Choosing the right database for your next project:

Looking at options beyond PostgreSQL and MySQL

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Speaker Introduction

- Marc-André Lemburg
  - Python since 1994
  - Studied Mathematics
  - CEO eGenix.com GmbH
  - Consulting CTO and Senior Solutions Architect
  - EuroPython Society Fellow and former Chair
  - Python Software Foundation Fellow
  - Python Core Developer
  - Based in Düsseldorf, Germany

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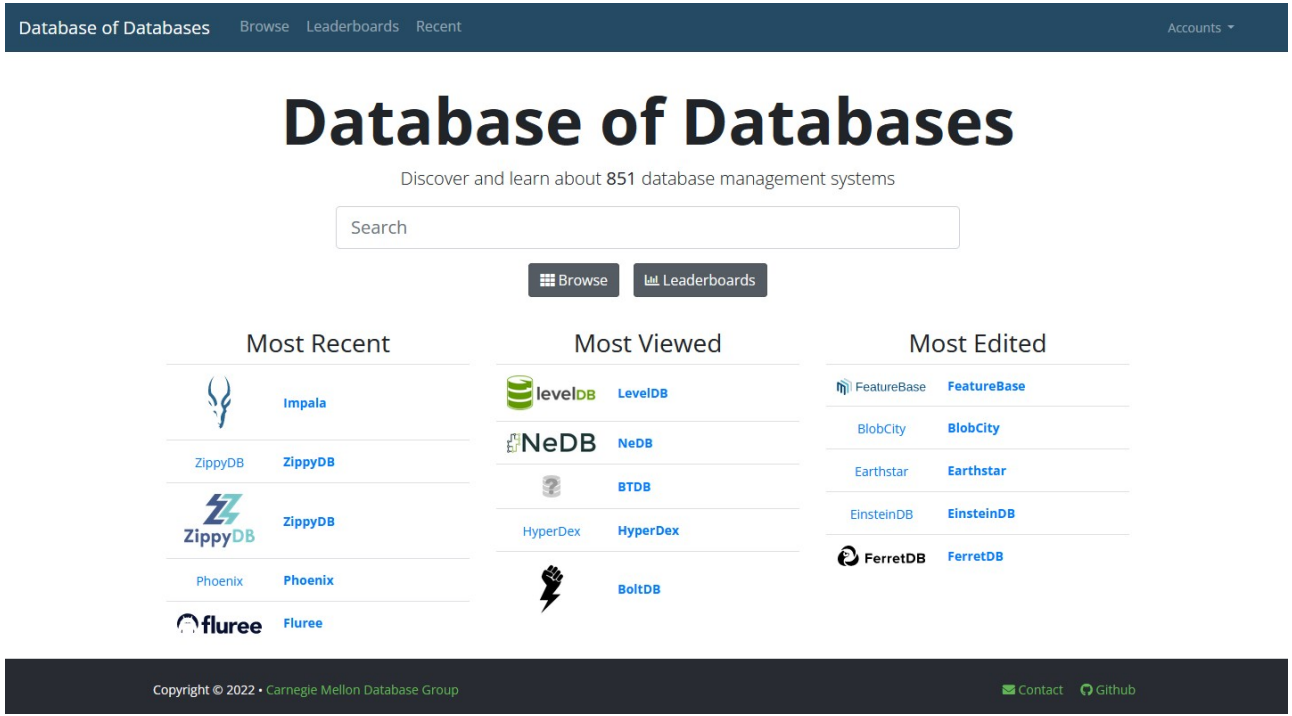
Motivation: You're thinking of building the next Big Thing ...

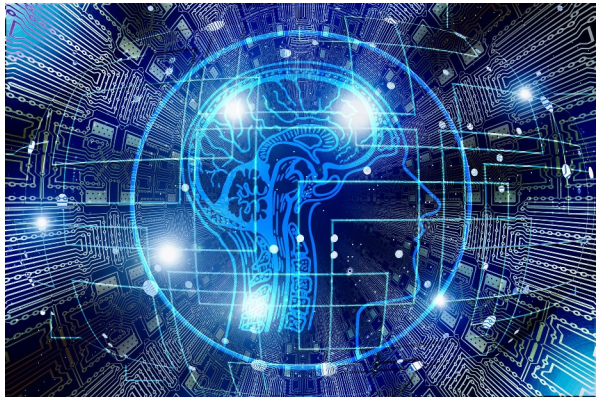
Motivation: … and you need a database for this.

