some challenges

- How do you ensure that the data remains correct and complete,
  - even when things go wrong internally?
- How do you provide consistently good performance to clients,
  - even when parts of your system are degraded?
- How do you scale to handle an increase in load?
- What does a good API for the service look like?

Data Systems – some requirements

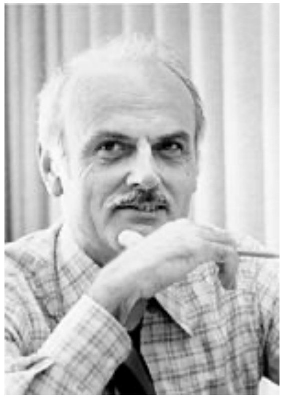
- **Reliability**: The system should continue performing the correct function at the desired performance,
  - even in the face of adversity (hardware or software faults, and even human error).
- **Scalability**: As the system grows (in data volume, traffic volume or complexity), there should be reasonable ways of dealing with that growth.
- **Maintainability**: Over time, many different people should all be able to work on it productively,
  - Engineering and operations, both maintaining current behavior and adapting the system to new use cases.

Database Systems

- A "database" is normally referred as a **set of related data** and its **organization**.
- A "database management system" (**DBMS**) controls the access to this data.
  - Providing functions that allow writing, searching, updating, retrieving, and removing large quantities of information.

Brief History of Database Systems

- Pre-relational era (1970’s)
  - Hierarchical (IMS), Network (Codasyl)
  - Many database systems
    - Complex data structures and low-level query language
    - Incompatible, exposing many implementation details
- **Relational DBMSs** (1980s)
  - Edgar F. Codd's relational model in 1970
  - Powerful high-level query language
  - A few major DB systems dominated the market



- Object-Oriented DBMSs (1990s)
  - Motivated by “mismatch” between RDBMS and OO PL
  - Persistent types in C++, Java or Small Talk
  - Issues: Lack of high level QL, no standards, performance

