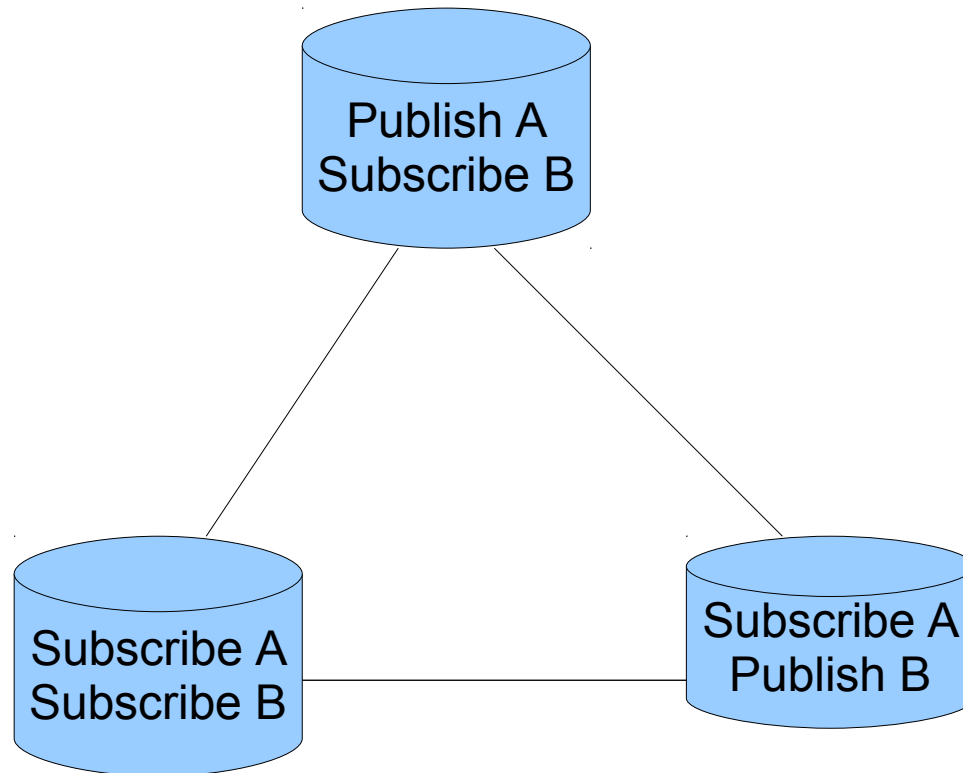


Data replication,
high availability,
load balancing,

Data replication

Publish – subscribe model



High availability – redundancy - primary server, secondary server(s)

Failover, switchover, replication, database cluster, split-brain

Load Balancing

- load balancing database servers is easy for r/o access.
- modification much more complicated – write requests must be propagated to all servers in the cluster – no single solution.

Master servers – R/W requests

Slave servers – R/O requests

Stand-by servers – not accessible until they become master

Some solutions – only one server can handle update requests

Synchronous solutions – the data modifying transaction is not committed until accepted by all servers (distributed transaction) => no data lost on failover

Asynchronous solutions – commit → delay → propagation to other servers in the cluster
=> some data updates may be lost on failover

If synchronous too slow => asynchronous

Granularity point of view:

per-server high availability solution

per-database

per-table

Types of solution:

Shared-disk failover

- **single disk array** shared by multiple servers
- if the main DB server fails, another DB server mounts the DB
- synchronization overhead avoided by having just one instance of the database
- rapid failover with no data loss
- SAN (storage area networks) lower level communication protocol than NFS
- NFS is OK if mounted synchronously (without caching)

- the stand-by server cannot never access the DB while the primary server is ON
- disk array – **single point** of failure, when failed/corrupted, the DB becomes unavailable

File-system Replication

- HW redundancy
- changes to a **filesystem mirrored** to another filesystem residing on another host
- mirroring must assure that the secondary filesystem is a consistent copy of the primary one
- the order of writes must be preserved

- LINUX world has a popular filesystem mirroring solution called DRBD

Warm stand-by through PITR (point-in-time recovery)

- a stand-by server is being kept current by reading the stream of **write-ahead log** (WAL) records (**warm standby** aka log shipping)
- when the master server fails, the stand-by server has almost all data available and can be quickly made the master

- asynchronous solution
- only the entire DB server granularity

Master-slave replication

- all data **modification queries go to the master server.**
- the master server asynchronously sends data changes to the slave server
=> possible data loss during fail over
- the **slave can answer read-only queries** while the master server is running.
- the slave server ideal for OLAP queries

Example: Slony-I (per-table granularity, support for multiple slaves)

Statement-based replication middleware

- a program **intercepts every SQL query** and sends it to one or all servers.
- each **server operates independently**.
- R/W queries are sent to all servers, while R/O queries can be sent to just one server, allowing the read workload to be distributed.

If queries are simply broadcast unmodified, functions like `random()`, `CURRENT_TIMESTAMP`, and sequences would have **different values on different servers**. If this is unacceptable, either the middleware or the application must query such values from a single server and then **modify the write queries** using those values before broadcasting them to the servers.

Also, care must be taken that all transactions either commit or abort on all servers, perhaps using two-phase commit.

Examples: Pgpool-II, Sequoia

Synchronous Multimaster Replication

- each server can accept write requests
- modified data is transmitted from the original server to every other server before each transaction commits.
- read requests can be sent to any server.
- sometimes shared disk used to reduce the communication overhead
- no problem with non-deterministic functions like random()
- advantage: any server can accept write requests. Hence, no need to distribute workloads between masters and slaves

- Heavy write activity can cause excessive locking, leading to poor performance.