There are **800+ databases** out there – https://dbdb.io/

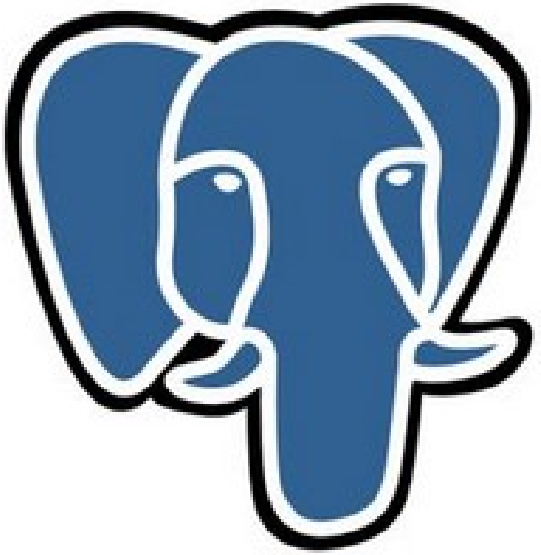


Developing databases has become the new hot thing

- Plenty of new databases were created in recent years
- Often by large Internet companies, e.g. Google, Facebook, LinkedIn, Uber, etc. or by smaller startups looking to fill a niche in the market
- Goals
  - Better performance
  - Faster intake
  - Faster analytics
  - More scalable, more reliable
  - Clustered, containerized, running on Kubernetes
  - Using GPUs, in-memory setups, separating compute / storage



Now, you could just pick one of these and be done ...



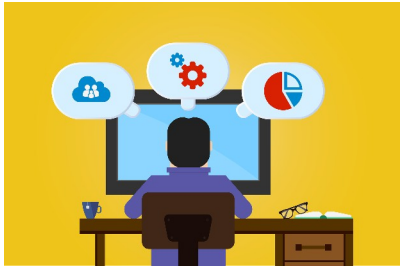
PostgreSQL

But you might lose a competitive edge ...

How to select a database engine ?

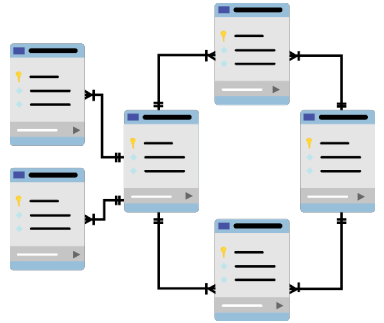
- Determine your typical data workload
- Look at the intended use case(s) to prioritize features
- Consider additional decision factors / constraints
- Get an overview of what's available on the market
- Pick the best fit !

- *For larger projects:*
  Create a POC to help determine the right choice



Determine the typical data workload

- OLTP – Online transaction processing
  - Main purpose: operations
  - Optimized for fast CRUD, simple joins
  - Data changes frequently
  - *Examples: General purpose databases*



- OLAP – Online analytical processing
  - Main purpose: analytics and reporting
  - Optimized for read, complex queries, large joins
  - Data is rather stable, sometimes even read- or append-only
  - *Examples: Data warehouse solutions*