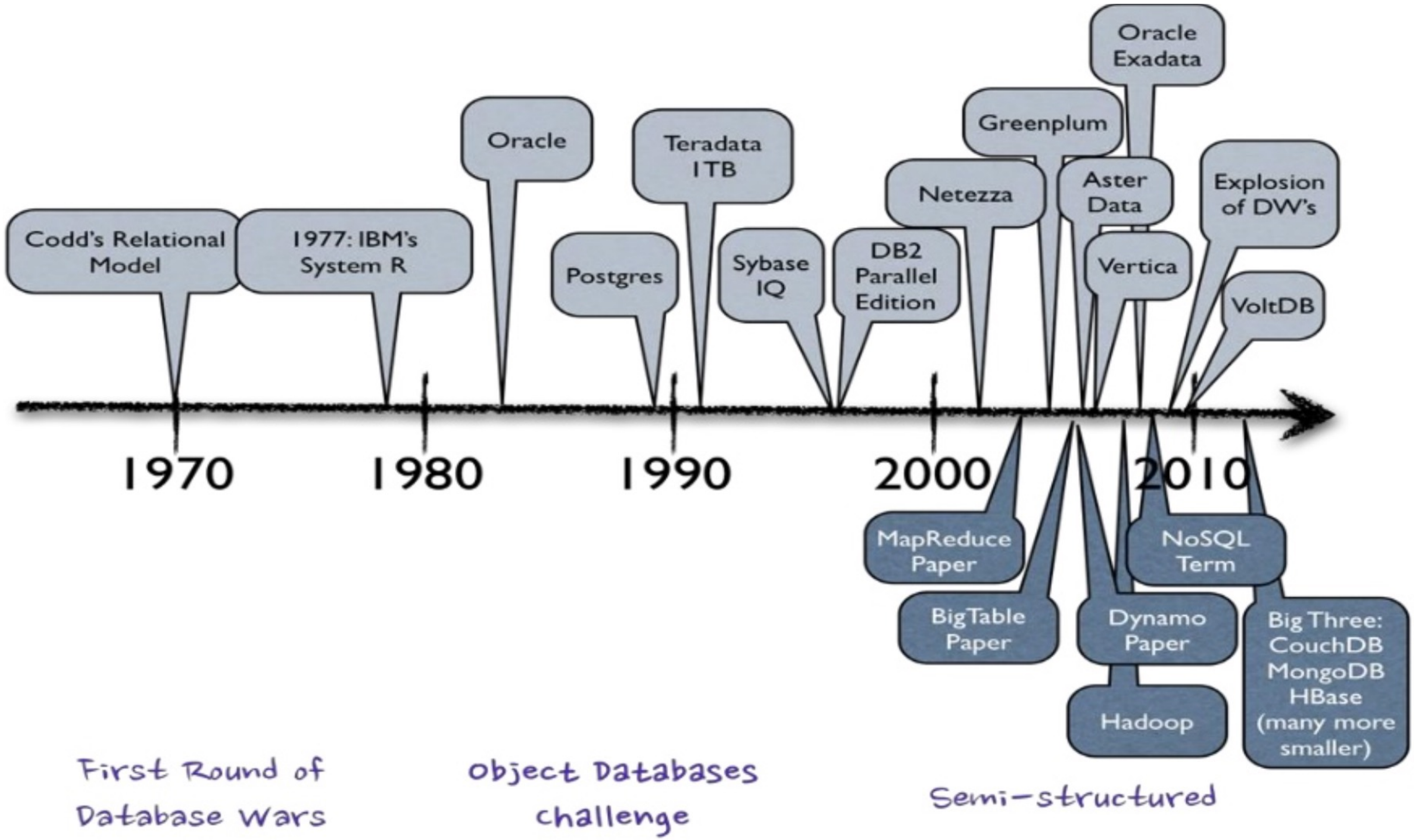
Brief History of Database Systems

- Object-relational DBMS (OR-DBMS) (1990s)
  - Relational DBMS vendors' answer to OO
  - User-defined types, functions (spatial, multimedia) Nested tables
  - SQL: 1999 (2003) standards. Plus performance.
- XML/DBMS (2000s)
  - Web and XML are merging
  - Native support of XML through ORDBMS extension or native XML DBMS
- Data analytics system (DSS) (2000s)
  - **Data warehousing and OLAP**

Brief History of Database Systems

- Data stream management systems (2000s)
  - Continuous query against data streams
- The era of big data (mid 2000-now):
  - **Big data**: datasets that grow so large (terabytes to petabytes) that they become awkward to work with traditional DBMS
  - Parallel DBMSs continue to push the scale of data
  - **MapReduce** dominates on Web data analysis
  - **NoSQL** (not only SQL) is fast growing

