DĚLAT
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B0M33BDT

Big data technologies

Marek Sušický

21. 9. 2022

Agenda

- Class intro - Important information
- Introduction of technologies
- Architectural overview
  - Global overview + insights
- User view
  - How to use the technologies
- Programmer view
  - How to develop big data applications
- Business view
  - Data Science as a motivation for Big Data
- Real world view

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Class intro

Important links

- **Courseware**
  - https://cw.fel.cvut.cz/b221/courses/b0m33bdt/start?animal=b221
  - Lessons
- **Description**
  - https://www.fel.cvut.cz/cz/education/bk/predmety/47/73/p4773206.html
- **Excercise storage**
  - GitHub - https://github.com/profinit/BDT
  - Trainings, solutions, links to guides
  - Will be updated
- **Metacentrum – computational cluster**
  - https://www.metacentrum.cz/cs/Sluzby/Hadoop/
  - Ask for access !
  - Still not confirmed !!!

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Lectures

"So what am I doing here—knighting, beheading, or what?"

English x Czech ?

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Lectures

- **Intro, organization, motivation**
  - Organizational stuff
  - Big Data
  - Big Data and Data Science
  - Big Data applications
- **Architecture**
  - Hadoop, distributions, resource management YARN, etc.
- **Storage**
  - HDFS, file formats, compression, HIVE, Impala
- **Map-reduce**
  - SQL relations, paradigm
- **Apache Spark**
  - Distributed processing
  - Streaming
- **Apache Kafka**

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Lectures

- **Cloud Big Data technologies**
  - **Azure**, AWS
  - Serverless principles
- **Elastic**
- **Big Data Science a Data architectures**
  - page rank, colaborative filtering, SNA
  - Big Data solutions

"So what am I doing here—knighting, beheading, or what?"

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Practices

- **First steps**
  - Connection, tests, work with filesystems, HDFS
- **Refresh of necessary prerequisities**
  - Linux, shell utility, SQL, Python
- **Hive**
  - Tables, int./ext., create, manage, queries, partitions
- **Spark**
  - Spark intro, transformactions and actions
  - Two approaches: RDD (map-reduce) a SQL (data frame)
- **Cloud**
  - Azure first steps
- **Test**
  - Real tasks processing with help of selected technologies

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Timeschedule – change from the last year

- **Classical even – odd weeks**
- **Odd week**
  - Lectures Wed: 9:15-10:45 KN:E-126
- **Even week**
  - Lectures Wed: 9:15-10:45 KN:E-126
  - Practices: 2 11:00-12:30 and 12:45-14:15 KN:E-307

- Possible switch to online if COVID19 …
  - Your opinion?

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Timeschedule – draft plan

Týden	Typ	Lekce	Obsah	Zodpovědná osoba	Poznámka
1	S	Přednáška	**Organizace přednášek, klasifikační požadavky** **Motivace, přehled, aplikace,**	@Susicky Marek	21.9.2022
2	L	Přednáška	státní svátek		28.9.2022
2	L	Cvičení	státní svátek		28.9.2022
3	S	Přednáška	**Storage (HDFS, Hive, Impala), Map+reduce – paradigma a implementace**	@Susicky Marek	5.10.2022
4	L	Cvičení	**První kroky na clusteru - metastore**	@Benešová Alisa @Fedotov Daniil	12.10.2022
4	L	Přednáška	**Hadoop, architektura clusteru**	@Susicky Marek	12.10.2022
5	S	Přednáška	Import dat - NiFi, (Kafka minimalne), **Big Datové Architektury a security**	@Susicky Marek	19.10.2022
6	L	Cvičení	**HDFS + Hive**	@Duda Tomáš @Fedotov Daniil	26.10.2022
6	L	Přednáška	**Spark basic - rozsirit o neco ze Spark adv.**	@Vonášek Josef - @Duda Tomáš	26.10.2022
7	S	Přednáška	**Streaming (Spark streaming atd.)**	@Vonášek Josef @Duda Tomáš	2.11.2022
8	L	Cvičení	**Spark + průběžný test (10 min) + zadání domácí úlohy**	@Vonášek Josef @Fedotov Daniil	9.11.2022
8	L	Přednáška	Kafka a její ekosystem	@Vonášek Josef	9.11.2022
9	S	Přednáška	**Cloudové technologie - obecně, Terraform - na priste Azure naklikat**	@Benešová Alisa , @Susicky Marek ?	16.11.2022
10	L	Cvičení	**Cviceni Azure - console, ukazka, komponenty, navazano na 10 - uloha**	@Benešová Alis @Fedotov Daniil	23.11.2022
10	L	Přednáška	**Azure (zejmena komponenty pro cviceni) + BigData stack**	@Benešová Alisa	23.11.2022
11	S	Přednášk-workshop	Azure - databricks - napojeni na Kafku apod ?		30.11.2022
12	L	Cvičení	**Spark Structured Streaming**	@Duda Tomáš @Fedotov Daniil	7.12.2022
12	L	Přednáška	**Serverless architektury - AWS ??? z MSD ?**	@Susicky Marek	7.12.2022
13	S	Přednáška	**Elastic - včetně OS varianty**	@Ulitin Valerii	14.12.2022
14	L	Cvičení	**Závěrečný praktický test**	@Fedotov Daniil	11.1.2023
14	L	Přednáška	**Big Data Science**	@Paščenko Petr	11.1.2023

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General warning

- This is not the first year of this lecture
- We will change approx. one third of the agenda
- You can use materials from the past but keep in mind that it is not enough

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Cloud – IMPORTANT!

- We have some lectures about cloud/Azure
- It is necessary to have Microsoft credits
- If you've used it in the past, let us know, there should be some solution

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1st practice - IMPORTANT!

- It is necessary to have metacentrum account !
- 12.10.2022

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How to get credits?