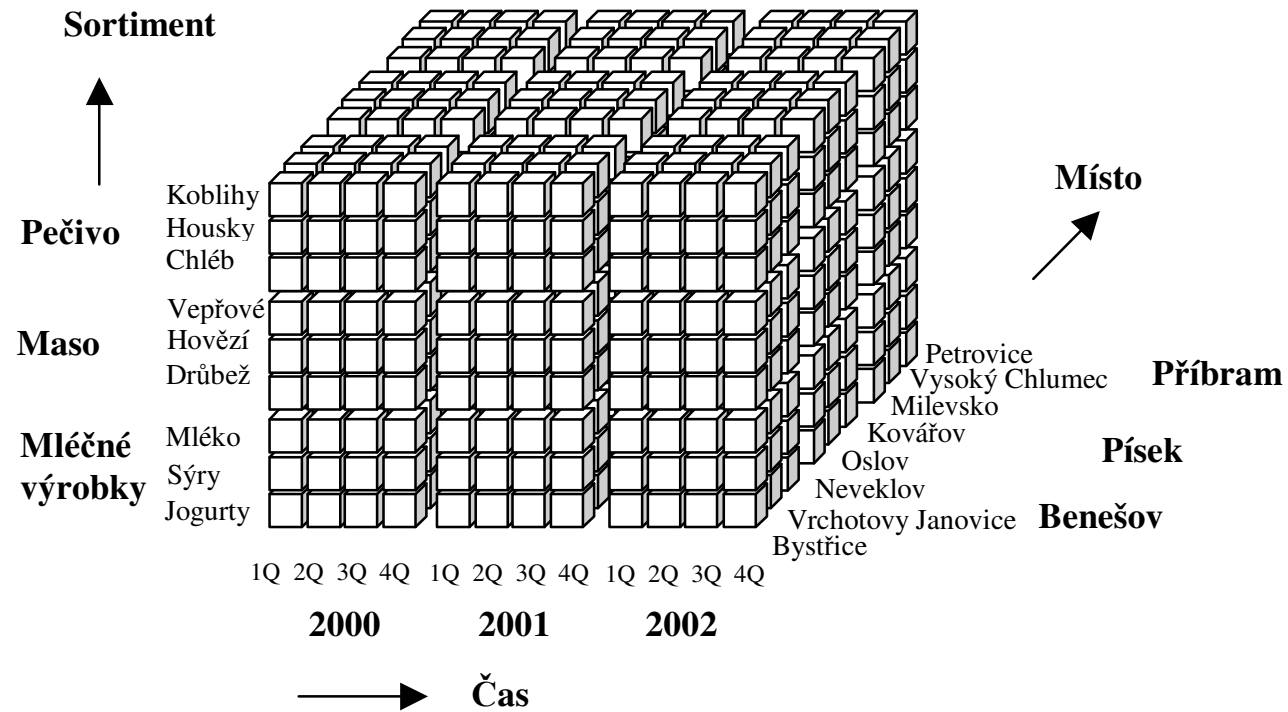
Asynchronous Multimaster Replication

- data synchronization for occasionally connected applications
- asynchronous multimaster replication
- each server works independently
- periodically communicates with the other servers to identify conflicting transactions
- the conflicts resolved by users / conflict resolution rules