Database Evolution Timeline



"Big data – an introduction", Peter Morgan

Database Systems Landscape

ORACLE

Microsoft SQL Server

SYBASE

PostgreSQL

DB2

TERADATA

amazon DynamoDB

MySQL

Redis

OrientDB

mongoDB

riak

MEMCACHED

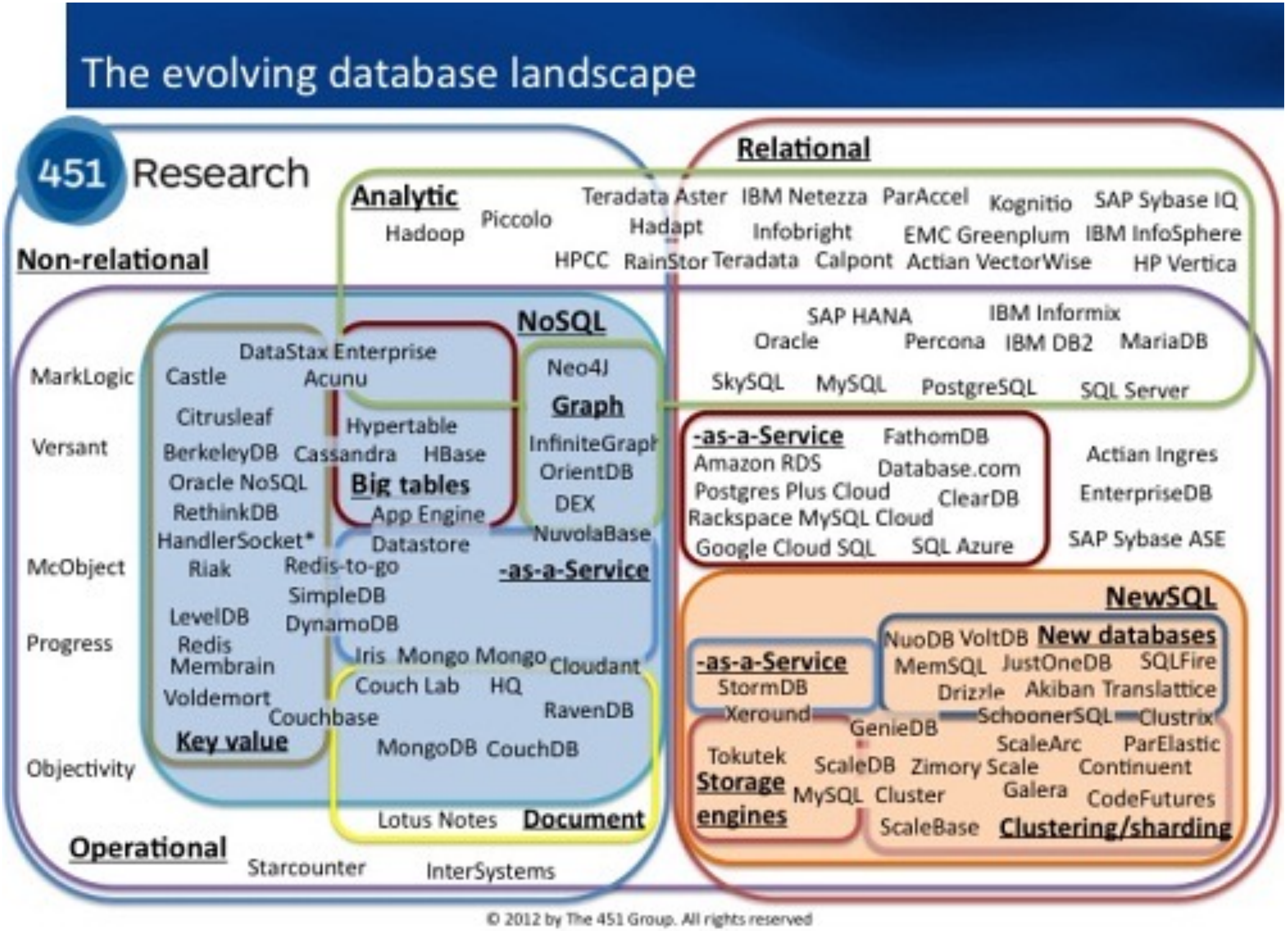
Cassandra

HBASE

CouchDB relax

Neo4j

Database Systems Landscape



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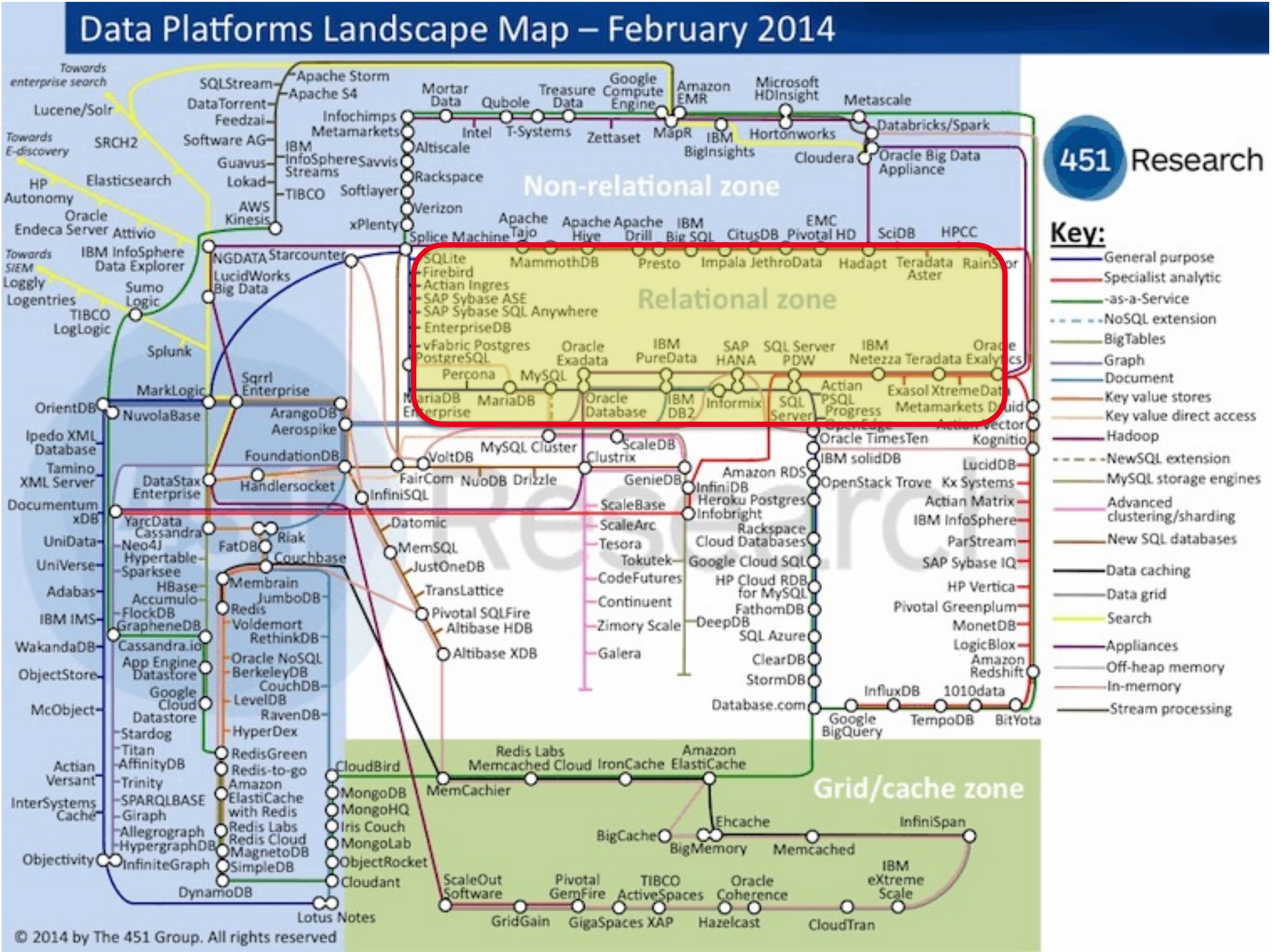
Data Platforms Landscape Map – February 2014
451 Research
Non-relational zone
Relational zone
Grid/cache zone
Towards enterprise search
Lucene/Solr
Towards E-discovery
SRCH2
HP Autonomy
Elasticsearch
Oracle Endeca Server
Attivio
Towards SIEM
IBM InfoSphere Data Explorer
Loggly
Logentries
Sumo Logic
TIBCO LogLogic
Splunk
SQLStream
DataTorrent
Feedzai
Software AG
Guavus
Lokad
AWS Kinesis
Apache Storm
Apache S4
IBM InfoSphere Streams
TIBCO
Infochimps
Metamarkets
Savvis
Softlayer
xPlenty
Mortar Data
Qubole
Intel
T-Systems
Treasure Data
Google Compute Engine
Zettaset
MapR
Amazon EMR
IBM BigInsights
Microsoft HDInsight
Hortonworks
Cloudera
Metascale
Databricks/Spark
Oracle Big Data Appliance
Altiscale
Rackspace
Verizon
Splice Machine
Apache Tajo
Apache Hive
Apache Drill
IBM Big SQL
CitusDB
EMC Pivotal HD
SciDB
HPCC
NGDATA
Starcounter