- **Get at least 50 points from 100**

1. Tests and homeworks
   - Small theory test, max. 20 points
   - Homework – 20 points
   - Final practice and theory test, max. 20 points

- Exam
  - 20 points - teoretical questions
  - 20 points – oral exam
  - Some basic questions can cause sudden death

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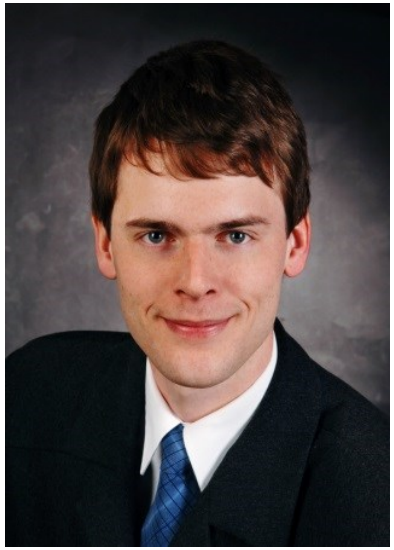
Mentors

Marek Sušický



- Skills
  - Databases – Oracle, PostgreSQL, graph dbs
  - Security, fraud, networks
  - Big data
- Experience
  - 12 years in Profinit
  - Work for large banks, telco operators, Prague airport
  - Experience from international teams

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Other colleagues (but not less important :)

- Josef Vonášek
- Tomáš Duda
- Alisa Benešová
- Daniil Fedotov
- Petr Paščenko

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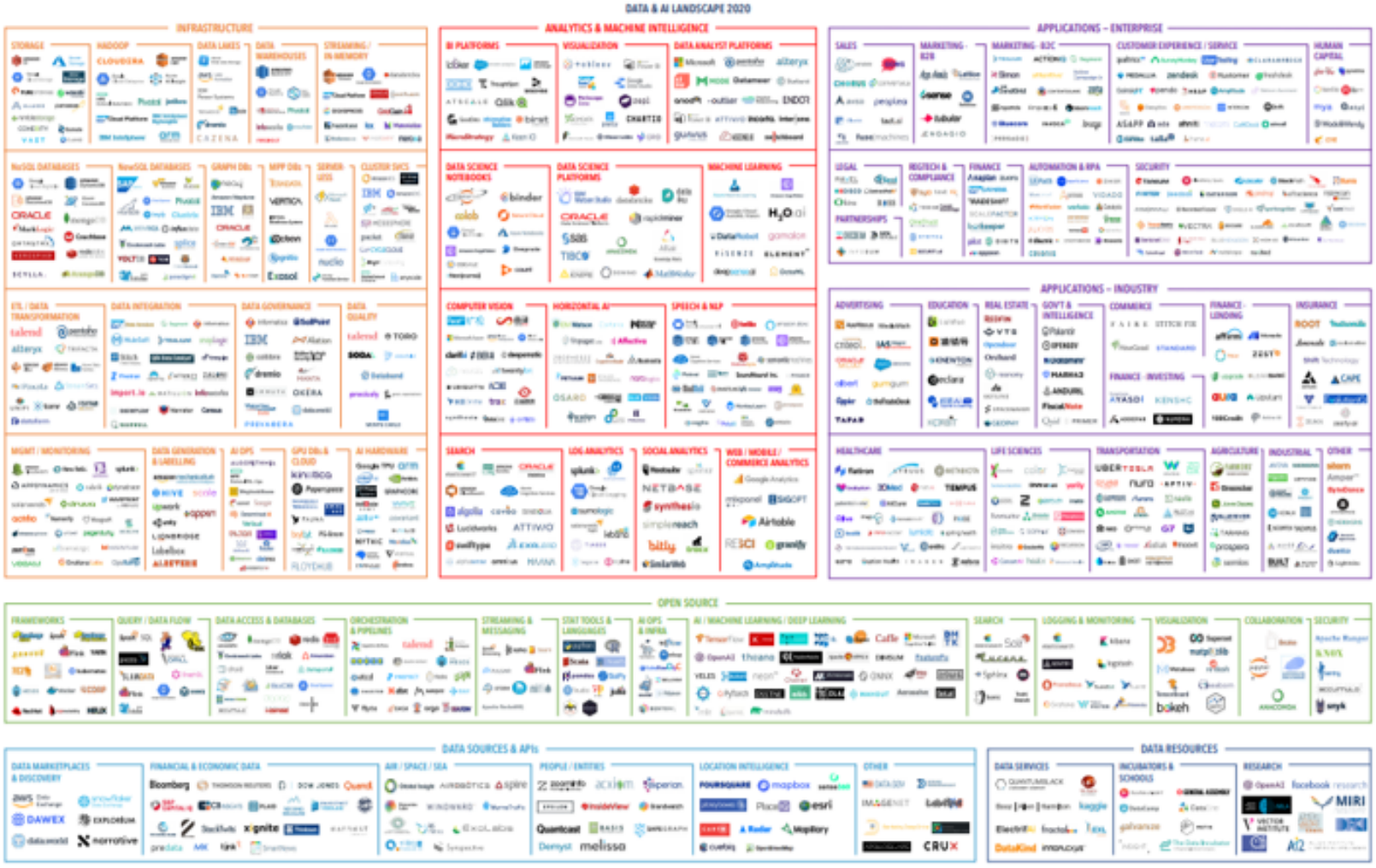
Big Data

Big Data?

› It is complicated…

Big Data?


DATA & AI LANDSCAPE 2020
INFRASTRUCTURE
ANALYTICS & MACHINE INTELLIGENCE
APPLICATIONS – ENTERPRISE
APPLICATIONS – INDUSTRY
OPEN SOURCE
DATA SOURCES & APIs
DATA RESOURCES
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Big Data?

- That’s the reason why to have multiple mentors
- We’d like to cover a typical technologies that you can meet during your work
- After this class you should have rough overview and not detailed knowledge

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Big Data – driving factors

Trend movements:

- Data
  - From small to large
  - From simple to complex
- Databases
  - From files to distributed clusters
- Programming
  - From procedural to functional

  frameworks
- Data Science
  - From chosen statistics to detailed contextual analysis

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Data

A Very Short History Of (Big) Data

Gil Press for forbes

- **1944:** Fremont Rider, Wesleyan University Librarian
  - „ American university libraries were doubling in size every sixteen years.“
  - „Yale Library in 2040 will have approximately 200,000,000 volumes, which will occupy over 6,000 miles of shelves“
- **1961:** Derek Price, Science Since Babylon
  - „the number of new journals has grown exponentially rather than linearly, doubling every fifteen years and increasing by a factor of ten during every half-century.“
  - „Each scientific advance generates a new series of advances at a reasonably constant birth rate, so that the number of births is strictly proportional to the size of the population of discoveries at any given time. “
- **1975:** The Ministry of Posts and Telecommunications in Japan
  - „information supply is increasing much faster than information consumption“
  - „the demand for information provided by mass media, which are one-way communication, has become stagnant, and the demand for information provided by personal telecommunications media, which are characterized by two-way communications, has drastically increased.“

