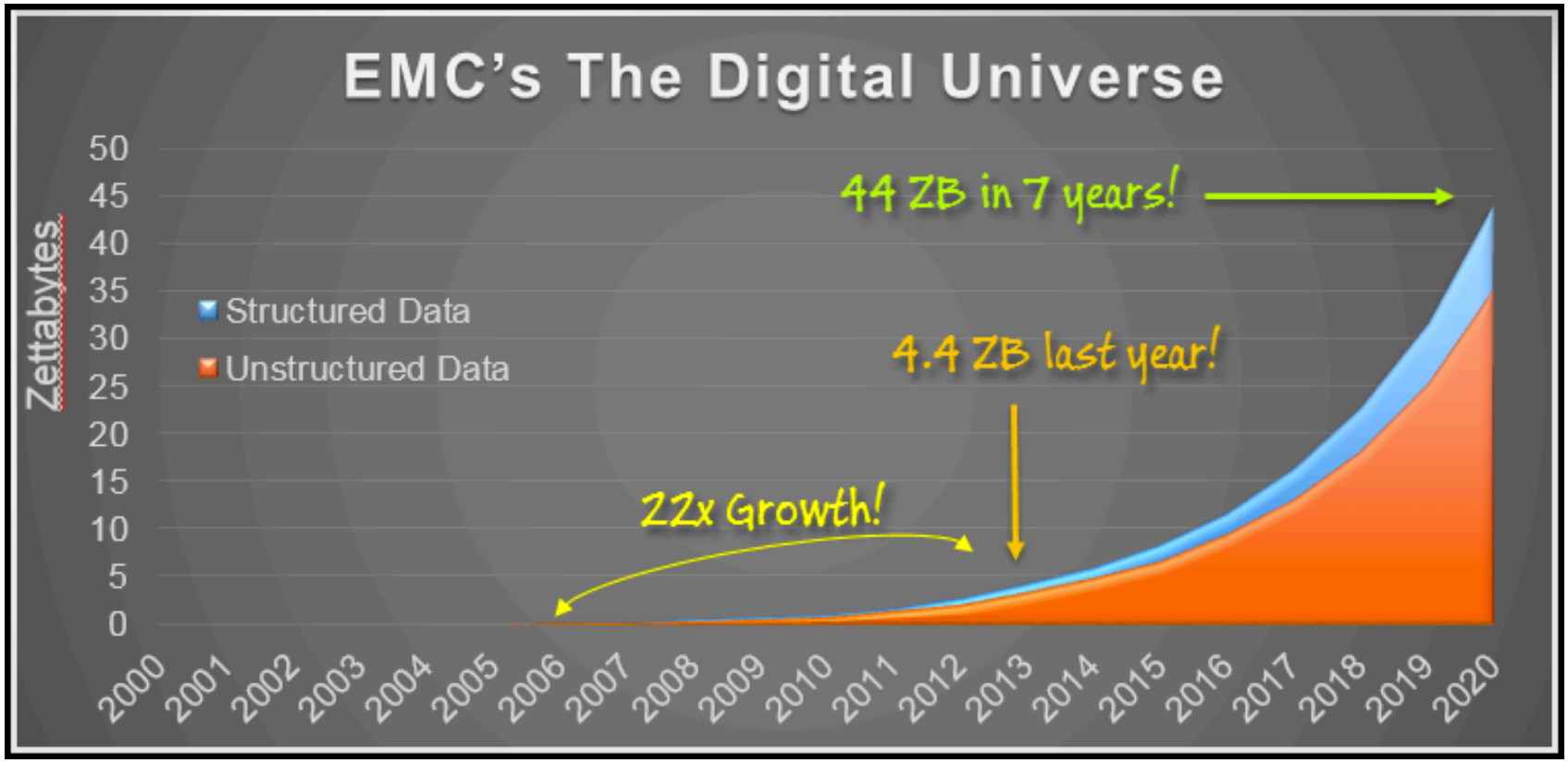
Introduction to big data management and processing

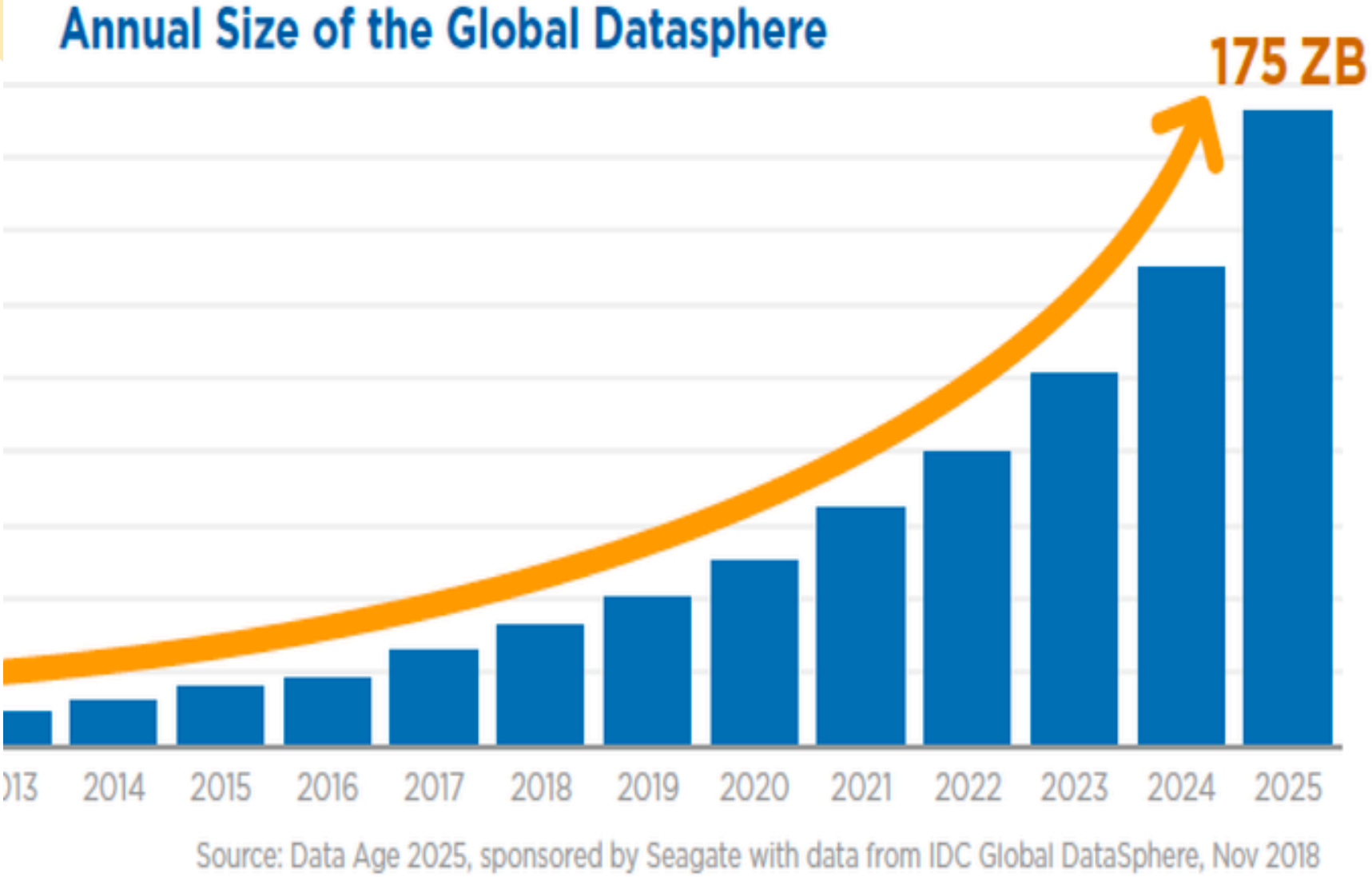
Viet-Trung Tran

Syllabus

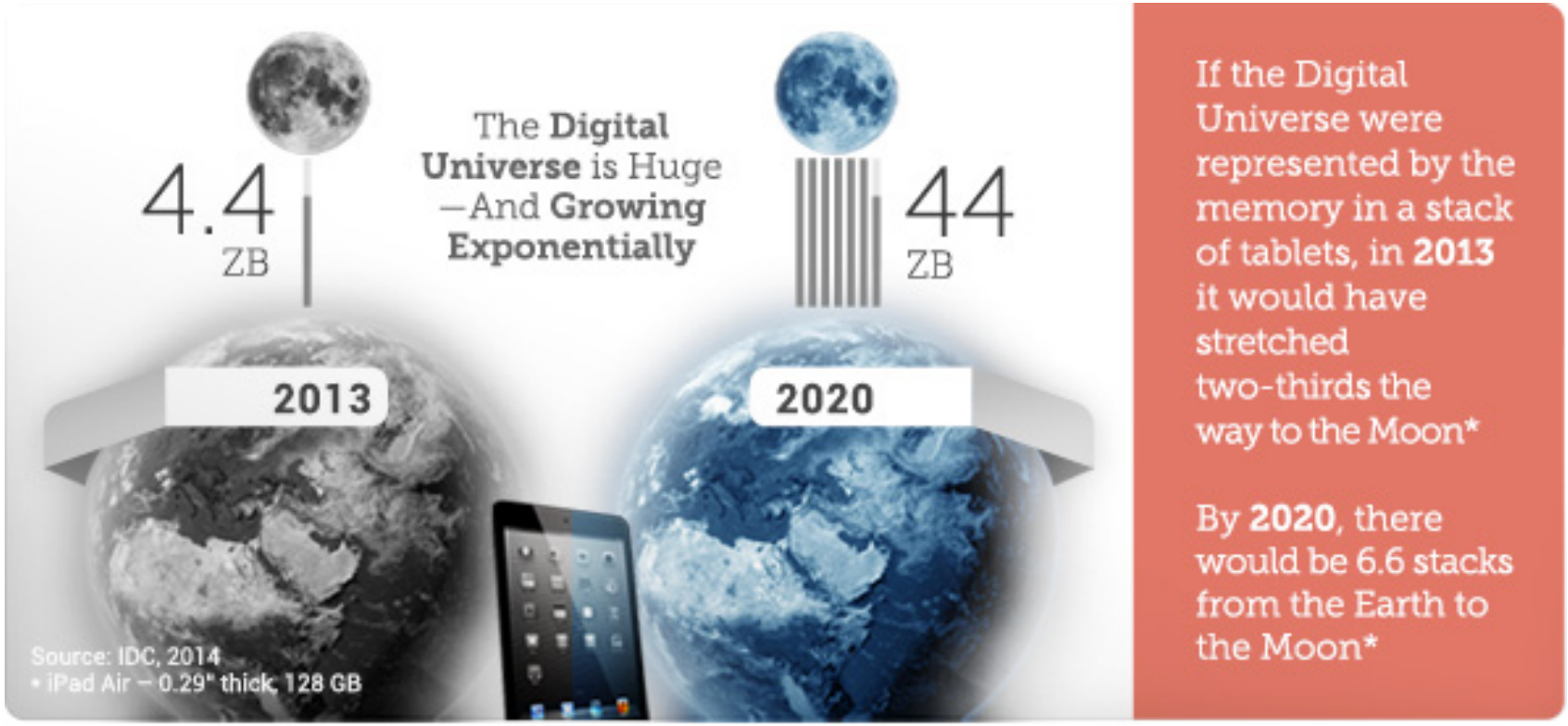
STT	Lecture
1	**Tổng quan về lưu trữ và xử lý dữ liệu lớn**
2	**Hệ sinh thái Hadoop (Hadoop ecosystem)**
3	**Hệ thống tập tin phân tán Hadoop HDFS**
4	**Cơ sở dữ liệu phi quan hệ NoSQL - phần 1** Tổng quan
5	**Cơ sở dữ liệu phi quan hệ NoSQL - phần 2** Kiến trúc phân tán phổ biến
6	**Cơ sở dữ liệu phi quan hệ NoSQL - phần 3** Truy vấn SQL trên NoSQL
7	**Hệ thống truyền thông điệp phân tán**
8	**Các kĩ thuật xử lý dữ liệu lớn theo khối - phần 1** Map Reduce
9	**Các kĩ thuật xử lý dữ liệu lớn theo khối - phần 2** Apache Spark
10	**Các kĩ thuật xử lý luồng dữ liệu lớn** Spark Streaming
11	**Kiến trúc dữ liệu lớn** Lambda architecture
12	**Phân tích dữ liệu lớn** Spark ML