LucidWorks Big Data
SQLite
Firebird
Actian Ingres
SAP Sybase ASE
SAP Sybase SQL Anywhere
EnterpriseDB
vFabric Postgres
PostgreSQL
MammothDB
Presto
Impala
JethroData
Hadapt
Teradata Aster
RainStor
Oracle Exadata
IBM PureData
SAP HANA
SQL Server PDW
IBM Netezza
Teradata
Oracle Exalytics
Percona
MySQL
MariaDB Enterprise
MariaDB
Oracle Database
IBM DB2
Informix
SQL Server
Actian PSQL
Progress
OpenEdge
Exasol
XtremeData
Metamarkets Druid
Actian Vector
Kognitio
Sqrrl Enterprise
MarkLogic
OrientDB
NuvolaBase
ArangoDB
Aerospike
FoundationDB
Ipedo XML Database
Tamino XML Server
DataStax Enterprise
Handlersocket
Documentum xDB
YarcData
Cassandra
Neo4J
Hypertable
Sparksee
HBase
Accumulo
FlockDB
GrapheneDB
UniData
UniVerse
Adabas
IBM IMS
WakandaDB
ObjectStore
McObject
Cassandra.io
App Engine Datastore
Google Cloud Datastore
Stardog
Titan
AffinityDB
Trinity
SPARQLBASE
Giraph
Allegrograph
HypergraphDB
InfiniteGraph
Actian Versant
InterSystems Cache
Objectivity
DynamoDB
Lotus Notes
Riak
FatDB
Couchbase
Membrain
JumboDB
Redis
Voldemort
RethinkDB
Oracle NoSQL
BerkeleyDB
CouchDB
LevelDB
RavenDB
HyperDex
RedisGreen
Redis-to-go
Amazon ElastiCache with Redis
Redis Labs Redis Cloud
MagnetoDB
SimpleDB
CloudBird
MongoDB
MongoHQ
Iris Couch
MongoLab
ObjectRocket
Cloudant
VoltDB
MySQL Cluster
ScaleDB