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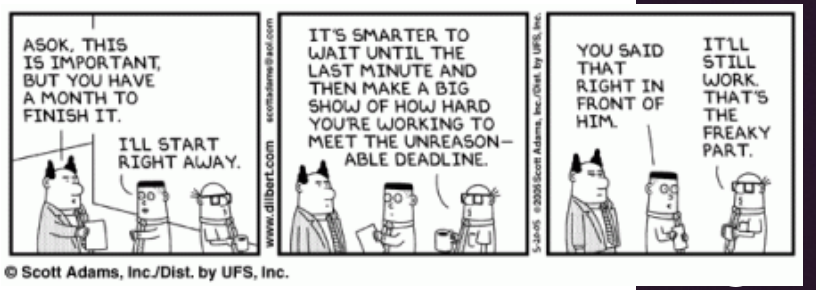
A Very Short History Of Big Data

Gil Press for forbes

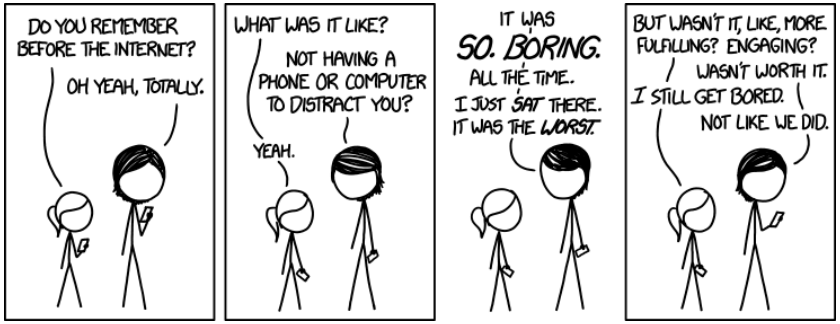


- **1980:** I.A. Tjomsland, Fourth IEEE Symposium on Mass Storage Systems
  - „Parkinson's 1st Law paraphrased: Data expands to fill the space available."
  - „The penalties for storing obsolete data are less apparent than are the penalties for discarding potentially useful data."
- **1986:** Hal B. Becker, Can users really absorb data at today's rates?
  - „The recoding density achieved by Gutenberg was approximately 500 symbols per cubic inch – 500 times the density of [4,000 B.C. Sumerian] clay tablets. By the year 2000, semiconductor random access memory should be storing 1.25×10^{11} bytes per cubic inch." – po pravdě o řád přestřelené v roce 2017
- **1996:** B.J. Truskowski, The Evolution of Storage Systems
  - Digital storage becomes more cost-effective for storing data than paper.
- **1997** Michael Cox and David Ellsworth
  - „Data sets are generally quite large, taxing the capacities of main memory, local disk, and even remote disk. We call this the problem of *big data*. When data sets do not fit in main memory (*in core*), or when they do not fit even on local disk, the most common solution is to acquire more resources. "

A Very Short History Of Big Data

Gil Press for forbes

- **1997** Michael Lesk, How much information is there in the world?
  - „In only a few years, (a) we will be able [to] save everything–no information will have to be thrown out, and (b) the typical piece of information will never be looked at by a human being.“
- **1998:** K.G. Coffman and Andrew Odlyzko
  - „ the growth rate of traffic on the public Internet, while lower than is often cited, is still about 100% per year, much higher than for traffic on other networks.“



- **2000: Big Data Era**
  - „the world produced about 1.5 exabytes of unique information, or about 250 megabytes for every man, woman, and child on earth. It also finds that “a vast amount of unique information is created and stored by individuals” (what it calls the “democratization of data”) and that “not only is digital information production the largest in total, it is also the most rapidly growing.“

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A Very Short History Of Big Data – summary

- The amount of data is rising exponentially, the same with transfer capacity
- The data supply is rising faster than the demand
- In communication prevails bidirectionality and active role of users
- It is easier to store data than sort them and delete them

- Storage capacity grows and data just fill it – we can store almost everything
- Data files can be larger than one data device / medium
- **Average information is not read by human**

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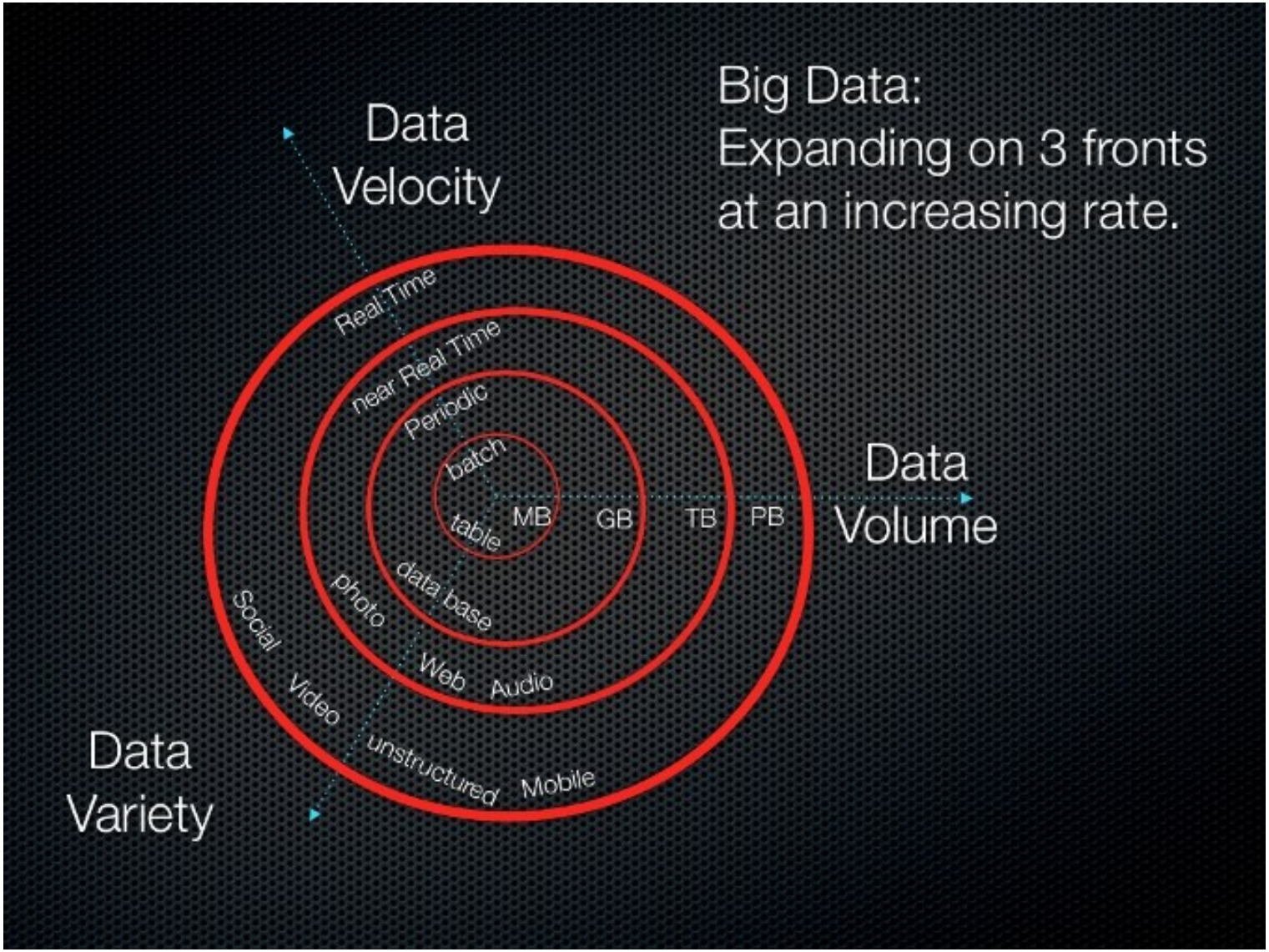
Big Data Definition – 3V



