NoSQL

CS460 Databases for Data Scientists

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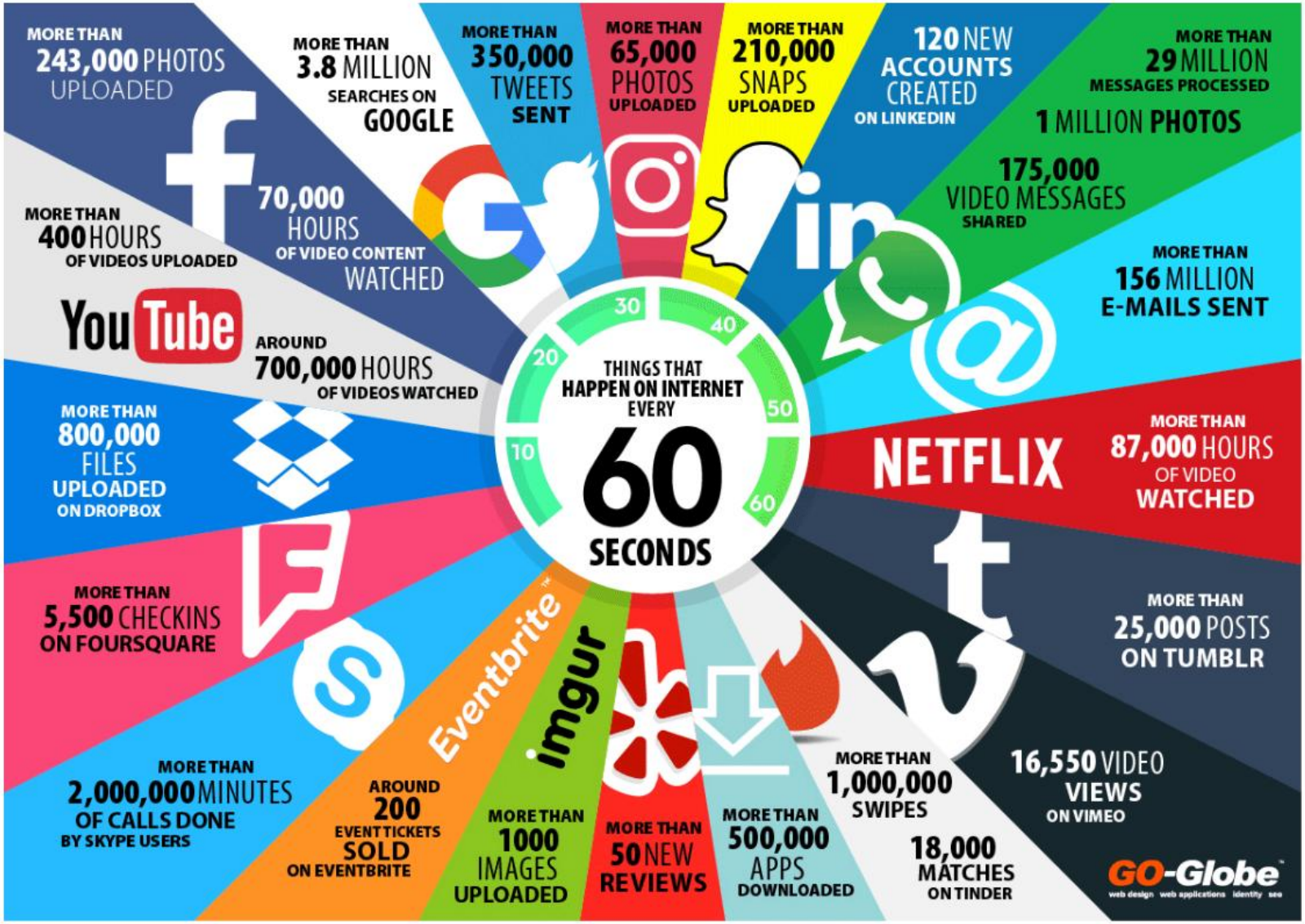
Slides partially from https://whytin.github.io/cs377_s16/slides/nosql-24.pdf