Clustrix
FairCom
NuoDB
Drizzle
InfiniSQL
GenieDB
Datomic
MemSQL
JustOneDB
TransLattice
Pivotal SQLFire
Altibase HDB
Altibase XDB
ScaleBase
ScaleArc
Tesora
Tokutek
CodeFutures
Continuent
Zimory Scale
Galera
Oracle TimesTen
IBM solidDB
Amazon RDS
OpenStack Trove
InfiniDB
Heroku Postgres
Infobright
Rackspace Cloud Databases
Google Cloud SQL
HP Cloud RDB for MySQL
FathomDB
DeepDB
SQL Azure
ClearDB
StormDB
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LucidDB
Kx Systems
Actian Matrix
IBM InfoSphere
ParStream
SAP Sybase IQ
HP Vertica
Pivotal Greenplum
MonetDB
LogicBlox
Amazon Redshift
InfluxDB
1010data
Google BigQuery
TempoDB
BitYota
Redis Labs Memcached Cloud
IronCache
Amazon ElastiCache
MemCachier
Ehcache
BigCache
BigMemory
Memcached
InfiniSpan
IBM eXtreme Scale
ScaleOut Software
Pivotal GemFire
TIBCO ActiveSpaces
Oracle Coherence
GridGain
GigaSpaces XAP
Hazelcast
CloudTran
Key:
General purpose
Specialist analytic
-as-a-Service
NoSQL extension
BigTables
Graph
Document
Key value stores
Key value direct access
Hadoop
NewSQL extension
MySQL storage engines
Advanced clustering/sharding
New SQL databases
Data caching
Data grid
Search
Appliances
Off-heap memory
In-memory
Stream processing
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Database Systems Landscape