How big is big data?



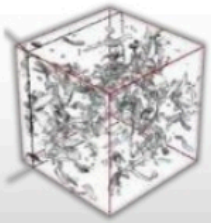

Annual Size of the Global Datasphere
175 ZB
013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Source: Data Age 2025, sponsored by Seagate with data from IDC Global DataSphere, Nov 2018

How big is big data?



Data science: The 4th paradigm for scientific discovery

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{4\pi G\rho}{3} - \mathrm{K}\frac{c^2}{a^2}$$



Experimental	Theoretical	Computational	The Fourth Paradigm
Thousand years ago	Last few hundred years	Last few decades	Today and the Future
Description of natural phenomena	*Newton's laws, Maxwell's equations...*	*Simulation of complex phenomena*	*Unify theory, experiment and simulation with large multidisciplinary Data* *Using data exploration and data mining (from instruments, sensors, humans...)* *Distributed Communities*

Big data in 2008

http://www.wired.com/wired/issue/16-07

September 2008

Big data in 2014

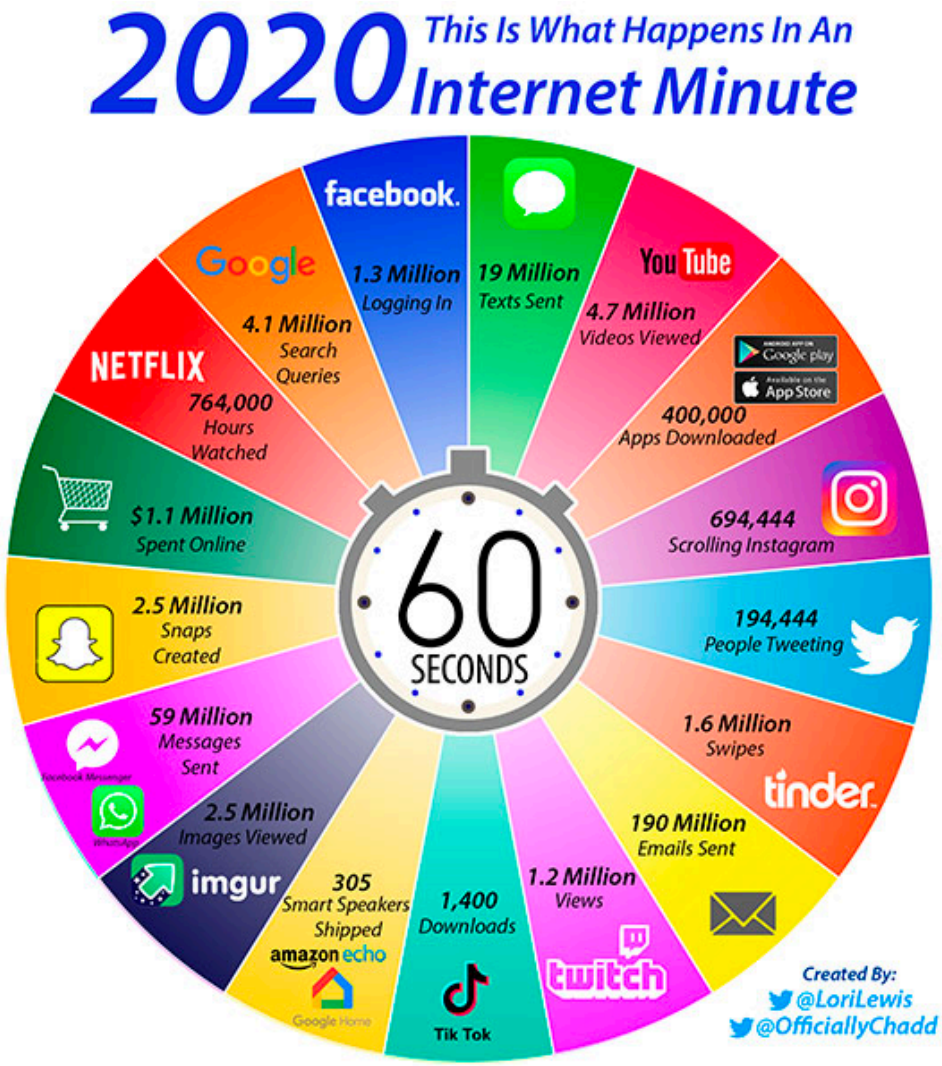
THE AVERAGE PERSON TODAY PROCESSES MORE DATA IN A SINGLE DAY THAN A PERSON IN THE 1500'S DID IN AN ENTIRE LIFETIME

LOOK TO THE LEFT, and you see Times Square at dusk. Look to the right, and you see the same location at midmorning. Internationally acclaimed photographer Stephen Wilkes's time-altering image of New York's Times Square is part of his body of work titled *Day to Night*. The image was created by blending more than 1,400 separate photos taken over the course of 15 hours—a meticulous process that took him nearly three months.