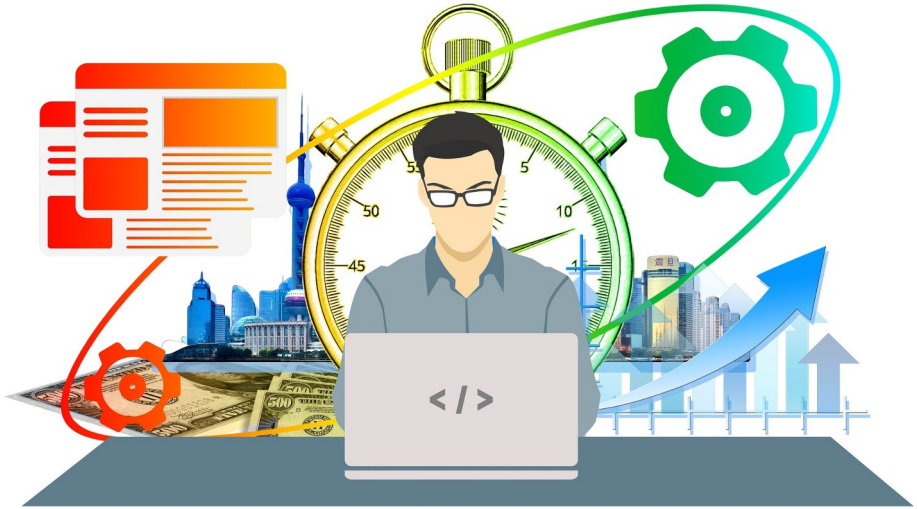
Use cases: Understanding your problem space

- The Knowns:
  Your database use case will often require
  a particular feature set

- The Unknowns:
  Plan for future developments
  - Scaling up
  - Change frequency of your designs / schemas
  - Additional requirements which you may not yet know

Use cases: Let's look at a few complexity dimensions

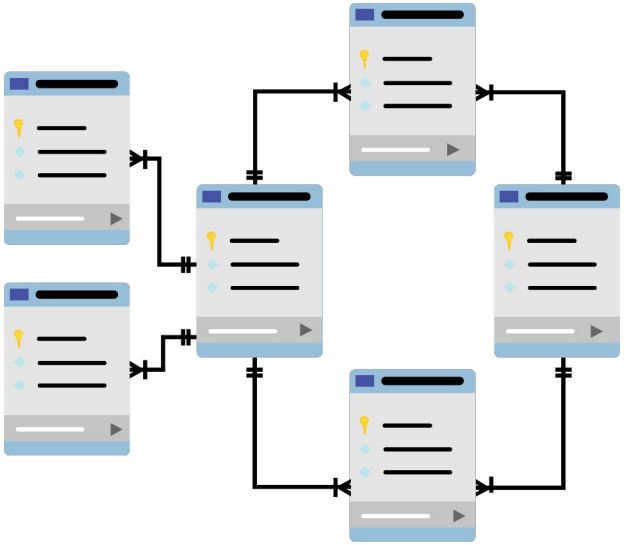
- Schema complexity
- Cardinal complexity
- Temporal complexity
- Query complexity
- Deployment complexity
- Operational complexity



(you may have more dimensions to add)

Use cases: Schema complexity

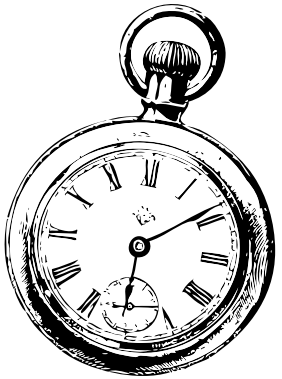
- Simple schemas
  - Session and user management
  - Lookup tables
  - *Examples: Web servers, logging, event storage*
- Complex schemas
  - Interconnected schemas from different systems
  - Wide tables to implement nested structures
  - *Examples: Accounting, trading or booking systems*
- Migrations



Use cases: Cardinal & Temporal complexity

- Cardinal complexity
  - Many simple rows
  - Fewer rows with many columns
  - Many rows with lots of columns
  - Scalability factors: Data growth rate per month

- Temporal complexity
  - Read-only or append-only (e.g. timeseries)
  - Data changes often
  - Requirement to run point-in-time queries