423 systems in ranking, September 2024

Rank			DBMS	Database Model	Score		
Sep 2024	Aug 2024	Sep 2023			Sep 2024	Aug 2024	Sep 2023
1.	1.	1.	Oracle	Relational, Multi-model	1286.59	+28.11	+45.72
2.	2.	2.	MySQL	Relational, Multi-model	1029.49	+2.63	-82.00
3.	3.	3.	Microsoft SQL Server	Relational, Multi-model	807.76	-7.41	-94.45
4.	4.	4.	PostgreSQL	Relational, Multi-model	644.36	+6.97	+23.61
5.	5.	5.	MongoDB	Document, Multi-model	410.24	-10.74	-29.18
6.	6.	6.	Redis	Key-value, Multi-model	149.43	-3.28	-14.26
7.	7.	↑ 11.	Snowflake	Relational	133.72	-2.25	+12.83
8.	8.	↓ 7.	Elasticsearch	Search engine, Multi-model	128.79	-1.04	-10.20
9.	9.	↓ 8.	IBM Db2	Relational, Multi-model	123.05	+0.04	-13.67
10.	10.	↓ 9.	SQLite	Relational	103.35	-1.44	-25.85
11.	11.	↑ 12.	Apache Cassandra	Wide column, Multi-model	98.94	+1.94	-11.11
12.	12.	↓ 10.	Microsoft Access	Relational	93.76	-2.61	-34.81
13.	13.	↑ 14.	Splunk	Search engine	93.02	-3.08	+1.63
14.	↑ 15.	↑ 17.	Databricks	Multi-model	84.24	-0.22	+9.06
15.	↓ 14.	↓ 13.	MariaDB	Relational, Multi-model	83.44	-3.09	-17.01
16.	16.	↓ 15.	Microsoft Azure SQL Database	Relational, Multi-model	72.95	-2.08	-9.78
17.	17.	↓ 16.	Amazon DynamoDB	Multi-model	70.06	+1.15	-10.85
18.	↑ 19.	18.	Apache Hive	Relational	53.07	-2.17	-18.76
19.	↓ 18.	↑ 20.	Google BigQuery	Relational	52.67	-2.86	-3.80
20.	20.	↑ 21.	FileMaker	Relational	45.20	-1.47	-8.40
21.	21.	↑ 23.	Neo4j	Graph	42.68	-1.22	-7.71
22.	↑ 23.	↓ 19.	Teradata	Relational, Multi-model	41.47	-0.78	-18.86