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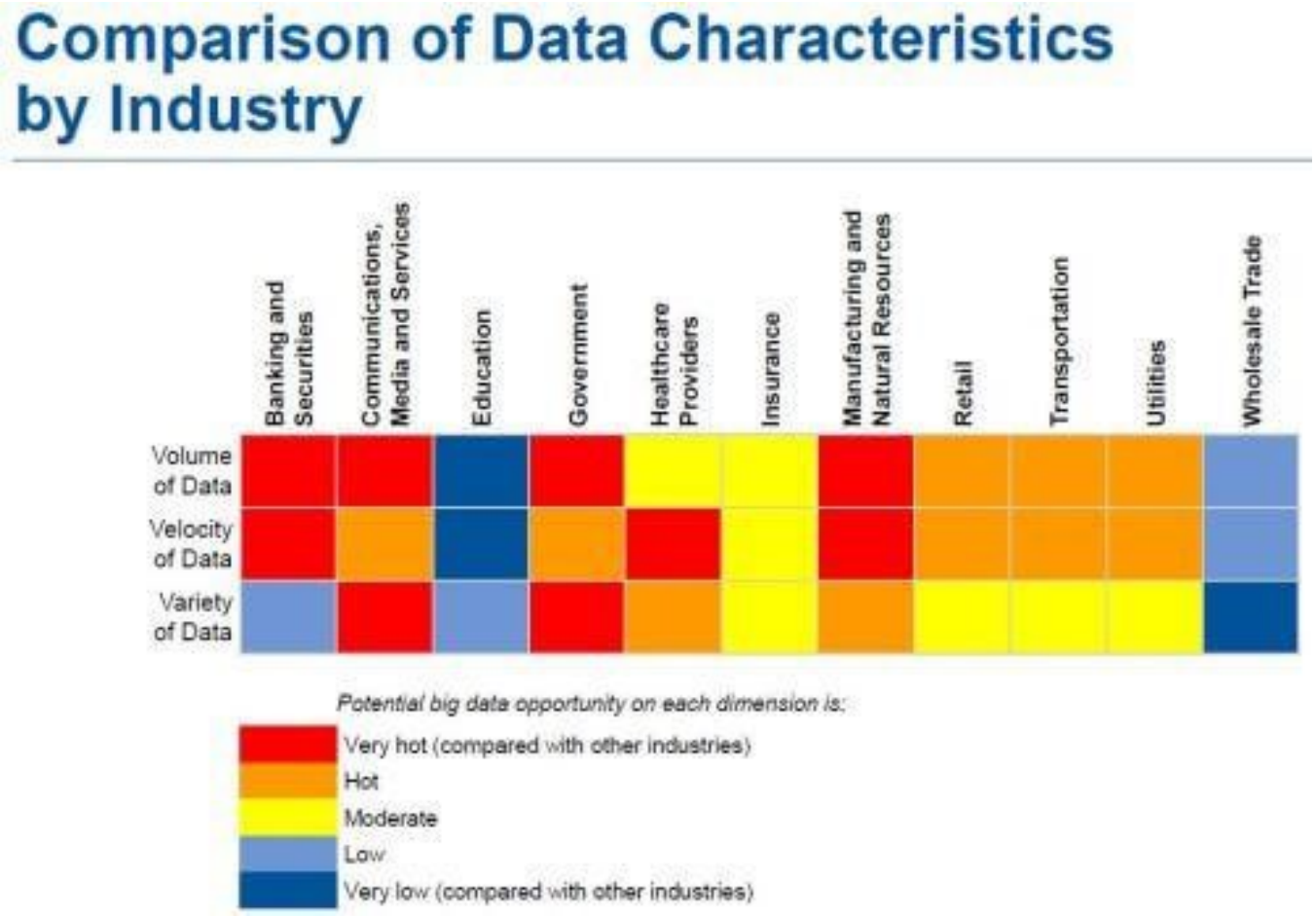
Big Data Definition – 3V

- Volume, Velocity, Variety



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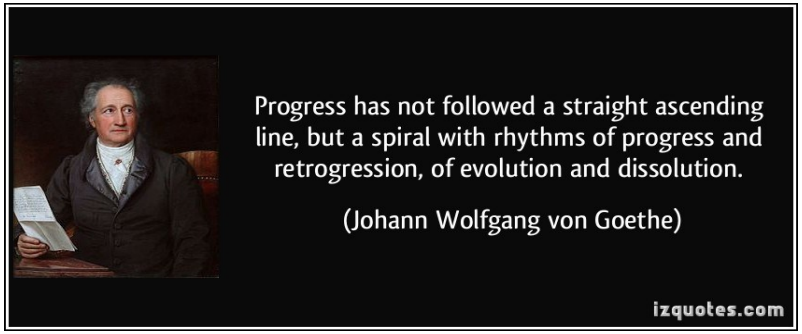
Databases

History of databases



- **40' – Ad hoc data streams**
  - Punch cards and tapes
- **50' – File System**
  - Files and folders with hierarchical structure and unique path
  - Media independence (tape, disk, …)
- **60' – DBMS**
  - Tables and indexing: hashing, B-trees. Client/server architecture
- **70' – R-DBMS**
  - Relational paradigm: normal forms, relational algebra, selection, projection, etc.