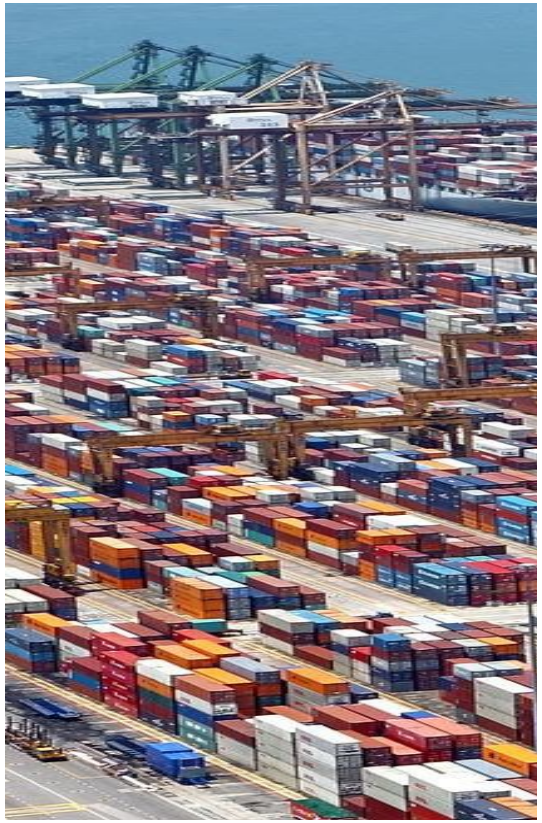


Use cases: Query complexity

- Query complexity
  - Performance requirements:
    Transactions per second (TPS) for OLTP or
    Analytics Timing for OLAP
  - Joins:
    Simple joins leading to small result sets or
    Complex joins across multiple large tables
  - Normalization:
    Fully normalized tables (DRY in databases) or
    Denormalized tables (to avoid online joins)
  - Need for Materialized Views, (special) Indexes

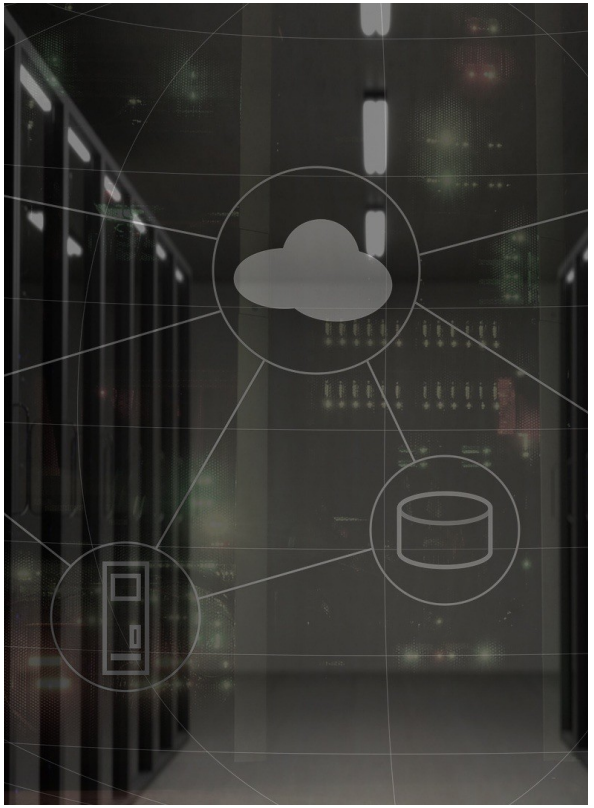
Use cases: Deployment complexity

- Compute
  - Single server / cluster
  - On-premises hardware / Cloud
  - Dedicated hardware / VMs / containers / Kubernetes
- Storage
  - Data close to nodes (memory, NVMes, NFS)
  - Object storage (e.g. S3)
- Resilience & Disaster Recovery (DR)
  - Fail-over / High Availability Setups
  - Monitoring
  - Automation and self-healing



Use cases: Operational complexity

- Managed / self-hosted
  - Complex configuration
  - Self-optimizing
  - Need for (elastic) scaling
- Devops Integration
  - VMs and servers: Ansible / Salt / Terraform / etc.
  - Kubernetes: Operators / Helm Charts
  - Manual intervention: Shell access, UI tools
- Upgrades
  - Zero downtime
  - Performance degradation



Additional decision factors

- Is the database mature enough for my needs ?
- Is the ecosystem strong enough to provide years of support ?
- How important is resilience / performance / scalability ?
- What are the cost implications ?
- Would the data fit into memory / a single server / cluster / S3 ?
- Does the database have good / supported Python interfaces ?
- Does the database provide interfaces to tools used in your stack ?
  - e.g. Django, SQLAlchemy, DBT, Pandas, Dask, fugue, etc.