PHOTO: STEPHEN WILKES

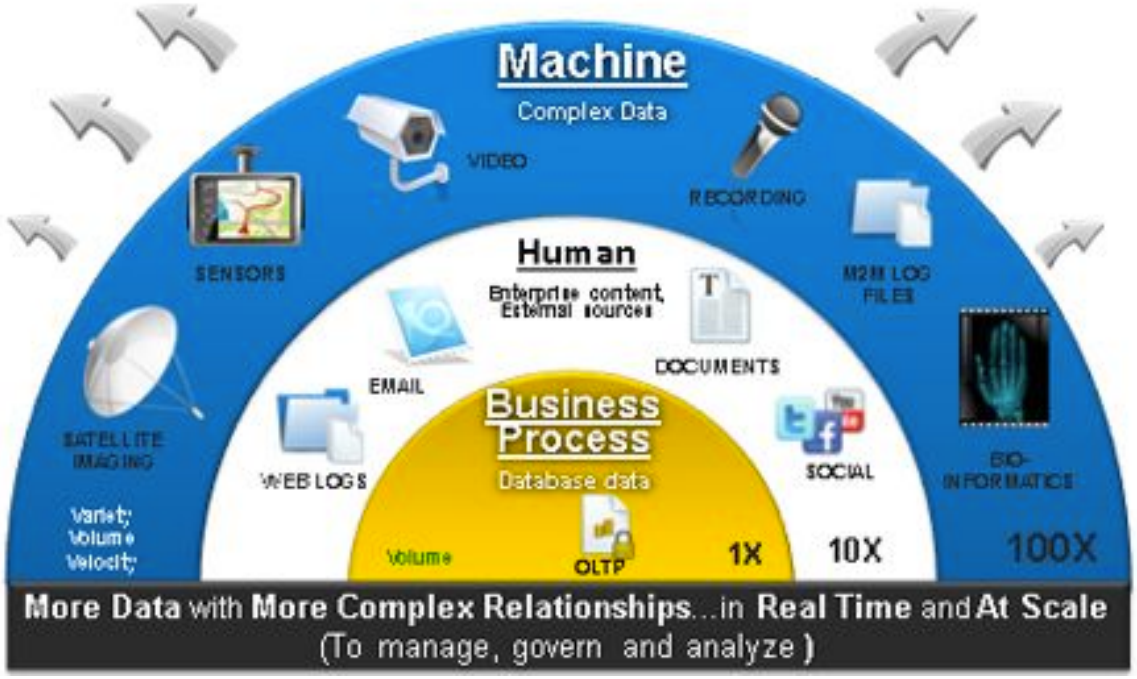
Big data today

Big data's numbers



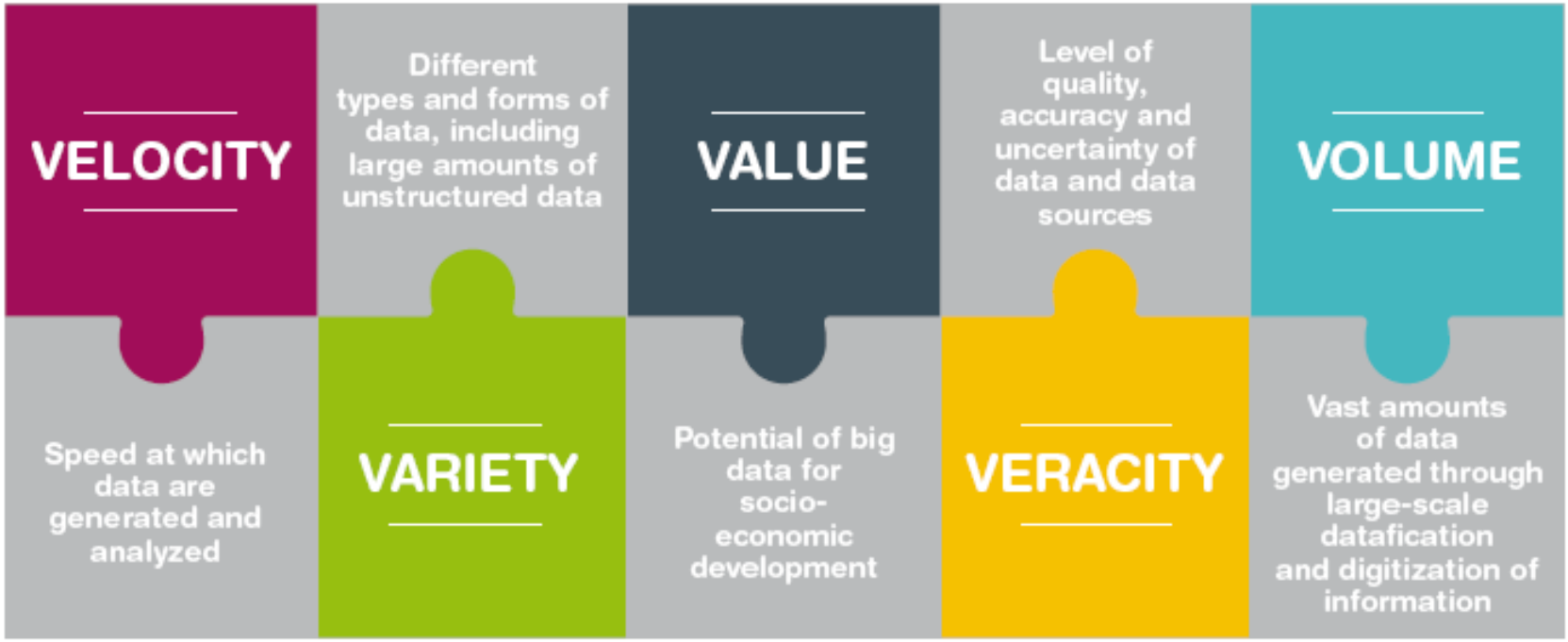
Big data sources

- E-commerce
- Social networks
- Internet of things
- Data-intensive experiments (bioinformatics, quantum physics, etc)



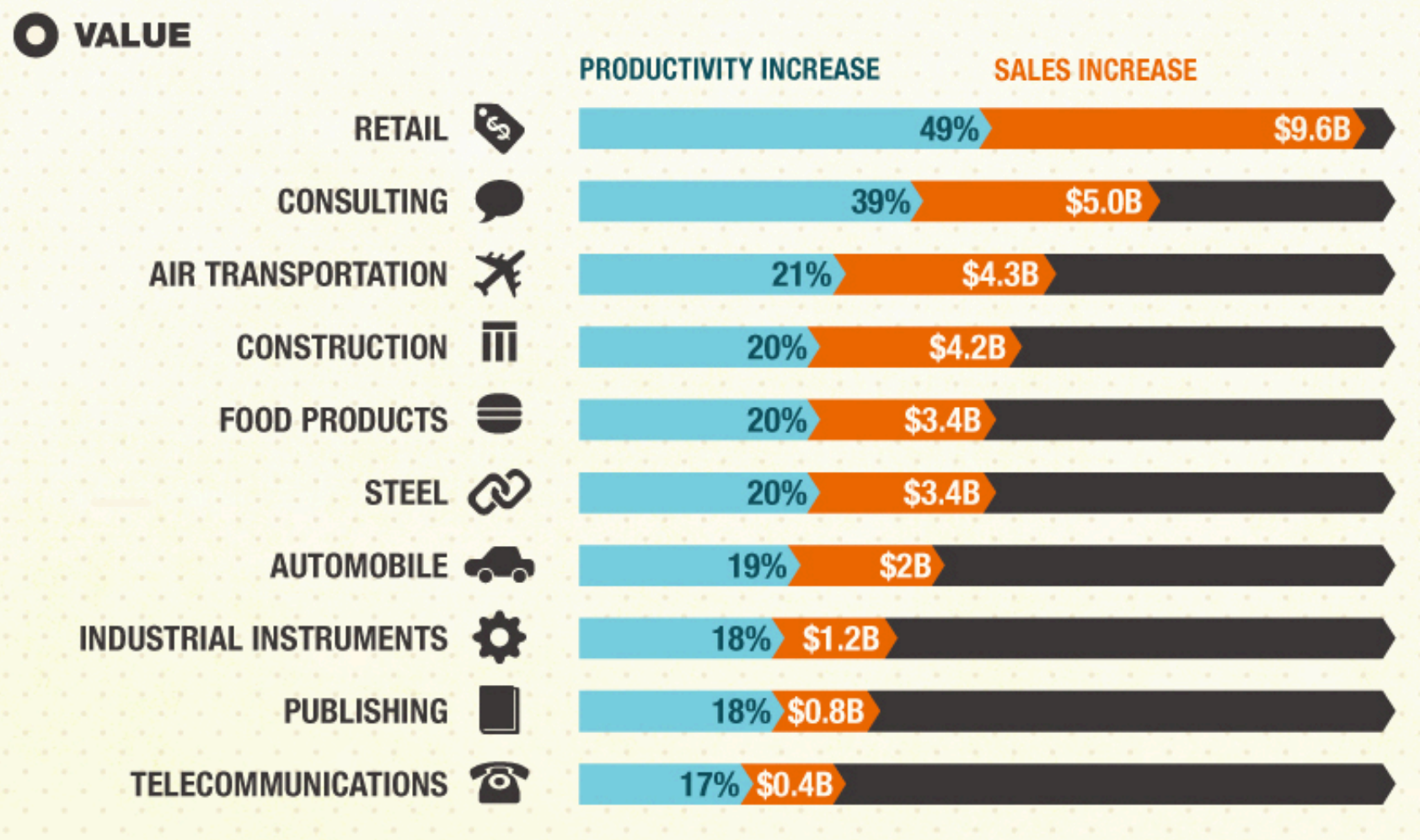
Data is the new oil

Big data 5'V



Big data is a term for data sets that are so large or complex that traditional data processing application software is inadequate to deal with them (wikipedia)

Big data – big value



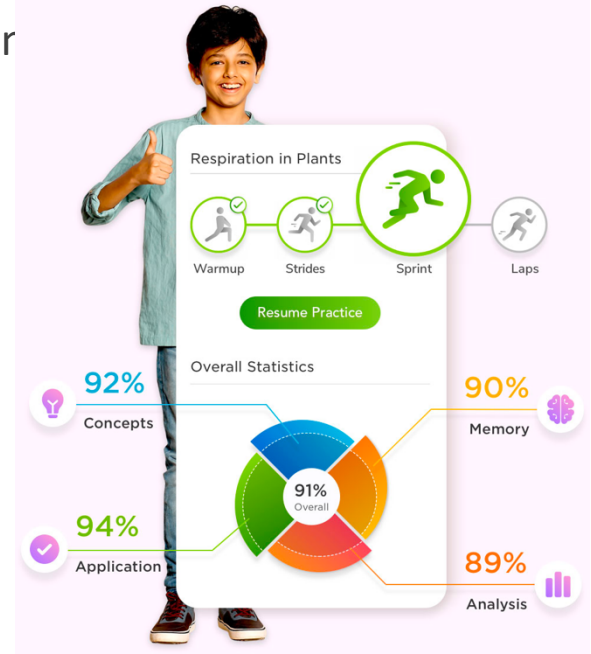
source: wipro.com

Big Data in education industry

- **Customized and Dynamic Learning Programs**
  - Customized programs and schemes to benefit individual students can be created using the data collected on the bases of each student's learning history. This improves the overall student results.
- **Reframing Course Material**
  - Reframing the course material according to the data that is collected on the basis of what a studen learns and to what extent by real-time monitoring of the components of a course is beneficial for the students.
- **Grading Systems**
  - New advancements in grading systems have been introduced as a result of a proper analysis of student data.
- **Career Prediction**
  - Appropriate analysis and study of every student's records will help understand each student's progress, strengths, weaknesses, interests, and more. It would also help in determining which career would be the most suitable for the student in future.

Edtech

- **Coursera**
- **VioEdu**
- https://byjus.com/
  - Engaging Video Lessons
  - Personalized Learning Journeys
  - Mapped to the Syllabus
  - In-depth Analysis
  - Engagir



Big Data in healthcare industry

- Big data reduces costs of treatment since there is less chances of having to perform unnecessary diagnosis.
- It helps in predicting outbreaks of epidemics and also in deciding what preventive measures could be taken to minimize the effects of the same.
- It helps avoid preventable diseases by detecting them in early stages. It prevents them from getting any worse which in turn makes their treatment easy and effective.
- Patients can be provided with evidence-based medicine which is identified and prescribed after doing research on past medical results.