Big Data



https://www.go-globe.com/things-that-happen-on-internet-every-60-seconds/

Motivation for NoSQL

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- Scalability
- RDBMS usually scale with hardware added to one server
  - very expensive when reaching maximum capacity
- On > 50GB data:
  - MySQL
    - Writes 300 ms avg
    - Reads 350 ms avg
  - Cassandra
    - Writes 0.12 ms avg
    - Reads 15 ms avg
- NoSQL stands for
  - No Relational
  - Not only SQL
  - An umbrella term for a class of products that don‘t follow RDBMS principles

CAP Theorem

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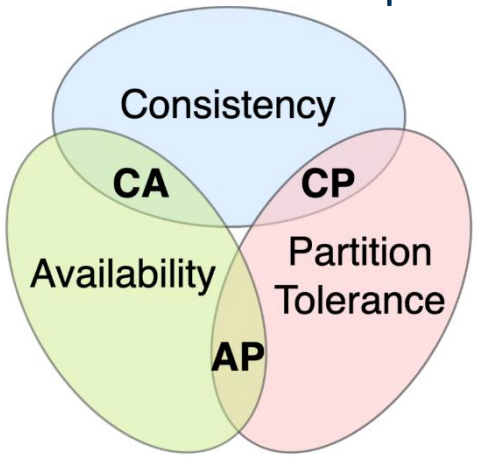
- "Of three properties of shared-data systems —
  data Consistency, system Availability, and tolerance to network Partitions —
  only two can be achieved at any given moment in time" — Brewer, 1999
  - **Consistency**: all nodes see the same data at the same time
  - **Availability**: guarantee that every request receives a response about whether it was successful or failed
  - **Partition tolerance**: system continues to operate despite arbitrary message loss or failure of part of the system



https://commons.wikimedia.org/wiki/File:CAP_Theorem_Venn_Diagram.png

NoSQL Categories

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- Four groups:
  - Key-value stores
  - Column-based families or wide column systems
  - Document stores
  - Graph databases

Key-value stores

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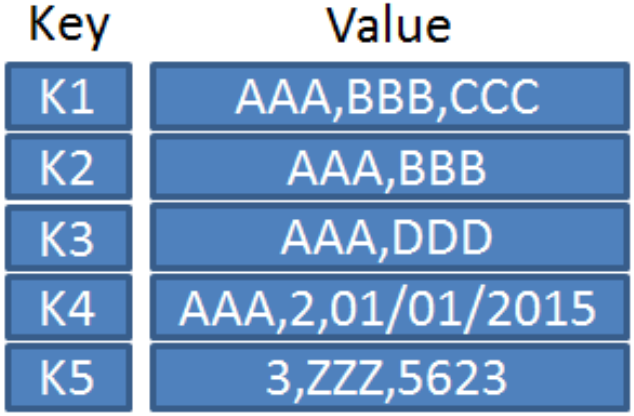
- Simplest NoSQL databases
  - collection of key, value pairs
- Queries are limited to query by key
- Examples:
  - Redis
  - Riak
  - Voldermort
  - DynamoDB
  - MemcacheDB



https://upload.wikimedia.org/wikipedia/commons/5/5b/KeyValue.PNG

Column-Based Families

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- Data is stored in a big table
- Access control, disk storage, and memory accounting performed on column families
- Example:
  - Cassandra
  - Hbase
  - DuckDB
  - Hypertable

id	user_name	current_balance	number_of_ transactions
1	'taggy@yahoo.com'	1059298	1045
2	'fra@hotmail.com'	3910	194
...	...	...	...

Column storage better

```
SELECT sum(current_balance)
            AS total_transactions
FROM table
WHERE user_id > 2
```

Row storage better

```
SELECT user_id, user_name, current_balance
FROM table
WHERE user_id = 1
```

Document Databases

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- Collections of similar documents
- Each document can resemble a complex model
- Good for single view or data hub applications
- Examples:
  - MongoDB
  - ArangoDB
  - CouchDB

```
{
   "firstName": "Bob",
   "lastName": "Smith",
   "address": {
      "type": "Home",
      "street1":"5 Oak St.",
      "city": "Boys",
      "state": "AR",
      "zip": "32225",
      "country": "US"
   },
   "hobby": "sailing",
   "phone": {
      "type": "Cell",
      "number": "(555)-123-4567"
   }
}
```