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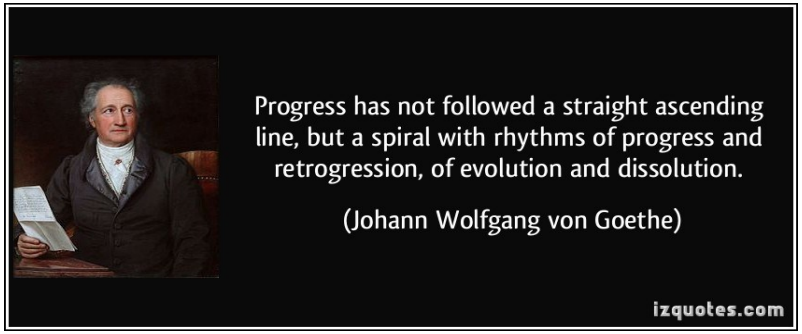
History of databases



- **80'– SQL**
  - Unified query language, proprietary databases
- **90' – Data warehouses**
  - Data integration, one thruth, analytical reporting
- **0' – NoSQL**
  - Web programming, graph databases, first clouds
- **10' – Big Data and cloud**
- **20' – Cloud**

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RDMS vs Big Data

	RDBMS	Hadoop
Size	GB, TB	TB, EB, PB
Access	Interactive and batch	Batch only
Queries	SQL + addons	Map-Reduce a SQL emulation
Changes	Repeatable rw	Write once, repeatable read
Structure	static database schema	dynamic schema
Integrity	ACID	no
Performance	Limited, optimization needed	„Linear“
Latency	minimal (ms)	high (dozens of seconds)
HW	Well tuned expensice	Commodity HW
License	Commercial, expensive	open source + support
Paralelization	Limited and expensive per core	Yes

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Programming

Programming – history of abstraction

- Procedural programming
  - Specify the order of commands
- **Unstructured paradigm** (<= 80')
  - Asembler instructions and conditional jumps – goto era
- **Structured paradigm** (circa 60'-80')
  - Functions grouped to libraries
- **Object paradigm** (circa 90')
  - Connect functions and data to objects, inheritance, polymorphismus
- **Virtualization** (circa 0')
  - Split programmer from specific OS a HW
- **The main idea**
  - Improve the level of abstraction (compiler, linker, vm)
  - Remove the complexity from the bottom – libraries can cover lowlevel tasks
- Problem: the complexity is everywhere, not only bottom

Paralel framework

- Paralel program issue – complexity comes from above
  - It is necessary (recommended) to define the algorithm as a parallel from the beginning
  - It is hard to maintain the program, debug it, optimize it and tune it
- **Framework improvements** (present)
  - Framework is a skeleton that describes the structure of the algorithm
    - For example quick-sort with user comparator
  - Programmer has to put his code to defined places – inheritance or templating can be used
  - Programmer can partially omit the complexity
  - Event driven programming, web frameworks, Tensorflow for neural networks, Map-Reduce paradigm etc.
- Paralel libraries (MPI, BSP, OpenMP …)
  - Universal frameworks have full power but don't solve algorithm complexity
- **Map-Reduce** paradigm
  - Limited functionality for data processing
  - But the structure is easy to understand

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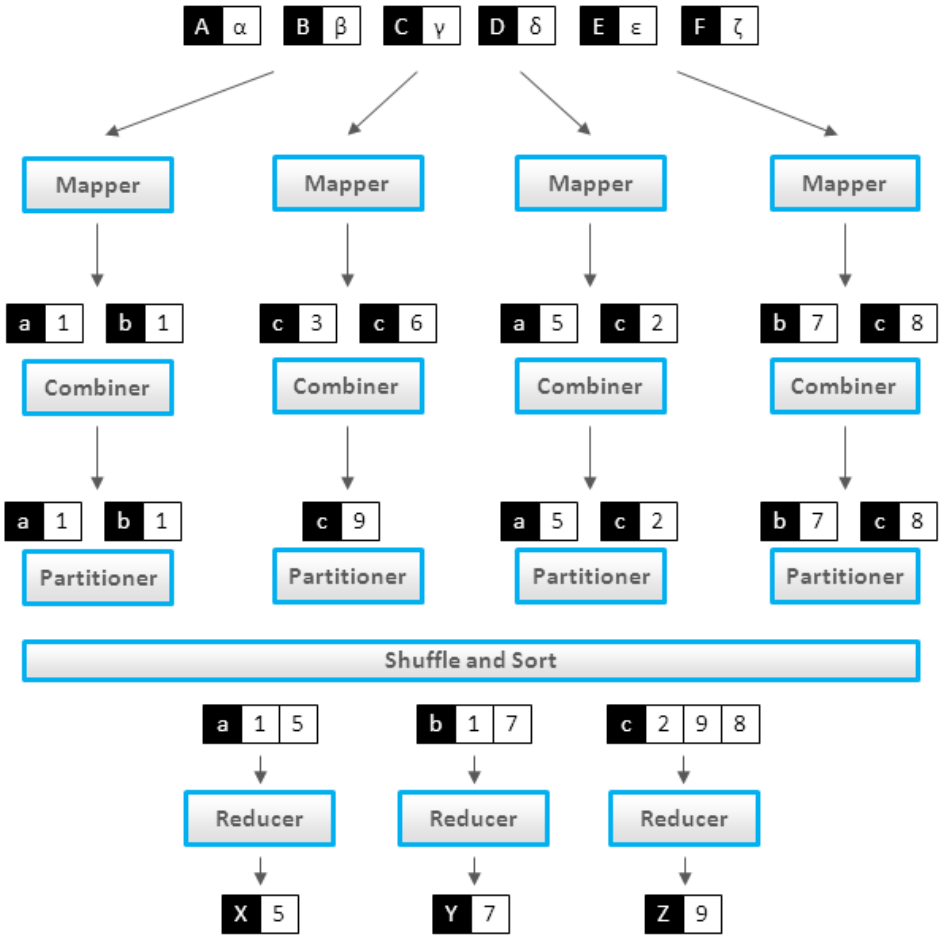
Map-Reduce