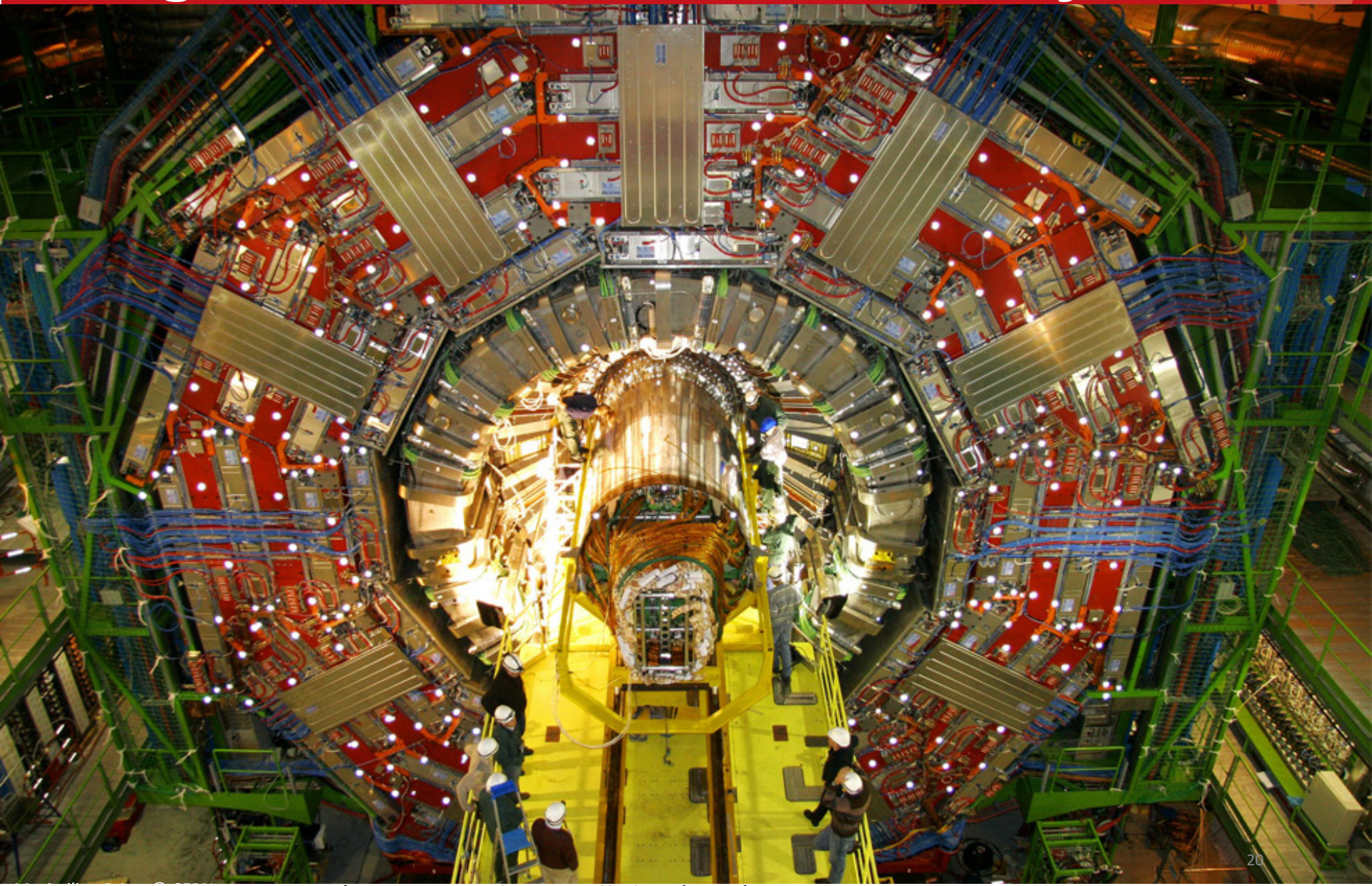
Big Data in government sector

- **Welfare Schemes**
  - In making faster and informed decisions regarding various political programs
  - To identify areas that are in immediate need of attention
  - To stay up to date in the field of agriculture by keeping track of all existing land and livestock.
  - To overcome national challenges such as unemployment, terrorism, energy resources exploration, and much more.
- **Cyber Security**
  - Big Data is hugely used for deceit recognition.
  - It is also used in catching tax evaders.

Big Data in media and entertainment industry

- Predicting the interests of audiences
- Optimized or on-demand scheduling of media streams in digital media distribution platforms
- Getting insights from customer reviews
- Effective targeting of the advertisements
- Example
  - Spotify, an on-demand music providing platform, uses Big Data Analytics, collects data from all its users around the globe, and then uses the analyzed data to give informed music recommendations and suggestions to every individual user.
  - Amazon Prime that offers, videos, music, and Kindle books in a one-stop shop is also big on using big data.

Big data in scientific discovery



CERN's Large Hydron Collider (LHC) generates 15 PB a year

Use Case: Thomson Reuters

- About: Thomson Reuters is the world's leading source of news and information for the financial and risk, legal, tax & accounting, and media markets.
- Challenge: Their data source (Twitter) produces a gigantic amount of data daily. It is challenging to (a) quickly analyze all the tweets and (b) disguise real news from fake news and opinions.
- Impact after applying Big Data solutions:
  - Able to process 13 million tweets daily
  - Captures and detects news events across millions of tweets in 40 milliseconds
- (Source: https://www.cloudera.com/about/customers/thomson-reuters.html)

THOMSON REUTERS

Use Case: MasterCard

- About: MasterCard operates the world's fastest payments processing network, delivering the products and services that make everyday commerce activities — such as shopping, traveling, running a business, and managing finances — easier, more secure, and more efficient.
- Challenge: Identify frauds from one million inquiries/month to their database which contains hundreds of millions of fraudulent businesses.
- Impact after applying Big Data solutions:
  - 5x increase in number of searches supported annually
  - 25x increase in searches per customer daily
  - Dramatically improved search accuracy
- (Source: https://www.cloudera.com/about/customers/thomson-reuters.html)

Use Case: Intel Supply Chain

- About: Intel's supply chain reflects the company's global operations—Intel does business in more than 100 countries, with over 450 supplier factories and 16,000 suppliers.
- Challenge:
  - Multiple data hops -- data latencies of up to 12 hours
  - Data fragmentation, data reconciliation and quality issues
- Impact after applying Big Data solutions:
  - Reduce planning DB by 63% and the enterprise common core (ECC) DB by 80%
  - DB transactions decreased by 25-50%; ECC processing time decreased by 50%
  - 75% efficiency gain in account reconciliation; 45% reduction of IT support staff
- (Source: https://www.intel.com/content/www/us/en/it-management/intel-it-best-practices/transforming-intels-supply-chain-with-real-time-analytics-paper.html)

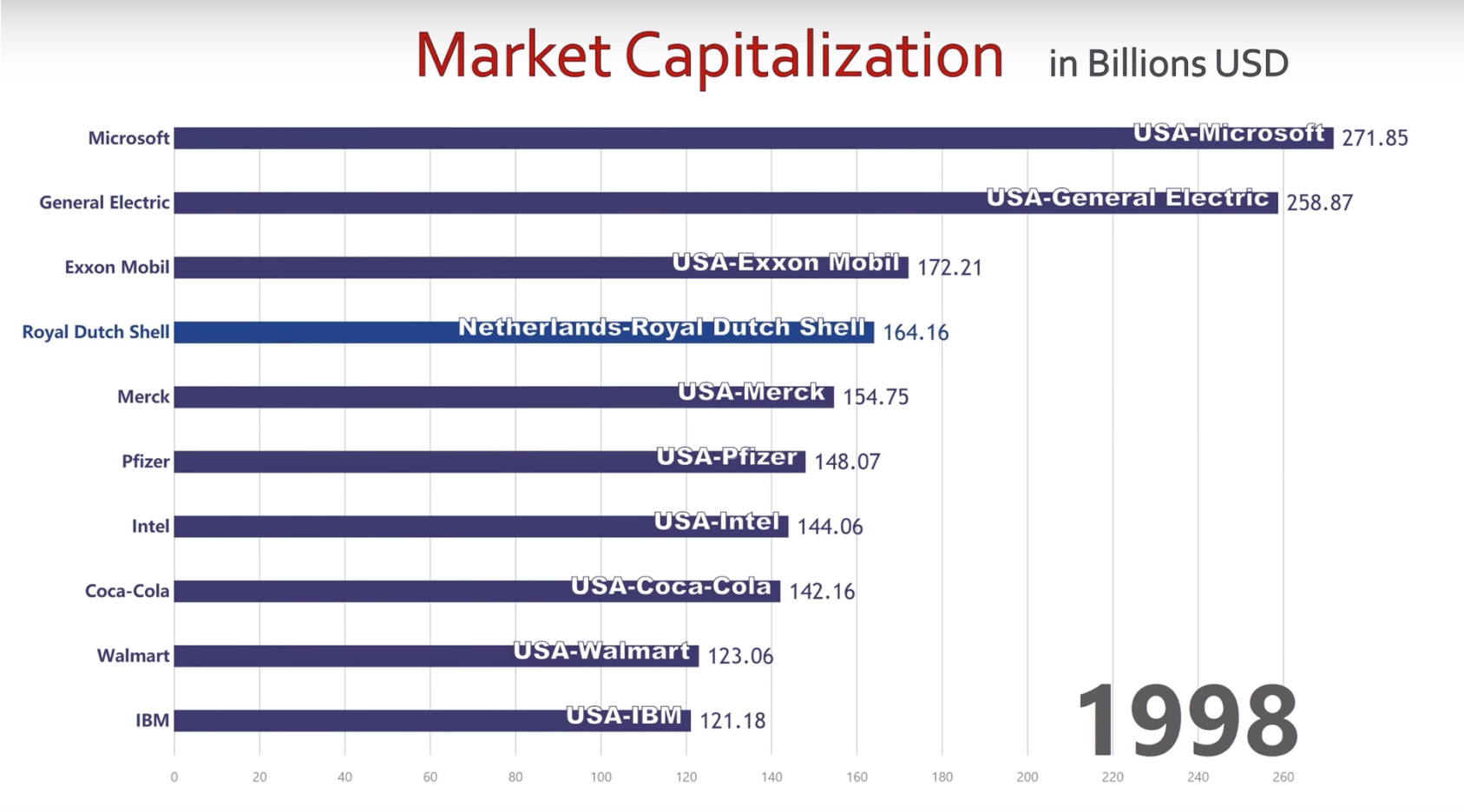
Use Case: Cisco WebEx

- About: Cisco WebEx supports more than 26 billion conference minutes each month. Its audio, video, and web conferencing services help users connect and collaborate with colleagues around the world.
- Challenge:
  - Gain an end-to-end view of the customer experience
  - Support an increasing volume of telemetry data
  - More rapidly uncover new fraud tactics
- Impact after applying Big Data solutions:
  - Identified 17x more fraud
  - Delivered platform at 1/10 the cost of traditional data warehouse and BI environment
- (Source:https://www.cloudera.com/about/customers/cisco.html)