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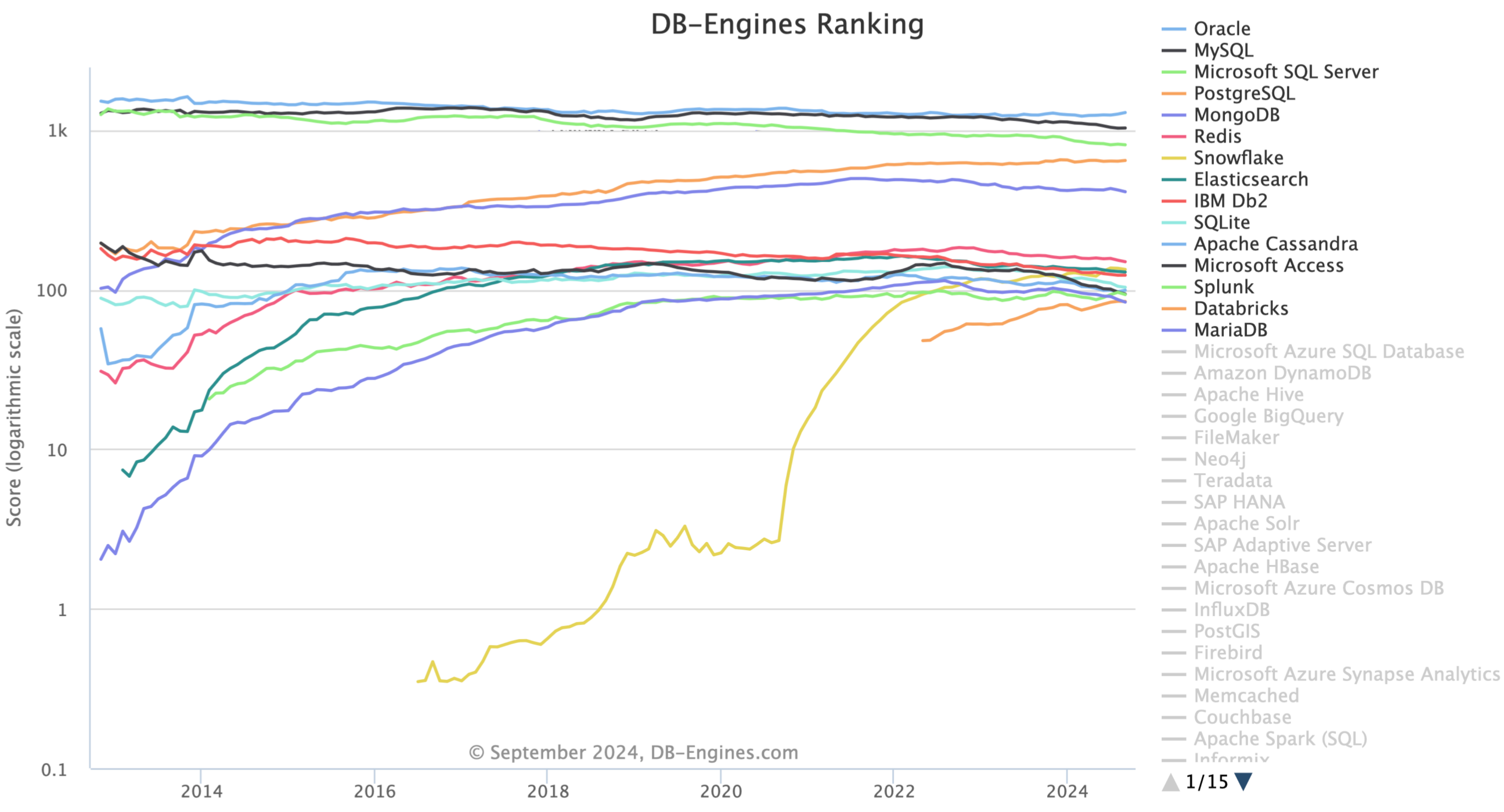
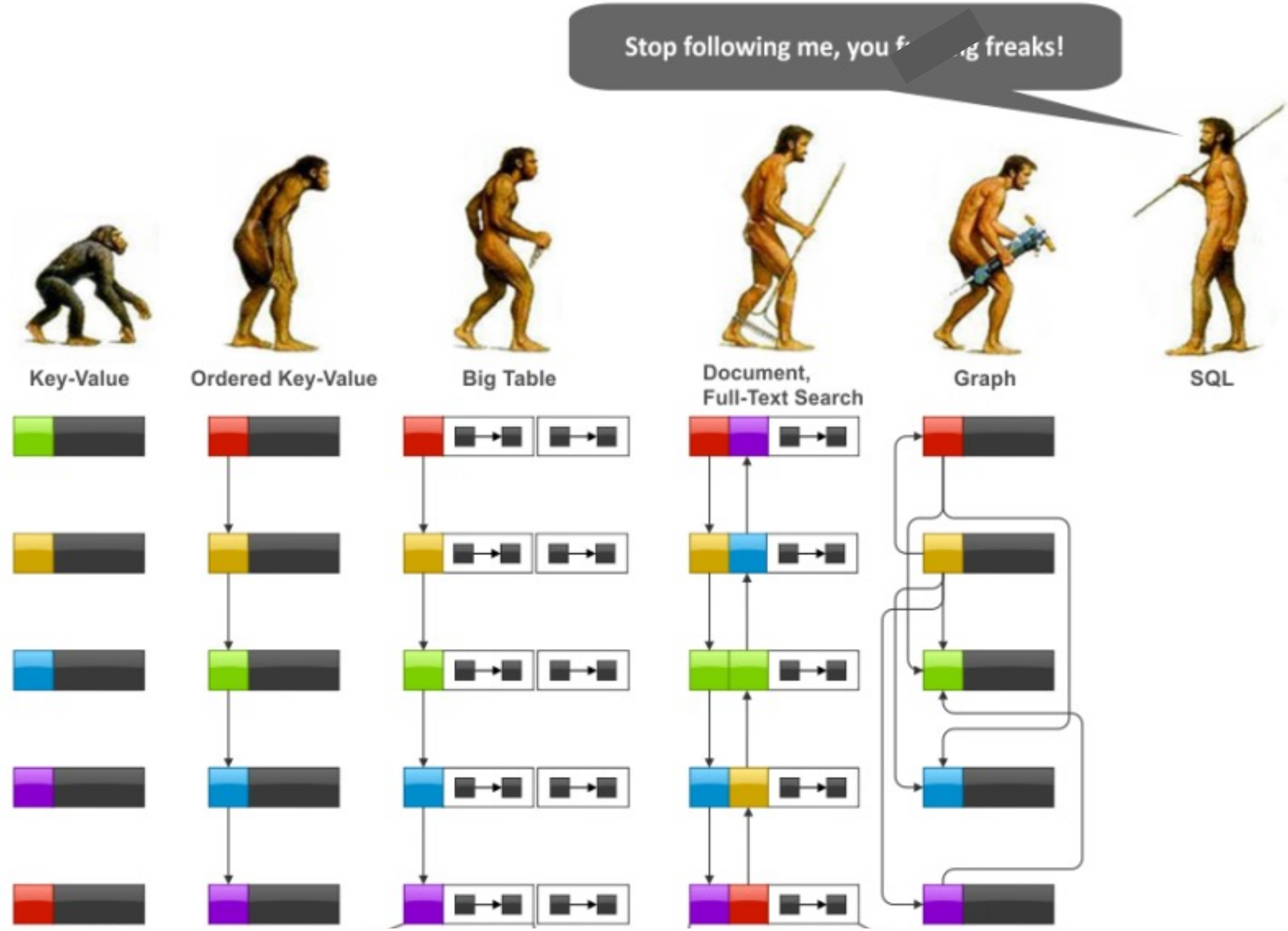
https://db-engines.com/en/ranking

Database Systems Landscape



https://db-engines.com/en/ranking_trend

Database Systems Landscape



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