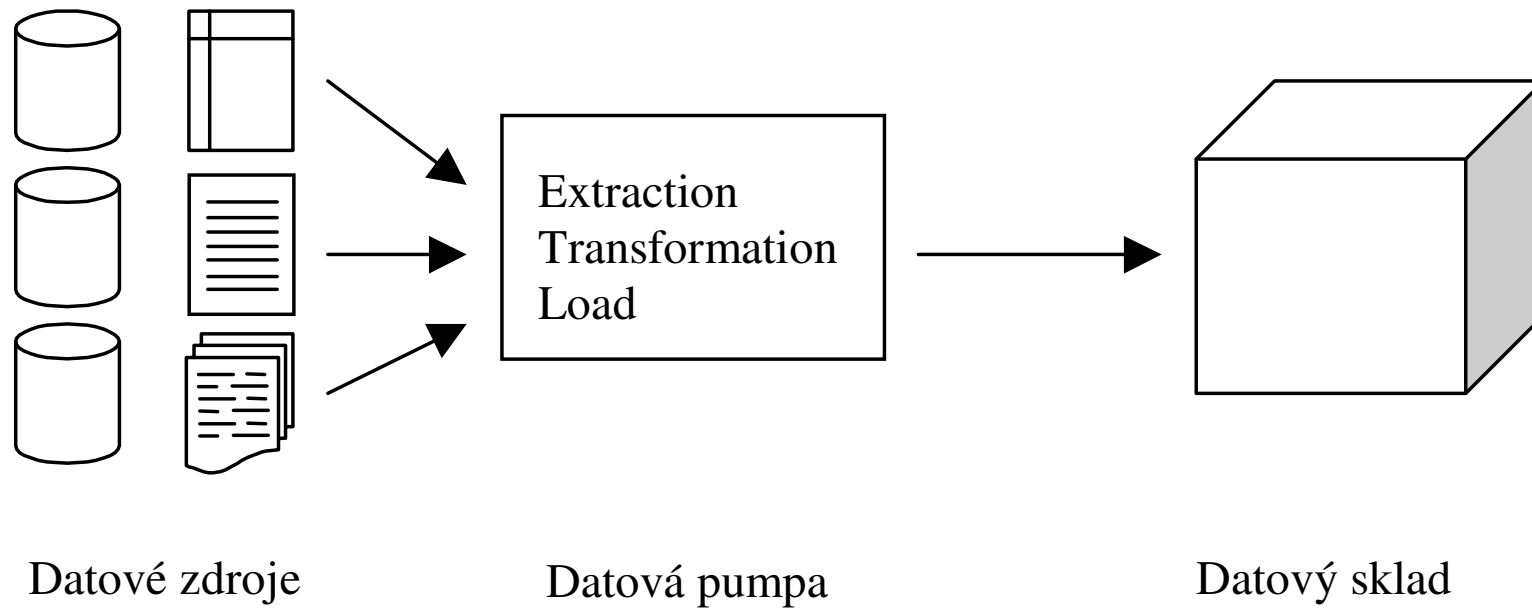
Datové sklady

Zdeněk Kouba

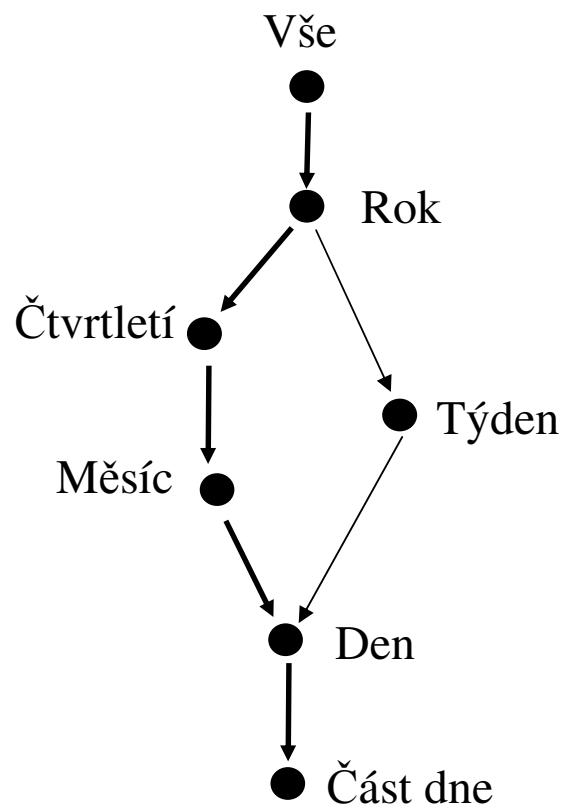
Data cube