Now, let's do some ~~beer~~ database tasting...

Selection of databases for various use cases

- General purpose OLTP client-server databases
- In-memory / embedded databases
- GPU based databases
- Data Warehouse OLAP databases
- Data Lake OLAP databases
- Distributed OLAP databases
- Document databases
- Timeseries databases
- Machine learning and databases
- Other types of databases

General purpose OLTP client-server databases

- PostgreSQL
- MySQL / MariaDB
- Oracle, MS SQL Server, IBM DB2
- Cloud versions of most of the above
  - Amazon AWS RDS, Aurora
  - Microsoft Azure Database
  - Google Cloud SQL

Most of these are row-oriented.

In-memory / embedded databases

- SQLite
  - Embedded, on-disk and in-memory
  - Focus: OLTP
- DuckDB
  - Embedded, on-disk and in-memory
  - Focus: OLAP
- Exasol
  - Very fast, client-server, runs in memory only (persists to disk)
  - Focus: OLAP

GPU based databases

- HeavyDB
  - Highly specialized and very fast
- SQream
  - Focus on fast ingest and analytics
- BlazingSQL
  - Written in Python; runs directly on local files
  - Part of the RAPIDS stack and can be used with Dask
- PG-Strom
  - PostgreSQL extension to use the GPU for faster queries

Data Warehouse OLAP databases

- Snowflake / Google BigQuery / Azure Synapse Analytics
  - Fully managed cloud platforms
- Amazon Redshift
  - PostgreSQL compatible, fully managed cloud platform
- Greenplum
  - PostgreSQL fork which adds clustering and MPP
- Teradata
  - Used to be on-prem, now fully managed cloud platform

Most of these are column-oriented.

Data Lake OLAP databases

- Amazon Athena
  - Queries against data stored on S3 (similar to Apache Presto)
  - Fully managed cloud platform
- Apache Presto / Trino
  - Database engines only, no storage (separates compute/storage)
  - Allows querying across several data sources (S3, Cassandra, MongoDB, Kafka)
- Delta Lake
  - ACID compliant storage layer with several compute integrations, e.g. for Trino

Most of these are column-oriented.

Distributed OLAP databases

- YugabyteDB and CockroachDB
  - PG compatible
- SingleStore
  - MySQL compatible
- ClickHouse
  - Fast OLAP engine, but lacks a few standard SQL features
  - Good for log analysis
- Exasol
  - Runs on RAM in a cluster, so very fast

Many of these can also be used for data warehouses / lakes.

Document databases

- ElasticSearch / OpenSearch
  - JSON document databases with focus on text queries
  - Part of the ELK Stack
- Apache Cassandra
  - High performance and highly scalable
  - SQL-like query language
- MongoDB
  - Full featured document database
- Apache CouchDB
  - Great for online / offline replicating data across different platforms

Timeseries databases

- InfluxDB
  - Fast intake and highly available, great for IoT and metrics
- Apache Druid
  - Fast intake and queries, real-time system for e.g. ad systems
- CrateDB
  - Combines ElasticSearch (document) and Presto/Trino (SQL)
- TimescaleDB
  - PostgreSQL extension

Timeseries databases (immutable)

- Apache Pino
  - Fast, append-only, immutable
- ImmuDB
  - Append-only, immutable, tamperproof
  - Great for auditing

Machine learning and databases

- Some database engines provide tooling to run Python ML inside the database server:
  - PostgreSQL and Greenplum: via MADlib
  - Oracle, MS SQL Server, DB2: via Python UDFs

- Other engines focus on making ML available via SQL:
  - MindsDB: works with a large range of databases as a SQL proxy

Other types of databases

- Key value storages
- Geo databases
- Graph databases
- Vector databases (for ML models)

… and many more

(perhaps in some future talk)

Lots of options available… hope this was helpful

Main takeaway: Never stop to learn and try out new things...

Thank you for your attention !

Time for discussion

Contact

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