Use Case: Deutsche Telekom

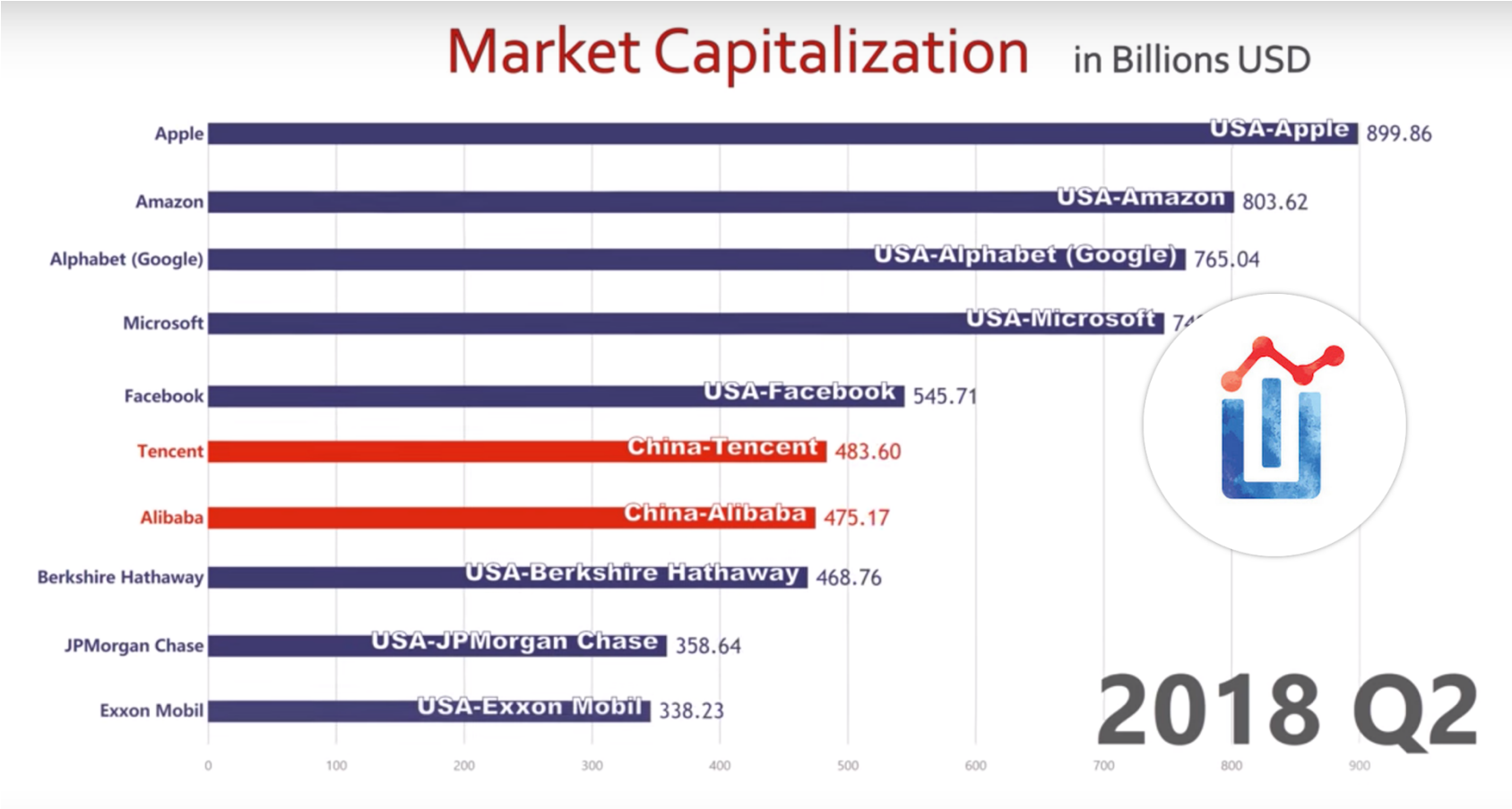
- About: Deutsche Telekom is a leading European telecommunications provider, delivering services to more than 150 million customers globally.
- Challenge:
  - Preventing network fraud
  - Data visibility and scalability
- Impact after applying Big Data solutions:
  - 5-10% lower customer churn
  - 10-20% lower revenue losses from fraud activities
  - 50% better operational efficiency
- (Source: https://www.cloudera.com/about/customers/deutsche-telekom.html)

Top 10 Company Market Cap Ranking History (1998-2018)

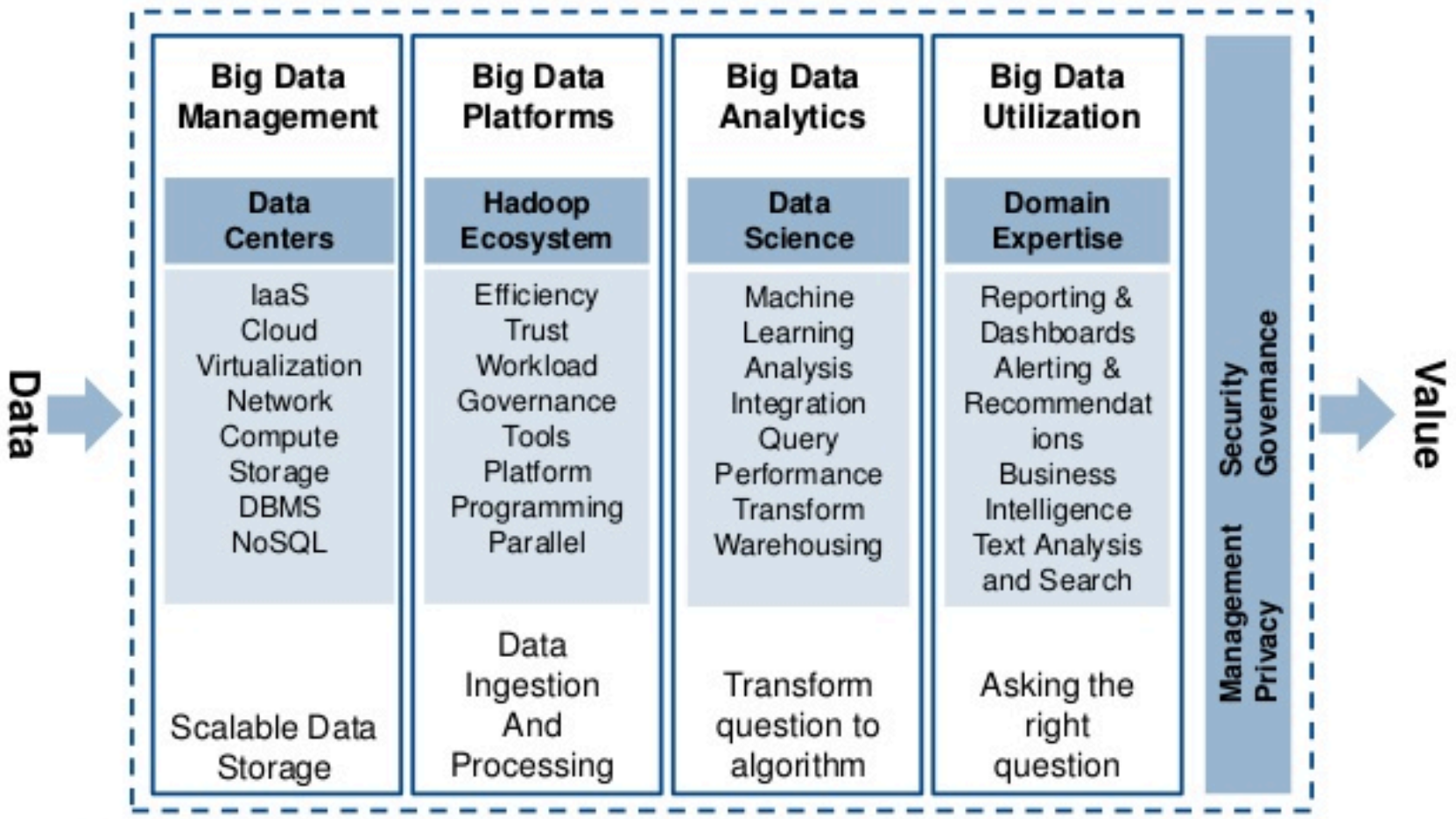


https://www.youtube.com/watch?v=fobx4wIS6W0

Top 10 Company Market Cap Ranking History (1998-2018)



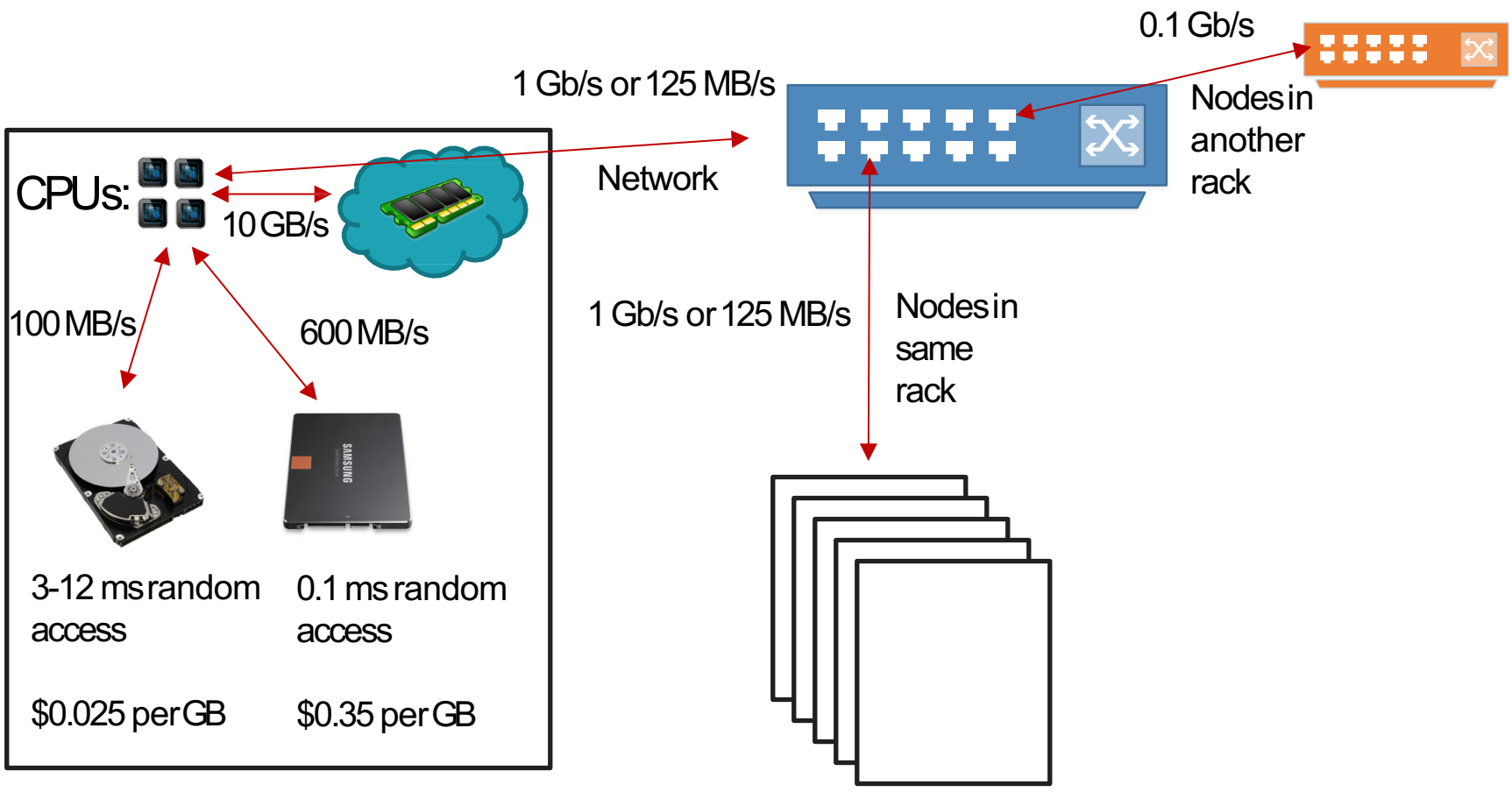
Big data technology stack



Scalable data management

- Scalability
  - Able to manage incresingly big volume of data
- Accessibility
  - Able to maintain efficiciency in reading and writing data (I/O) into data storage systems
- Transparency
  - In distributed environment, users should be able to access data over the network as easily as if the data were stored locally.
  - Users should not have to know the physical location of data to access it.
- Availability
  - Fault tolerance
  - The number of users, system failures, or other consequences of distribution shouldn't compromise the availability.