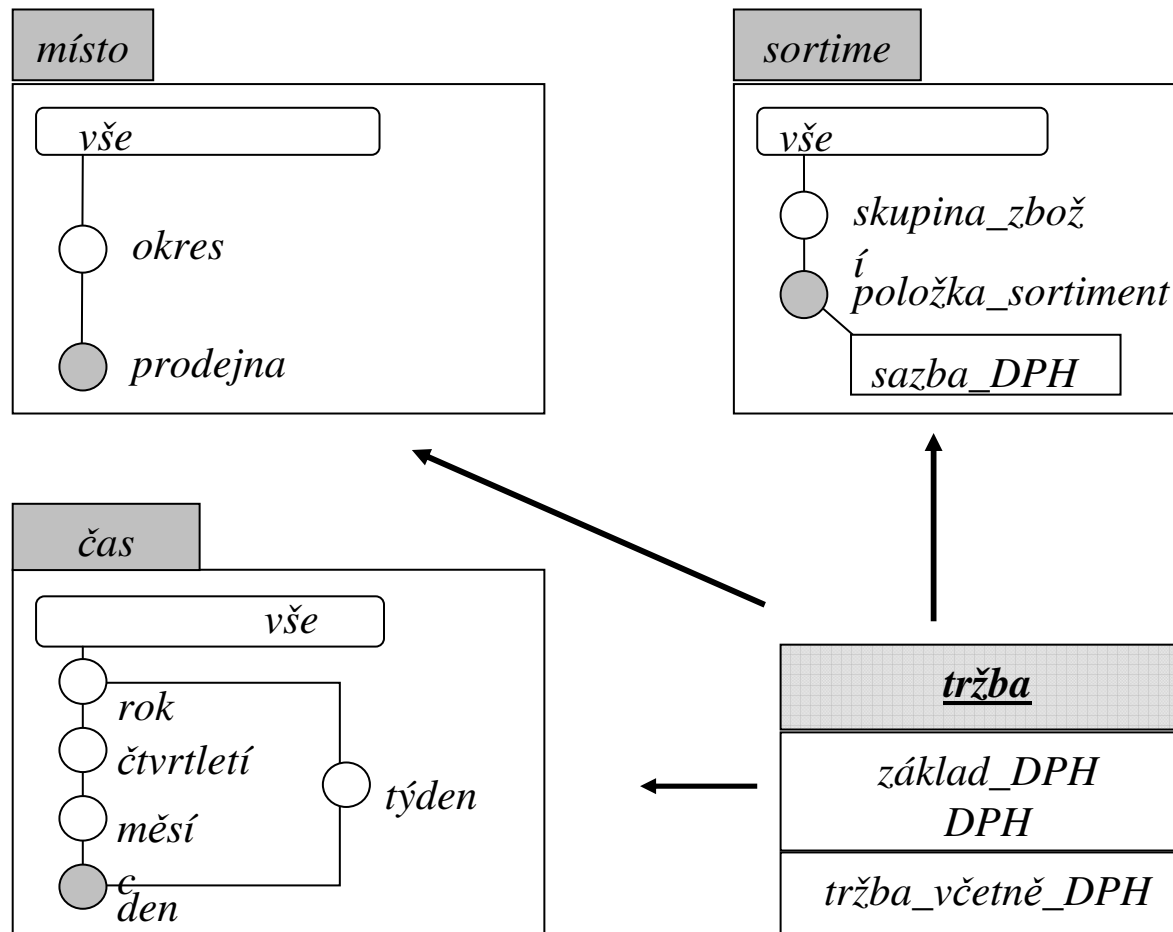
Proces ETL



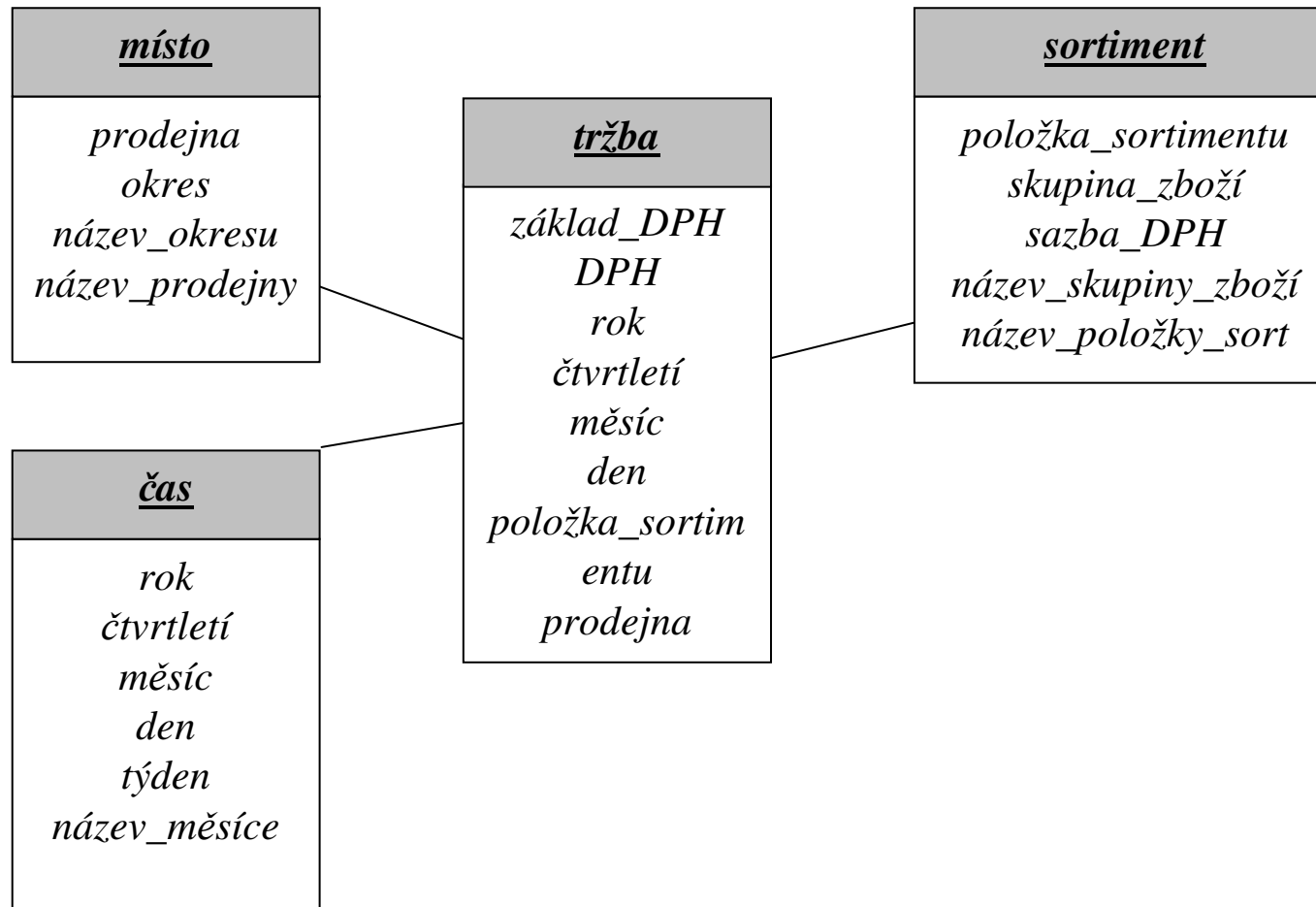
Agregační hierarchie dimenze “čas”