- Algorithm is known
- Add method implementation
- Map
  - Build pairs <key,val>
- Combine*
  - It is possible to merge pairs with the same key to save network transfer
- Shuffle and Sort
  - Transfer between nodes
- Reduce
  - Result aggregation
- Functions can be complex
- Algorithm = chain Map and Reduce



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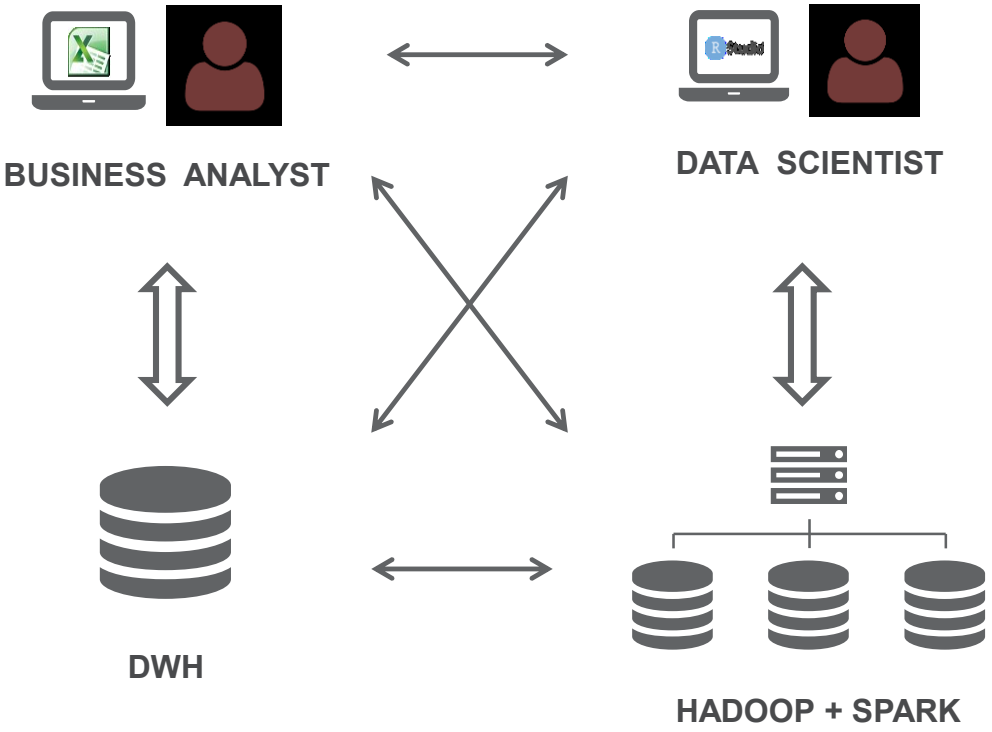
Data Science

Big Data and Data Science

DWH is to Business Intelligence

like

Big Data to Data Science



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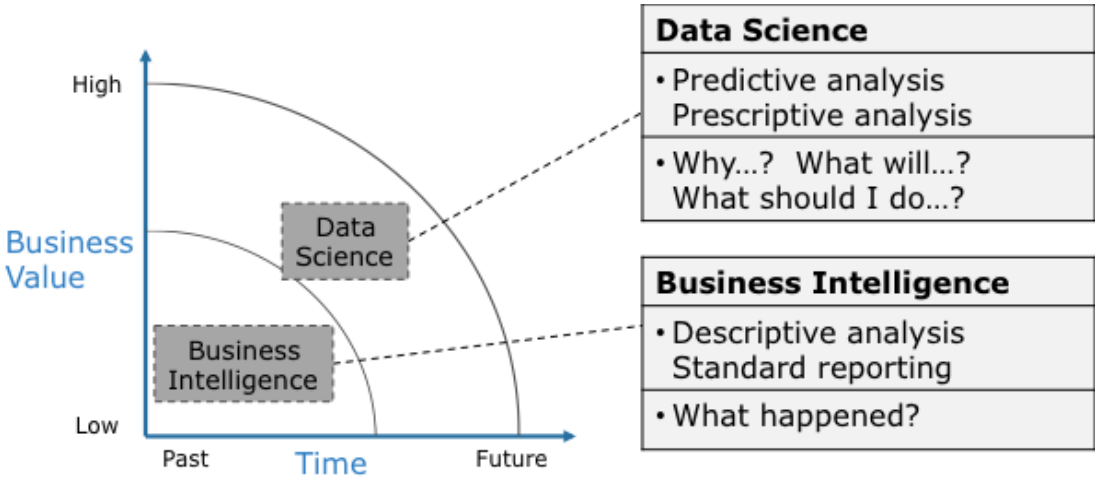
Data Science

- Specialization merge
  - Statistics, informatics, Data mining, machine learning, AI
- Data Science versus Business Intelligence
  - BI: How many pens we sold in September?
  - DS: How many will we sell in October?
- Work with uncertainty, probabilistic result
  - Predictive modelling
  - Segmentation, clustering
  - Similarity modelling, collaborative filtering, recommendation
  - Anomaly detection
  - Text-mining,
  - Web-mining,
  - Image processing,
  - SNA,
  - etc.