Data I/O landscape



Scalable data ingestion and processing

- Data ingestion
  - Data from different complementing information systems is **to be combined to gain a more comprehensive basis** to satisfy the need
  - How to ingest data efficiently from various, distributed heterogeneous sources?
    - Different data formats
    - Different data models and schemas
    - Security and privacy
- Data processing
  - How to process massive volume of data in a timely fashion?
  - How to process massive stream of data in a real-time fashion?
  - Traditional parallel, distributed processing (OpenMP, MPI)
    - Big learning curve
    - Scalability is limited
    - Fault tolerence is hard to achive
    - Expensive, high performance computing infrastructure
  - Novel realtime processing architecture
    - Eg. Mini-batch in Spark streaming
    - Eg. Complex event processing in Apache Flink

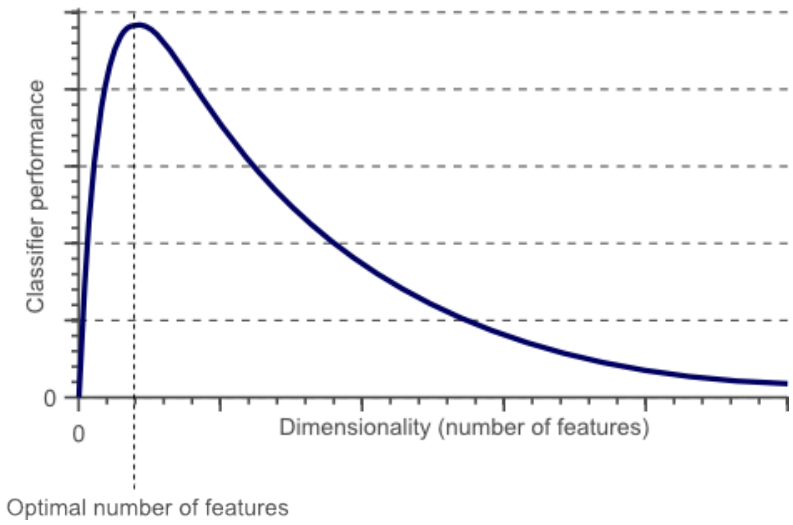
Scalable analytic algorithms

- Challenges
  - Big volume
  - Big dimensionality
  - Realtime processing
- Scaling-up Machine Learning algorithms
  - Adapting the algorithm to handle Big Data in a single machine.
    - Eg. Sub-sampling
    - Eg. Principal component analysis
    - Eg. feature extraction and feature selection
  - Scaling-up algorithms by parallelism
    - Eg. k-nn classification based on MapReduce
    - Eg. scaling-up support vector machines (SVM) by a divide and-conquer approach

Eg. Curse of dimensionality

- The required number of samples (to achieve the same accuracy) grows exponentionally with the number of variables!
- In practice: number of training examples is fixed!

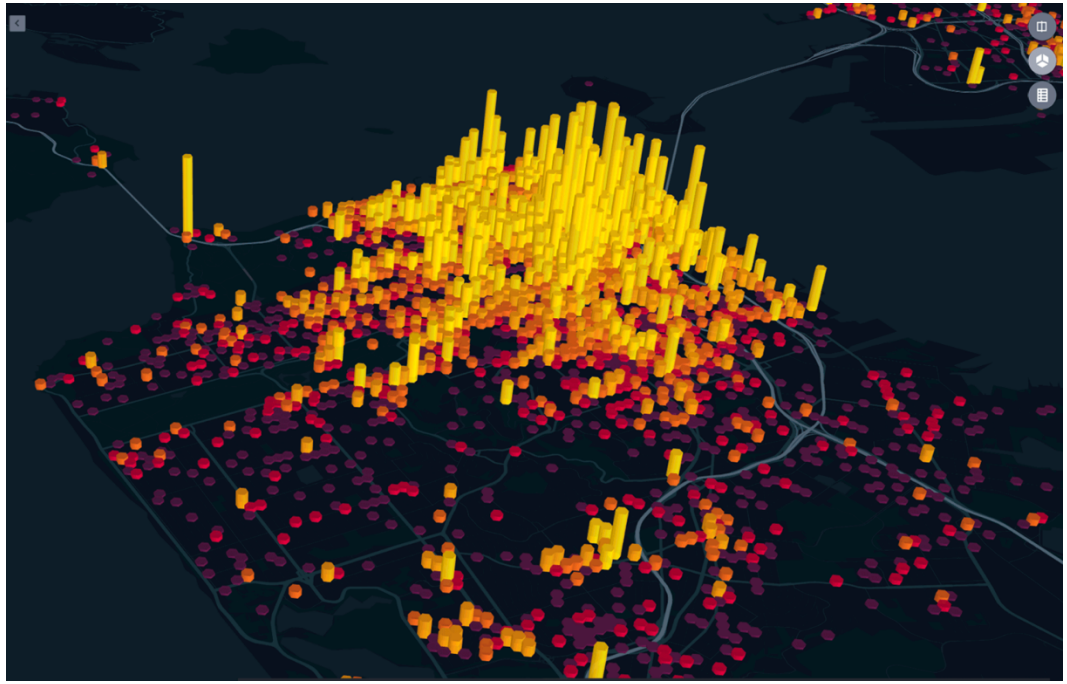
  => the classifier's performance usually will degrade for a large number of features!

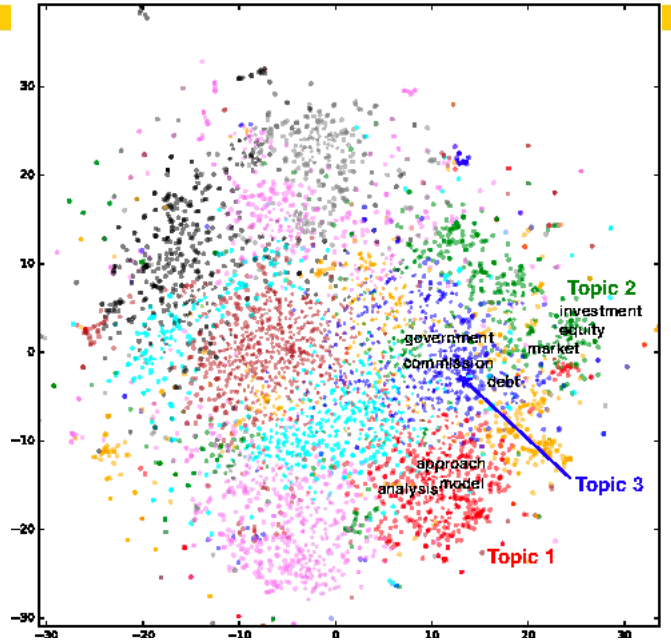


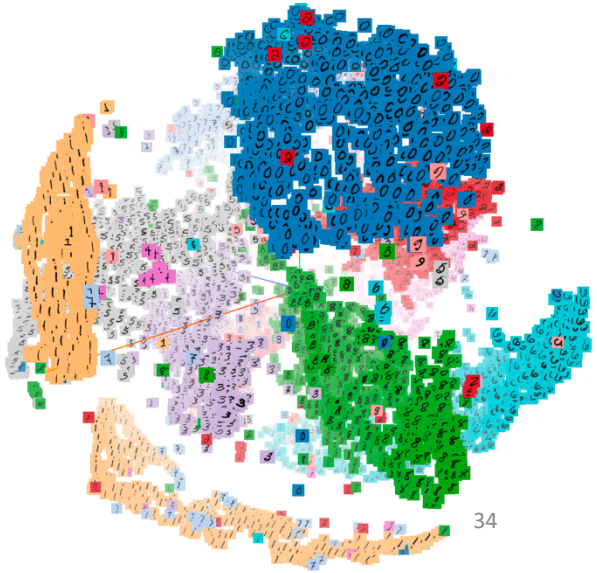
In fact, after a certain point, increasing the dimensionality of the problem by adding new features would actually degrade the performance of classifier.

Utilization and interpretability of big data

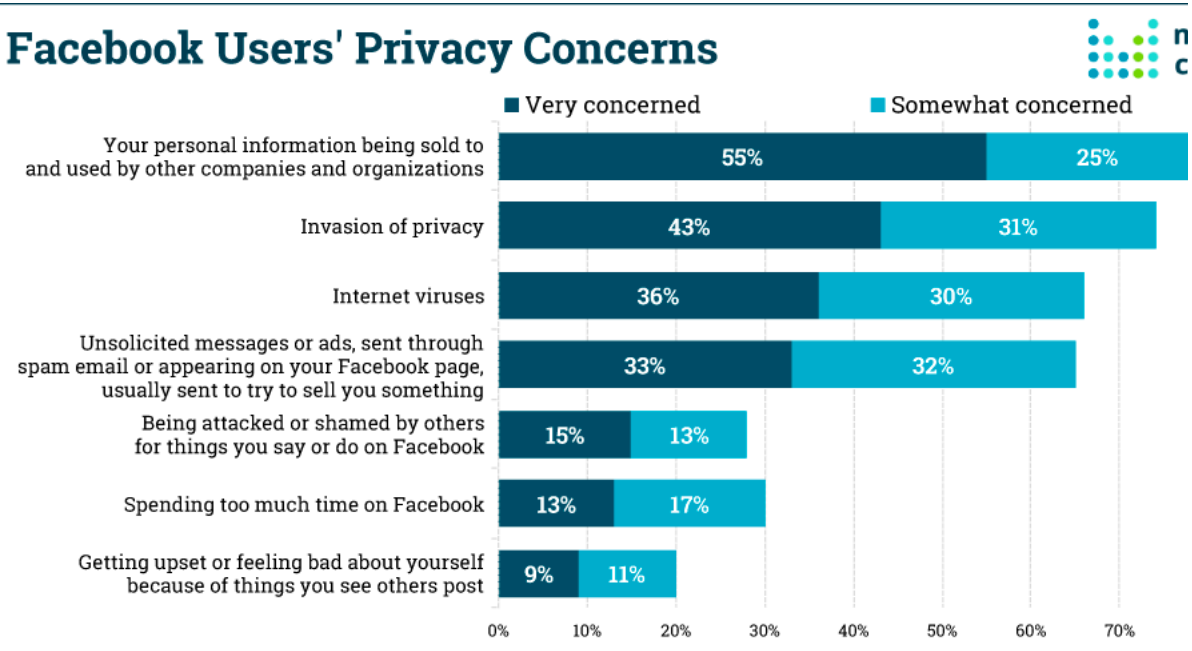
- Domain expertise to findout problems and interprete analytics results
- Scalable visualization and interpretability of million data points
  - to facilitate their interpretability and understanding