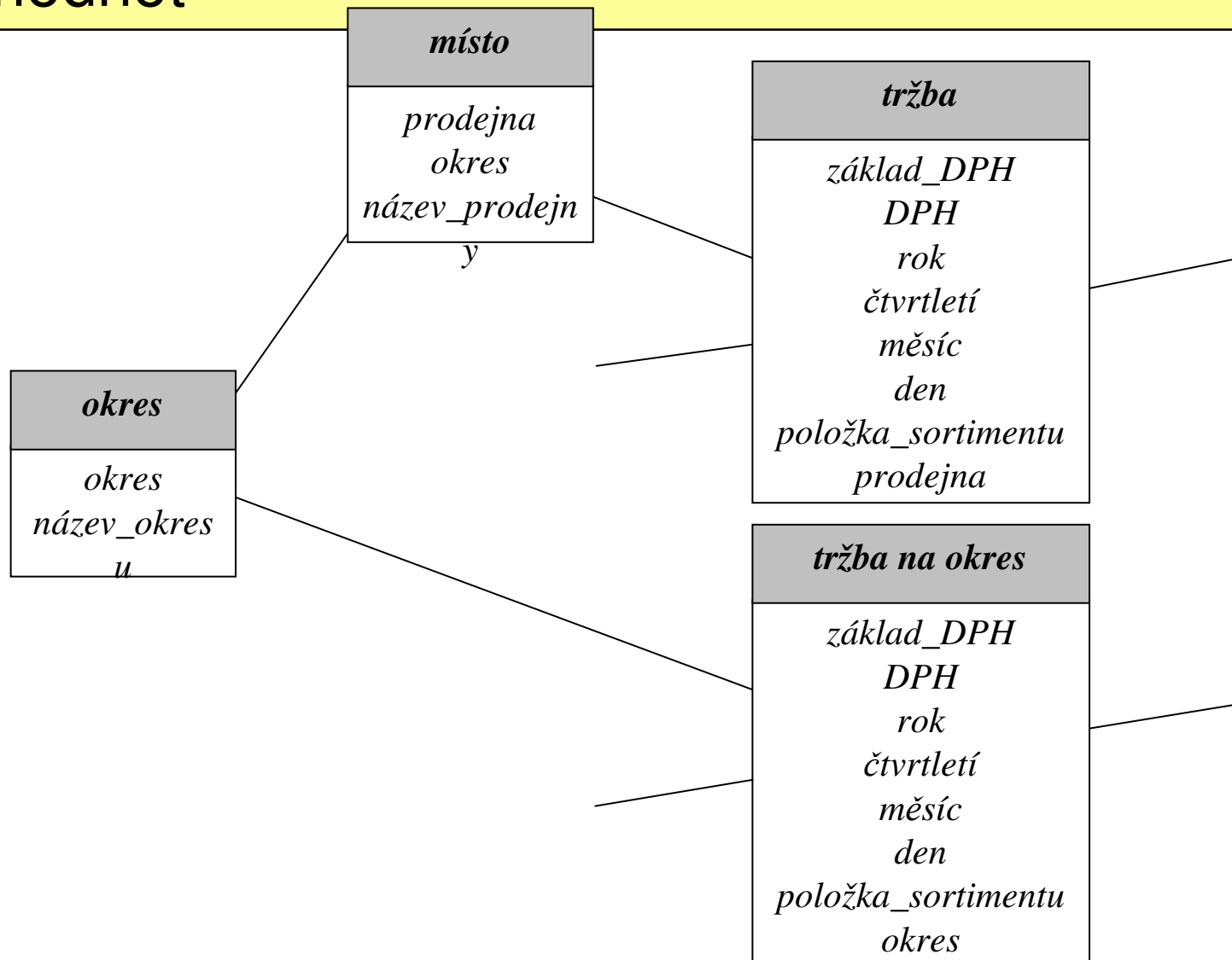
Konceptuální model motivačního příkladu



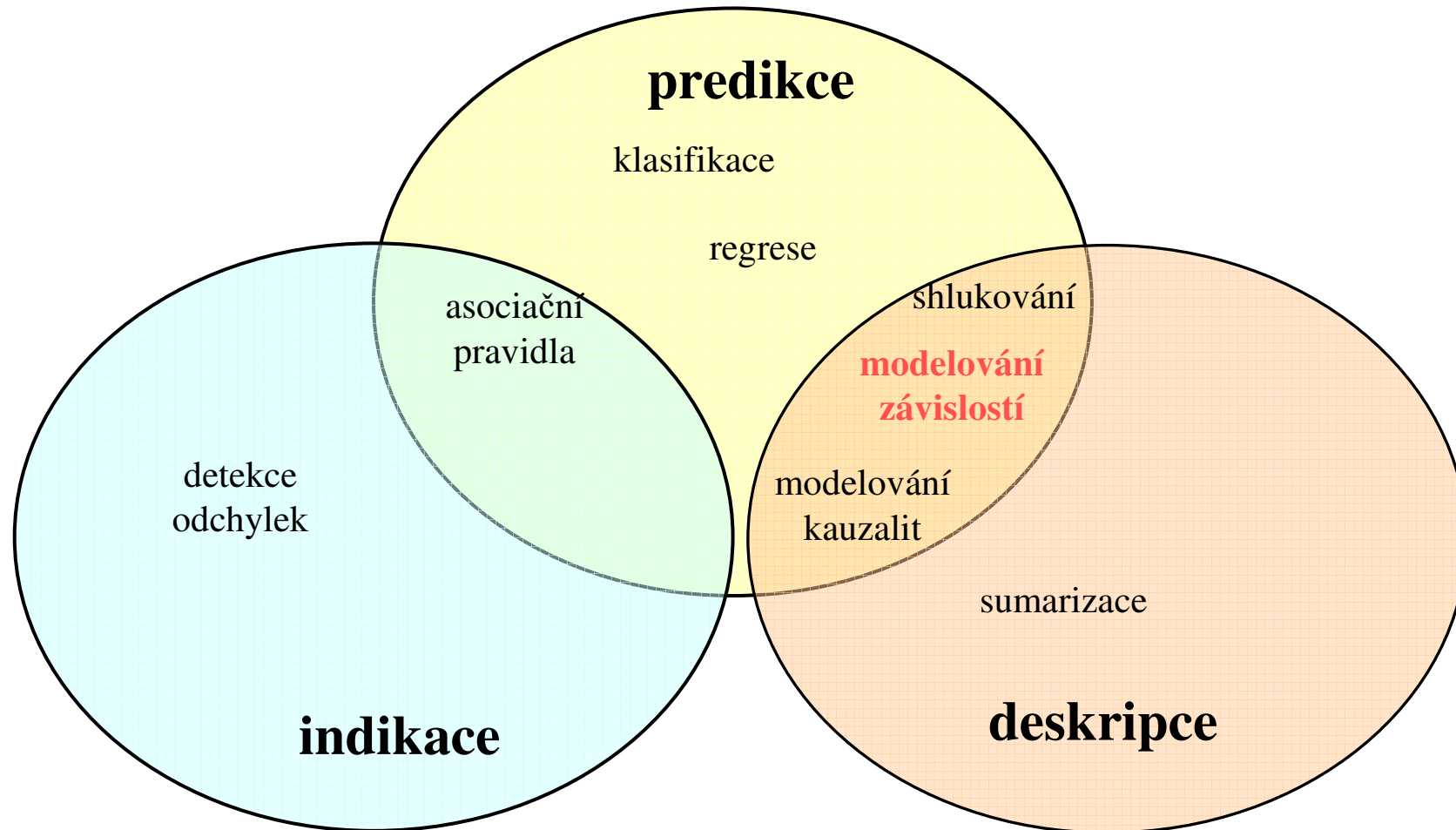
Logický model (*star-schema*) motivačního příkladu