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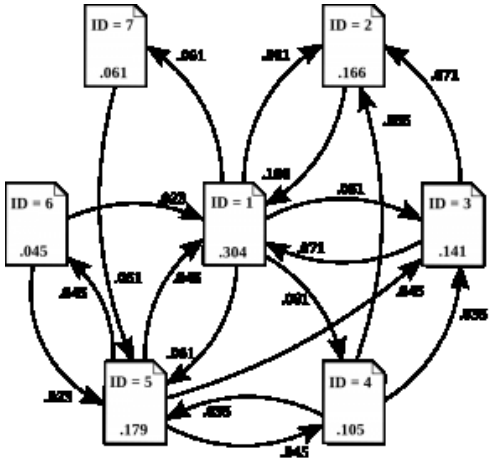
Google

- Google is not searching but sorting
- 100T+ pages with much more links
- Fulltext search
  - Crawlers crawling and indexing – engineering task
  - User enters a query (word, phrase) and the result is list of pages
- In which order should they appear?
  - What about the relevancy?
- Google Pagerank
  - Interactive method for page ranking
  - Pages are nodes, links are edges
  - Markov chains with conditions
  - Sparse matrix multiplication
  - Spark implementation



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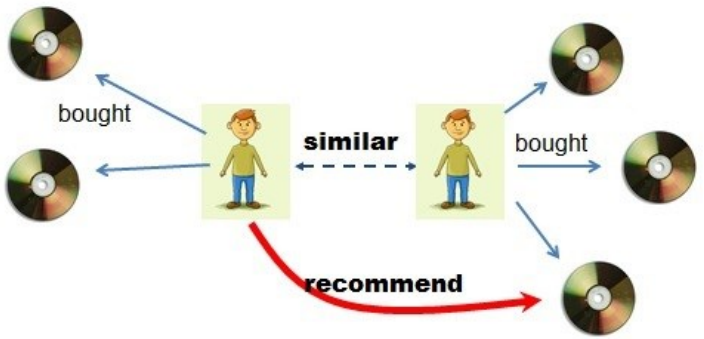
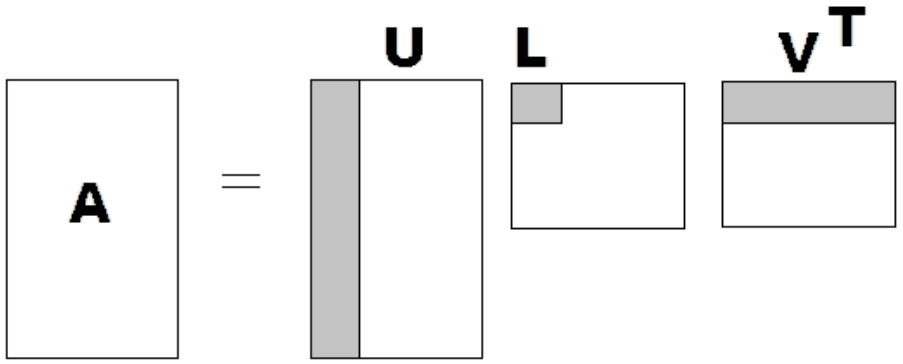
Amazon, Netflix, YouTube

- Recommendation
  - You saw these 10 movies, watch this one
  - When you buy Babička, offer Broučci
- Two approaches
  - Goods similarity
  - Customer similarity
- Collaborative filtering
  - Singular Value Decomposition
  - Alternating Least Squares (Spark)
- A – matrix client x product
- U – matrix client x factor
- L – matrix factors
- V – matrix factor x product
- Multiply it again
  - Recommend the missing





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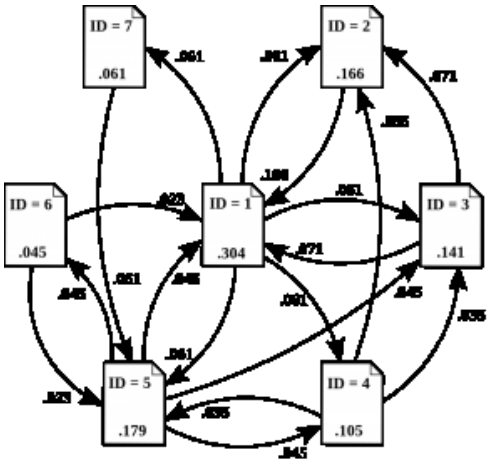
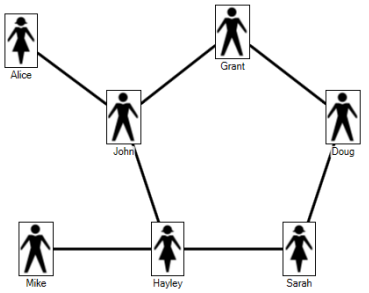
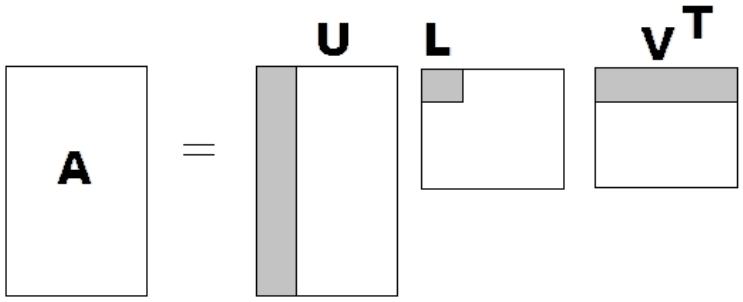
Big Data Science - summary

- Google
  - Google is not searching but sorting
  - 1G pages with much more links
  - How to sort them?
  - Big Data algorithm PageRank
    - Find own vector of the large matrix
- Amazon, Netflix, YouTube
  - How to recommend?
  - When you buy Babička, offer Broučci
  - Big Data Algorithm Colaborative filtering
    - Singular Value Decomposition
- Facebook
  - Which content to show?
  - Combination
    - SNA – friends
    - Collaborative filtering – like
- What about banks?