Privacy and security



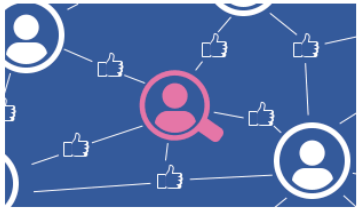
Published on MarketingCharts.com in April 2018 | Data Source: Gallup

Based on telephone interviews consuted April 2-8, 2018 among 1,509 US adults ages 18 and older, of whom 785 are Facebook users. The remaining respondents answered "Not too concerned" or "Not concerned at all."

How was Facebook users' data misused?

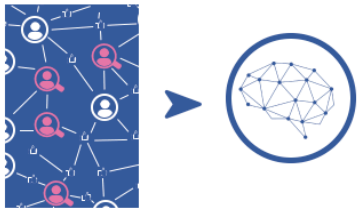
1. In 2014 a Facebook quiz invited users to find out their personality type

2. The app collected the data of those taking the quiz, but also recorded the public data of their friends



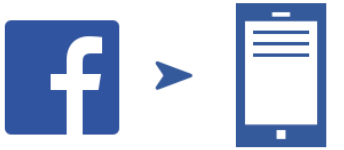
3. About 305,000 people installed the app, but it gathered information on up to 87 million people, according to Facebook

4. It is claimed at least some of the data was sold to Cambridge Analytica (CA) which used it to psychologically profile voters in the US



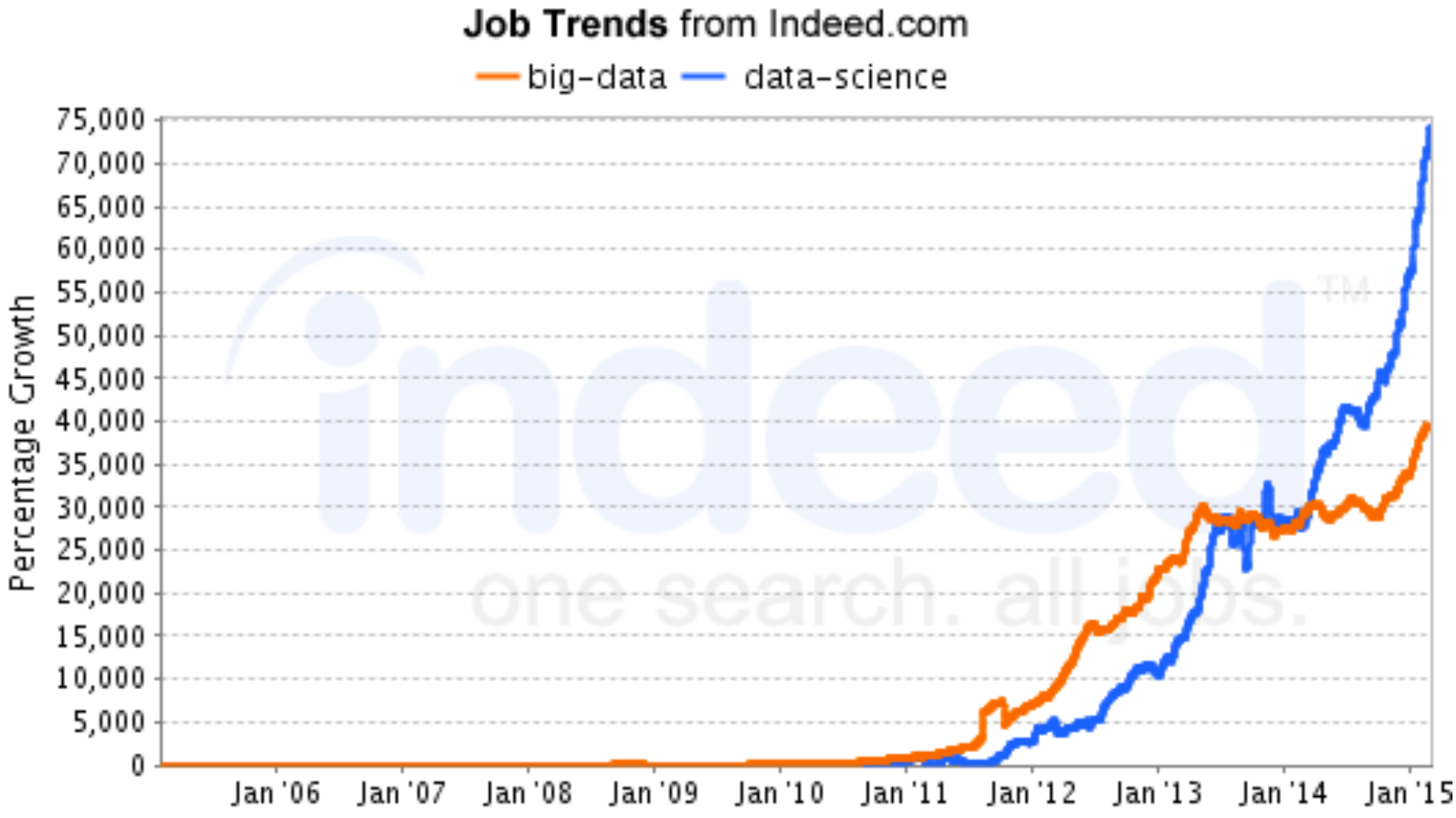
5. CA denies it broke any laws and says it did not use the data in the US presidential election

6. Facebook sends notices to users telling them whether their data was breached



CA denies any wrongdoing. Facebook has apologised to users and says a "breach of trust" has occurred.

Big data job trends



Talent shortage in big data

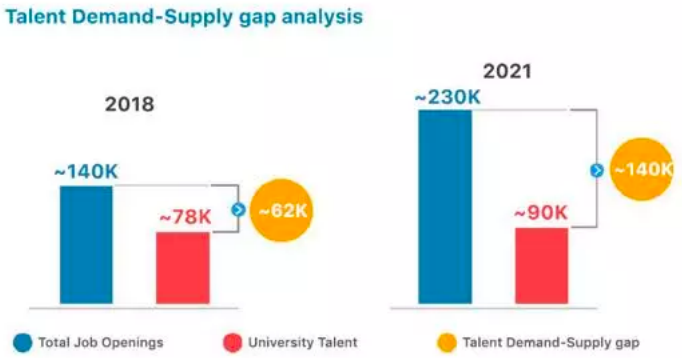
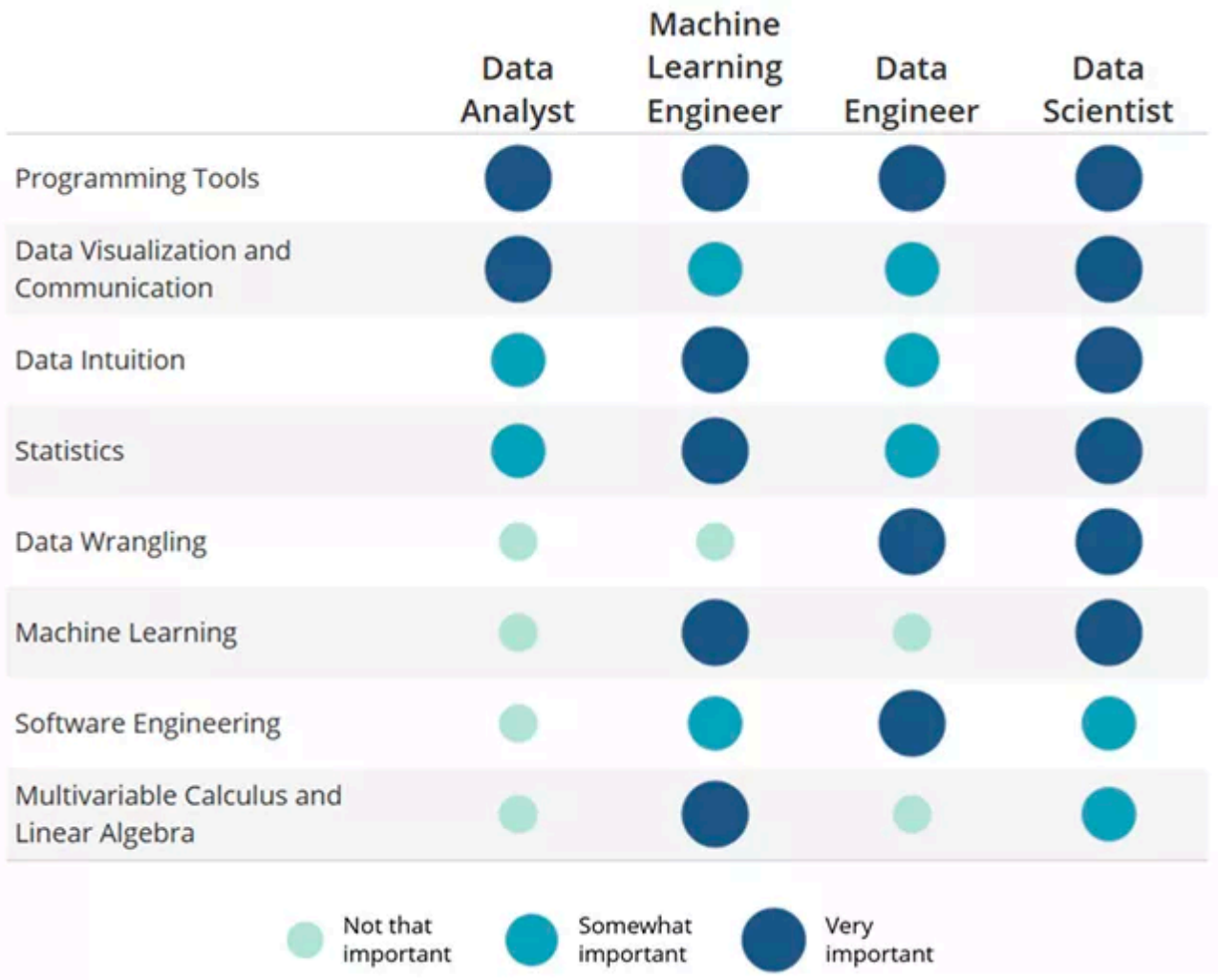