Snowflake schema s tabulkou agregovaných hodnot



Data mining (vytěžování/dolování dat)



Využití nalezených závislosti k predikci

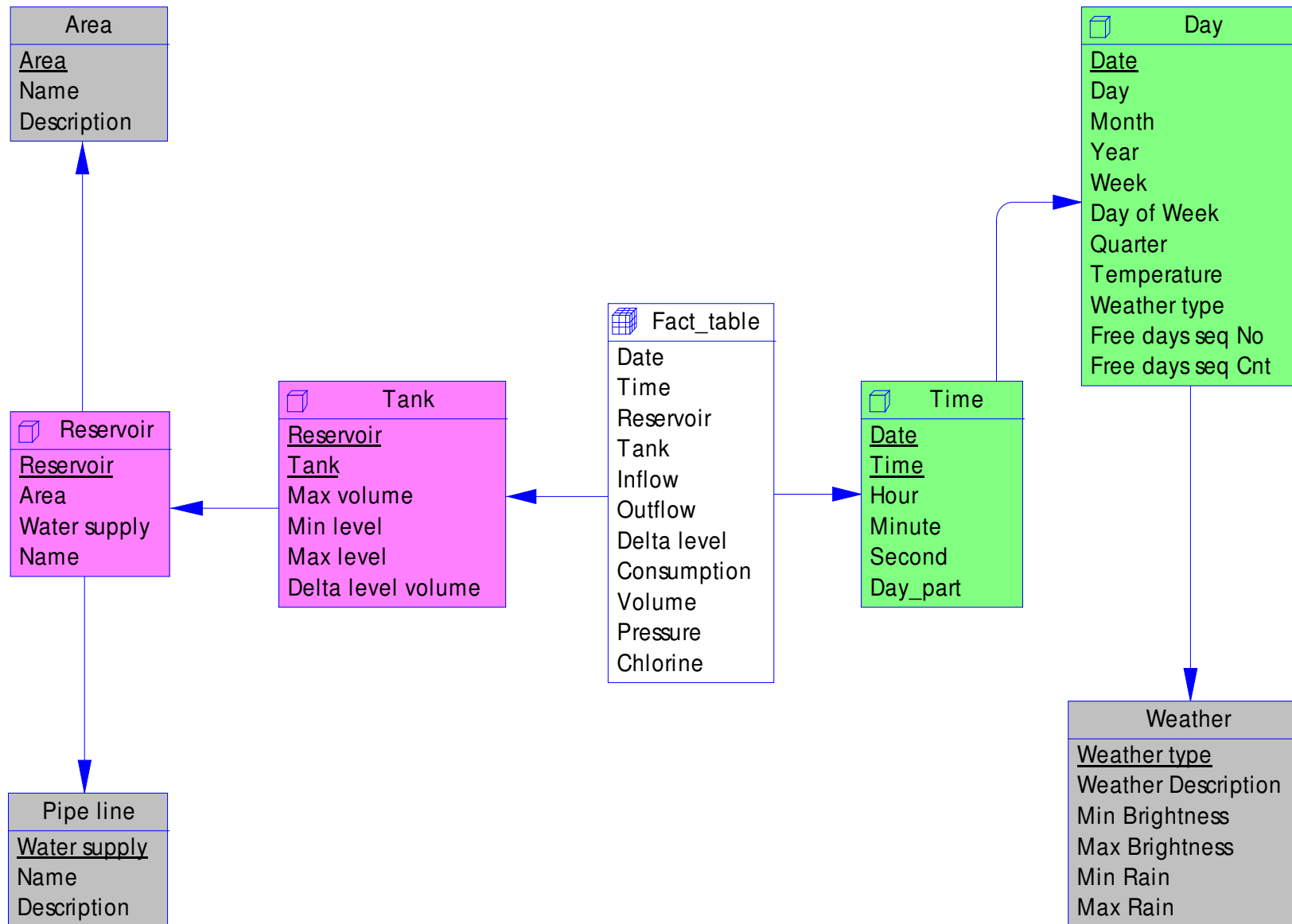
Příklad aplikace datového skladu v predikční úloze:

Predikce spotřeby pitné vody

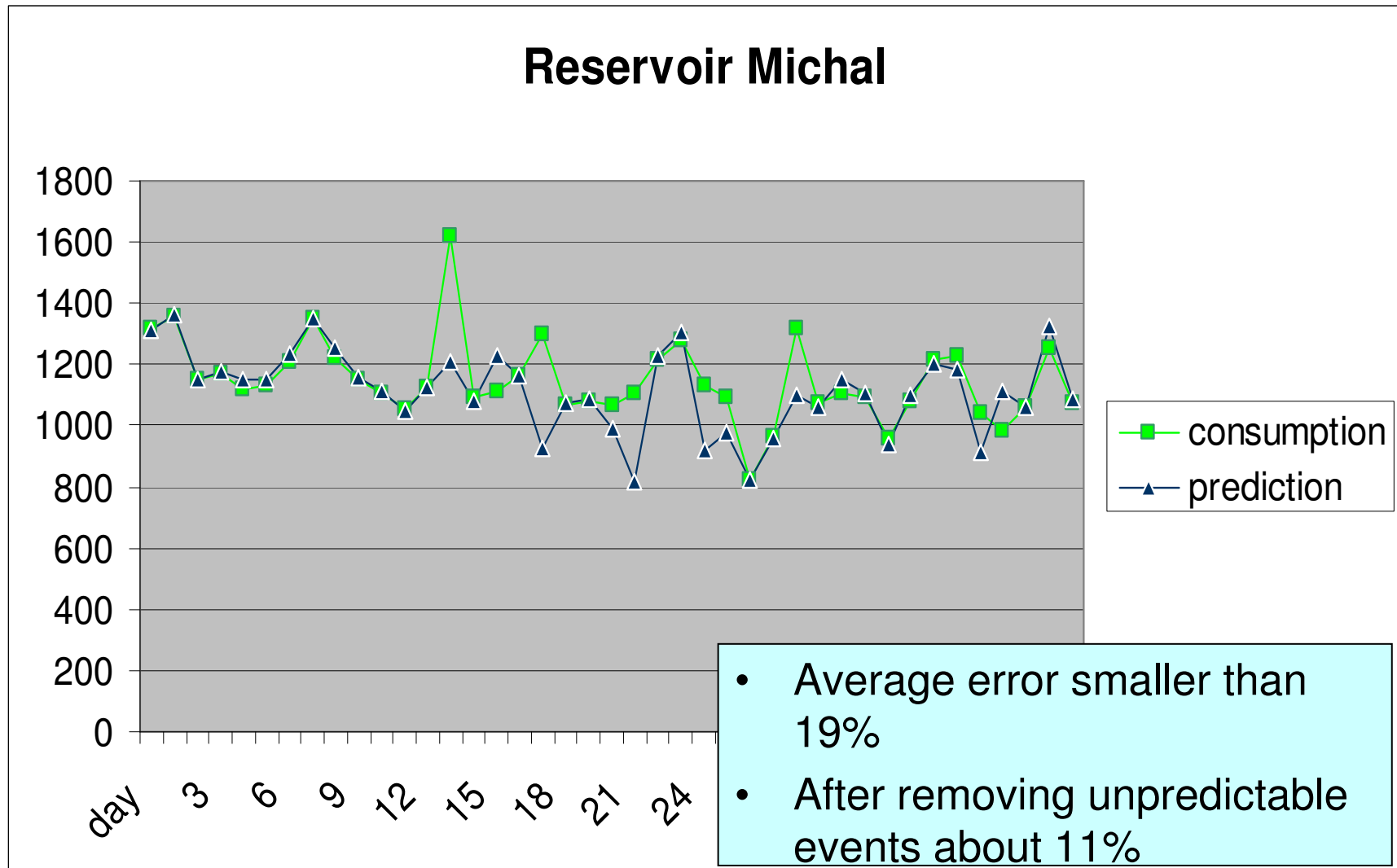
Faktory, které mohou spotřebu ovlivňovat, nalezeny metodami data mining:

- počasí
- den v týdnu
- roční období
- poloha (zahradkářská kolonie/sídliště)

Star schema datového skladu



Výsledky



Moderní trendy databázových systémů

Motivace

- neplatí, že “one size fits all” (RDBMS/SQL)
- Cloud Computing + Big Data boom
- rapidní růst globálních dat
- potřeba efektivně k datům přistupovat
 - data mining
 - stojové učení
 - umělá inteligence

Motivace

1 THE RAPID GROWTH OF GLOBAL DATA

CSC

The production of data is expanding at an astonishing pace. Experts now point to a 4300% increase in annual data generation by 2020. Drivers include the switch from analog to digital technologies and the rapid increase in data generation by individuals and corporations alike.

■ Size of Total Data ■ Enterprise Created Data
■ Enterprise Managed Data

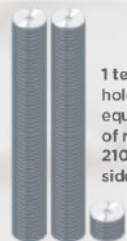
2020: MORE THAN 1/3 OF THE DATA PRODUCED WILL LIVE IN OR PASS THROUGH THE CLOUD.

2012: CUSTOMERS WILL START STORING 1 EB OF INFORMATION.



WHAT IS A ZETTABYTE?

- 1,000,000,000,000 gigabytes
- 1,000,000,000,000 terabytes
- 1,000,000,000,000 petabytes
- 1,000,000,000,000 exabytes
- 1,000,000,000,000 zettabyte



1 terabyte holds the equivalent of roughly 210 single-sided DVDs.

It took roughly 1 petabyte of local storage to render the 3D CGI effects in Avatar.



In 2007, the estimated information content of all human knowledge was 295 exabytes.