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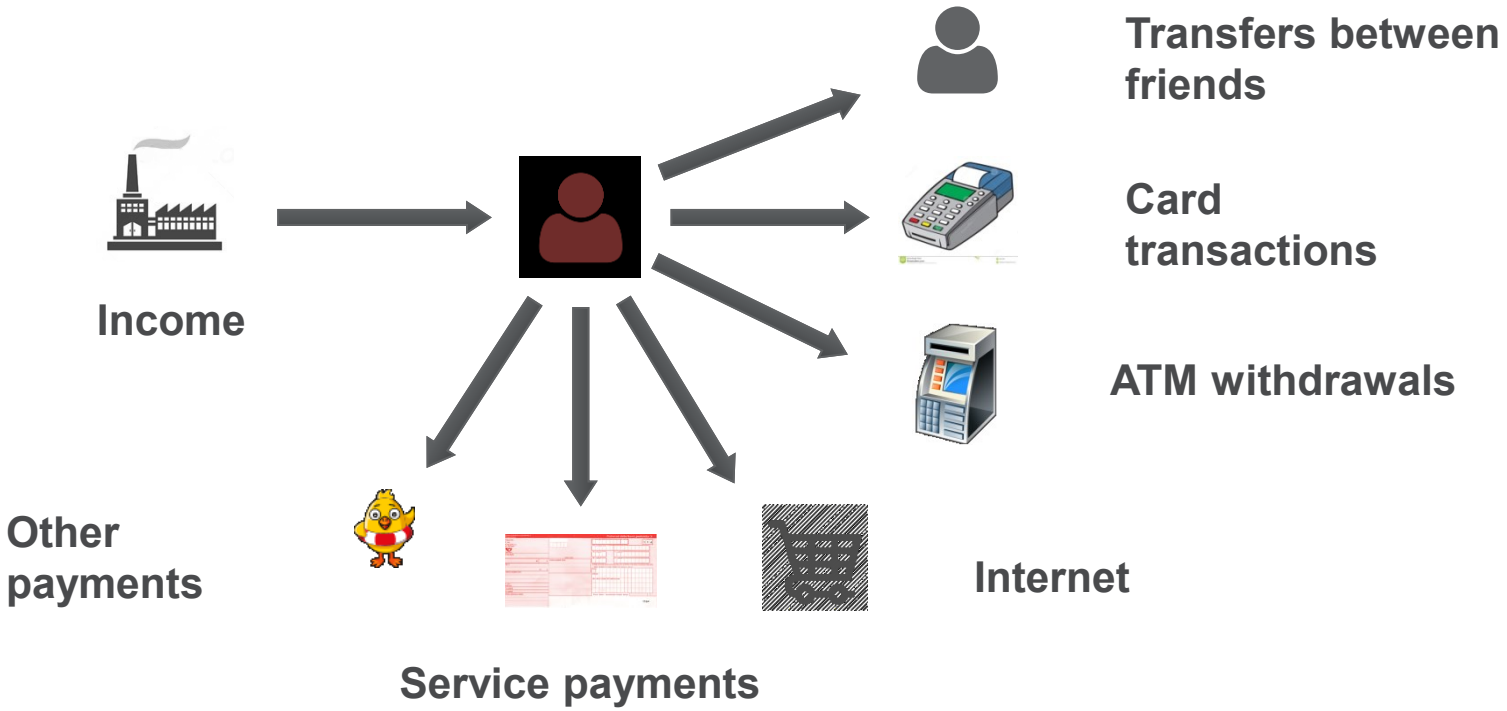
„Czech“ reality

Big Data transactional analysis

- We create models for retail banks
- Input – financial transactions
- Output – valuable information, events, labels
- The main goal is to enrich the standard process with new knowledge



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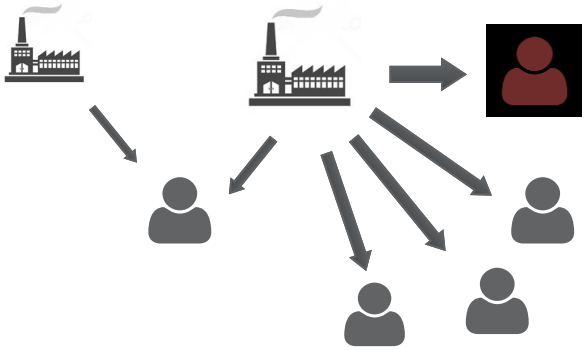
Salary detector



- Input
  - Financial transactions – company- client
- Output
  - Relations – employer - employee
- Business case
  - Risk score, event detection, similarities (c2c/b2b),…
- Principles
  - Detect transactional patterns, text mining, advanced statistics
- High accuracy not only for large corporations, but for
  - Short contracts – lenght under 3 months
  - Notstandard contracts (part-time jobs, contractors etc.)
  - Small businesses

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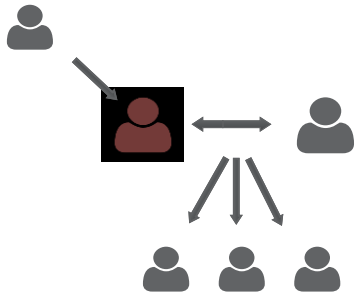
Household detection – Bank/Telco



- Input
  - Client transactions – bank (c2c, card transactions,…)
  - Network information – telco (cdr, location, billing)
  - Basic demografy (age, sex, address, surname,…)
- Output
  - Identified household members and family relations
- Business opportunities
  - Family marketing, robust risk score,…
- Principles
  - Detect the patterns, transaction analysis, text mining

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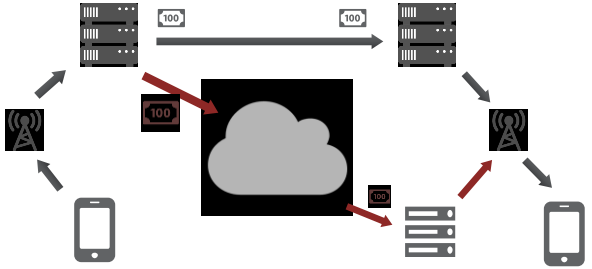
Telco Big Data SimBox Fraud



- Scenario
  - Foreign operator is cheating and using VoIP to save money for the interconnection fees
- Input
  - Telco, network data (cdr, location, billing)
- Output
  - Suspected SIM cards detected
- Principles
  - Detect unusual behavior of SIM cards
  - Identify groups with the same behavior
  - Automatic detection with roaming data

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Data masking - UMT

- Universal masking tool
  - Pseudonymization
  - Anonymization
  - Spark is used
  - “Back to school” – math (bijection, encryption, etc.)

Goal is to create good testing data that are safe and fully compliant with regulations

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Automotive – our competitor

- Warranty fraud
  - Detect fraudulent claims
  - Type of the claim x country
- Automation, IoT analysis

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Summary

Summary

- Check the links
- Ask for Metacentrum access
- Check if you have still Microsoft credits

- It is not possible to cover all technologies
- Most used will be covered
  - But the world is still changing

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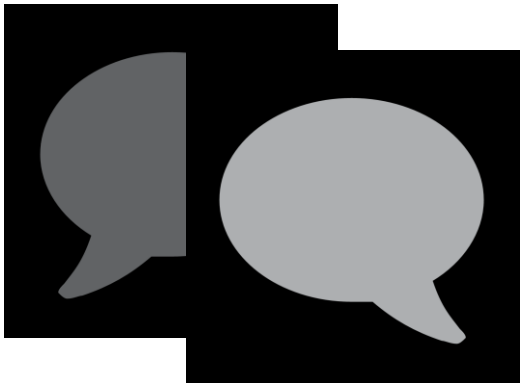

Dotazy