Graph Database

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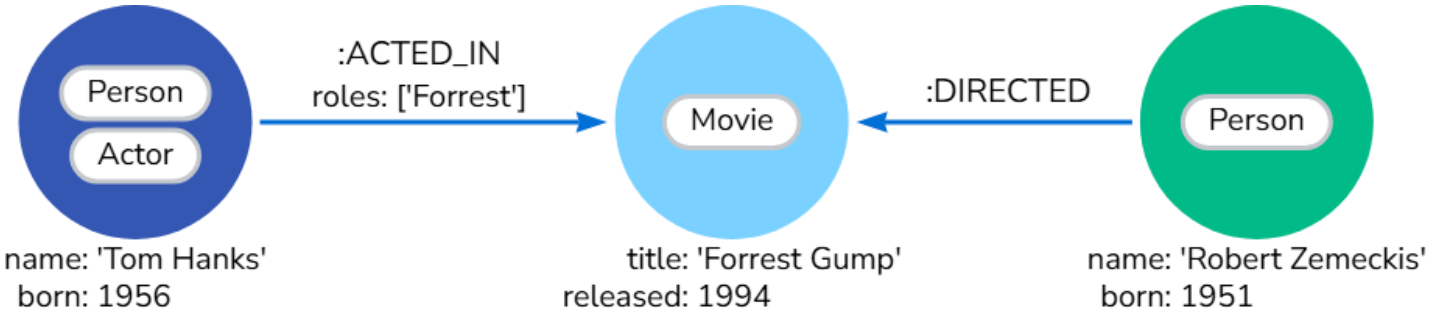
- Collection of vertices (nodes) and edges (relations) and their properties
- Example:
  - Neo4j
  - Amazon Neptune
  - AllegroGraph
  - VertexDB



https://neo4j.com/docs/getting-started/appendix/graphdb-concepts/

What's Next?

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- Database Systems II (FSS, Moerkotte)
  - e.g., distributed DBMS, object-relational DBs, deductive DBs
- Query Optimization (FSS, Moerkotte)
  - more sophisticated query optimization
- Large-Scale Data Management (HWS, Gemulla)
  - e.g., parallel & distributed databases, MapReduce, SPARQL, NoSQL
- Knowledge Graphs (Hertling)
  - Graph Representation and Inference
  - Knowledge Modeling and Integration

What's Next?

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- Data Security and Privacy (FSS, Armknecht)
  - also covers aspects such as encryption
- Web Data Integration (HWS, Bizer)
  - dealing with multiple databases
  - automatically integrating them into a single one
  - can be accompanied with a practical project
- Data Mining (FSS/HWS, Bizer/Hertling)
  - finding patterns in data
  - entry point to more specific lectures in the data analytics field
  - includes a practical project

Exam

- Date: Monday, 01.06.2026
- Time: 12:00-13:00
- Location:
  - Room: B 243
  - Building: A 5, 6 Part B

Exam

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- 6 questions
  - Each question 10 points
- Prepare for similar questions as the exercise
- Focus:
  - Be able to apply your knowledge to a specific database / example at hand

Exam

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- SQL
  - Be able to write SQL queries (know the syntax)
    - **No** views, no roles
    - **No** temporary relations using WITH
- ER Models
  - Write and understand ER models
  - Be able to reduce a ER model to Relation Schema
- Normalization
  - Be able to normalize a given database

Exam

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- Indexing/Hashing
  - Understand differences between different indices
  - Create and modify given indices
    - **Excluding** special cases like „merge siblings“ or „redistribute pointers“ for B+ tree
- Database Architectures
  - General understanding of concepts (no details)

Exam

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- Query Processing
  - Know the different join possibilities
  - Know how indices can be used for selections
- Query Optimization
  - Be able to apply equivalence rules (don‘t need to remember them)
  - Understand execution/evaluation plans
    - Be able to decide which one is better given a concrete example
  - Be able to compute the number of tuples for a given selection

Exam

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- Transactions & Concurrency
  - Understand and Write schedules
  - Know what Conflicts are (detect conflicts)
  - Know the Two-Phase Locking Protocol
  - Know/detect deadlocks
  - **No** Timestamp-based Scheduling or Validation Based Protocol
- Recovery
  - Know and apply log-based recovery mechanism (undo, redo operations)
    - Including checkpoints

Exam

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- Applications
  - Know the security implications
    - SQL Injection
    - Cross Site Scripting
    - Password storage
  - **No** HTML or servlet code etc
- NoSQL
  - **Not** exam relevant

Course Evaluation

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- See Message Board in Ilias

Q & A

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