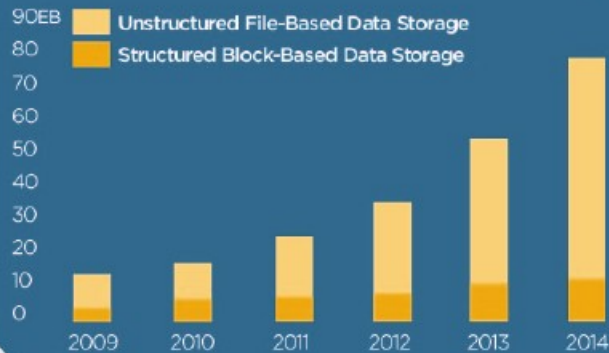
DATA PRODUCTION WILL BE 44 TIMES GREATER IN 2020 THAN IT WAS IN 2009

More than 70% of the digital universe is generated by individuals. But enterprises have responsibility for the storage, protection and management of 80% of it.*

Motivace

2 TAKING ON THE EXPLOSION WITH RADICAL NEW DATABASES

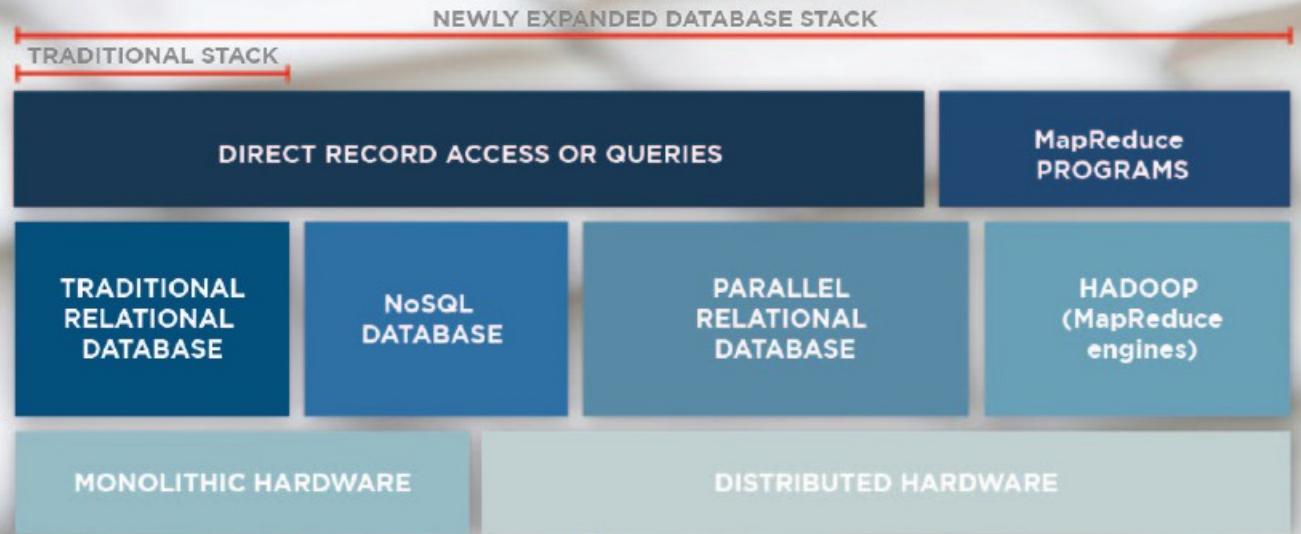
The dramatic rise of unstructured data like photos, videos and social media has ushered in a new breed of non-relational databases that allow data to reveal its own structure and patterns. This shift is a revolutionary change after 40 years of dominance by relational databases – an eternity in the world of IT.



Source: IDC, Worldwide File-Based Storage 2010-2014 Forecast: Consolidation, Efficiency, and Objects Shape Market. #223669



UNSTRUCTURED DATA IS LESS RIGID, LESS ORDERED AND MORE INTERRELATED THAN TRADITIONAL DATA.



Motivace

3 CONNECTING THE DATA DOTS TO MAKE NEW DISCOVERIES

As we make the important shift from collecting to connecting data, businesses are searching for relationships between data sets to reveal valuable new insights.

TODAY, STRUCTURED AND UNSTRUCTURED DATA CAN BE VIEWED FROM MULTIPLE PERSPECTIVES.

These new, unexpected patterns are helping businesses find new solutions to complex problems.

THIS NEW WORLD OF DATA ANALYTICS IS **REVEALING INSIGHTS** IN LITERALLY EVERY FIELD IMAGINABLE



CASE STUDY:

FINDING GENOMES

Using the leading open-source predictive analytics language to sort through 10 GB of data, a biotech company recently isolated 23 optimal genes, thereby creating the first gender-specific diagnostic tests for heart disease.



42,000 blood samples
50,000 genes per sample
1-2 million pieces of genetic information per sample

23 KEY GENES ISOLATED

The evolution of the way we produce, process and analyze data is changing the world around us in fundamental ways. To learn more about how to prepare for what's ahead, download our **DATA rEVOLUTION** white paper at **CSC.com**.

Přehled

- Tradiční RDBMS [1970 →]
 - Oracle [1980 →]
 - PostgreSQL [1995 →]
 - MySQL [1997 →]
- MapReduce (Hadoop) [2005 →]
- NoSQL (not **only** SQL) [2007 →]
 - Databáze klíč-hodnota (Redis)
 - Dokumentové databáze (MongoDB, ale i PostgreSQL)
 - Grafové databáze (Neo4j)
 - (Wide) sloupcové databáze (Cassandra)
 - “fifth NoSQL” – částečně strukturované, MultiValue
- Paralelní/distribuované databáze (Datomic)

36DB2

- připravovaný předmět 36DB2 (OI magistr)
- Big Data a NoSQL databáze
- Princip MapReduce
- Databáze klíč-hodnota, dokumentové, sloupcové
- Grafové databáze
- NewSQL (Traditional RDBMS + NoSQL)
- Cloud computing
- Datové sklady a Big Data