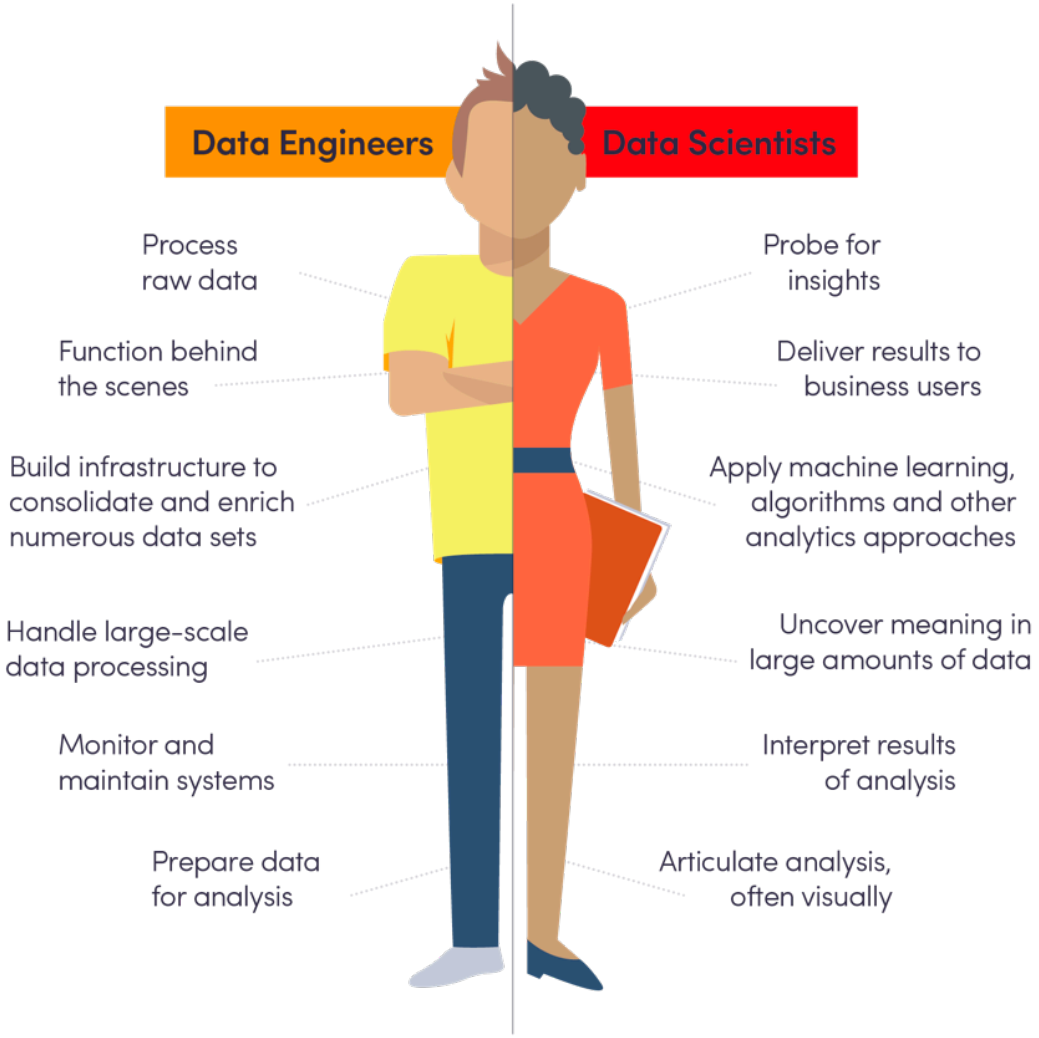
Table 2. Summary Demand Statistics

DSA Framework Category	Number of Postings in 2015	Projected 5-Year Growth	Estimated Postings for 2020	Average Time to Fill (Days)	Average Annual Salary
All	2,352,681	15%	2,716,425	45	$80,265
Data-Driven Decision Makers	812,099	14%	922,428	48	$91,467
Functional Analysts	770,441	17%	901,743	40	$69,162
Data Systems Developers	558,326	15%	641,635	50	$78,553
Data Analysts	124,325	16%	143,926	38	$69,949
Data Scientists & Advanced Analysts	48,347	28%	61,799	46	$94,576
Analytics Managers	39,143	15%	44,894	43	$105,909

Big data skill set

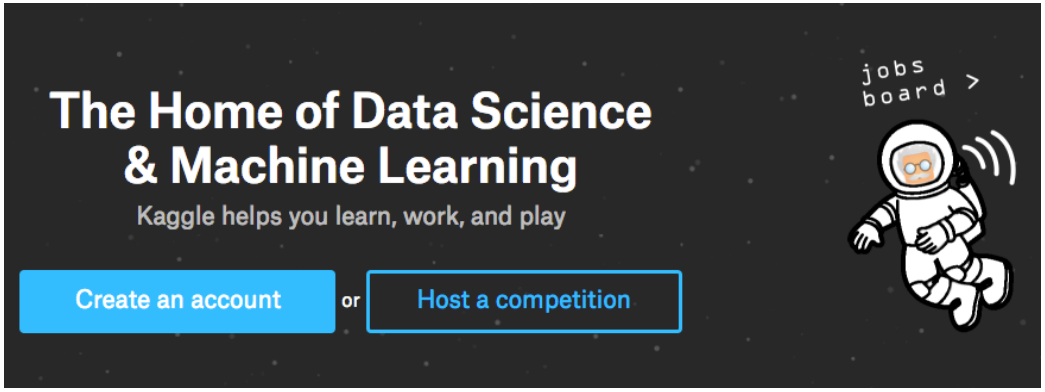


Data engineers vs. data scientists

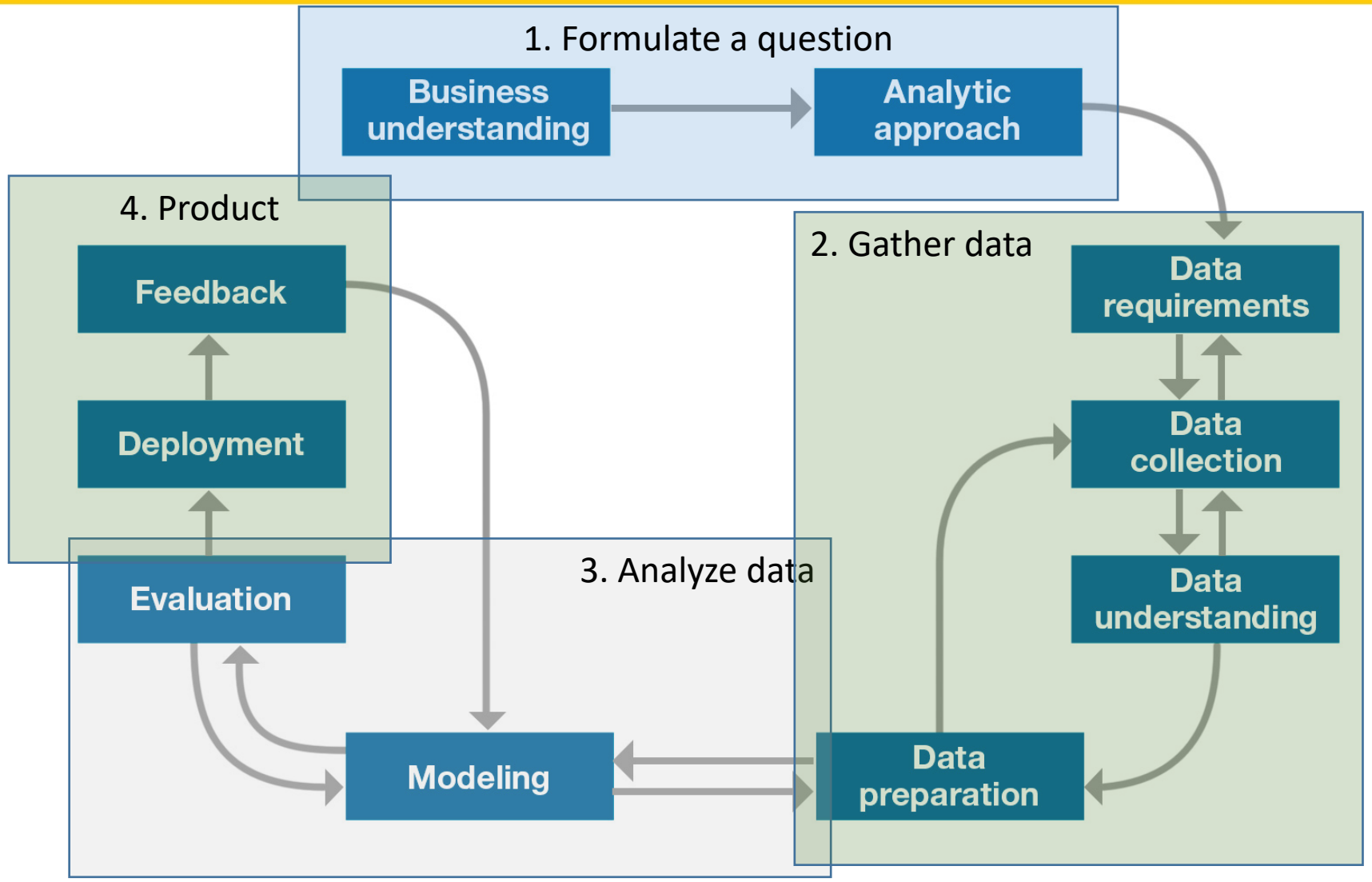


How to land big data related jobs

- Learn to code
  - Coursera
  - Udacity
  - Freecodecamp
  - Codecademy
- Math, Stats and machine learning
  - Kaggle
- Hadoop, NoSQL, Spark
- Visualization and Reporting
  - Tableau
  - Pentahoo
- Meetup & Share
- Find a mentor
- Internships, projects

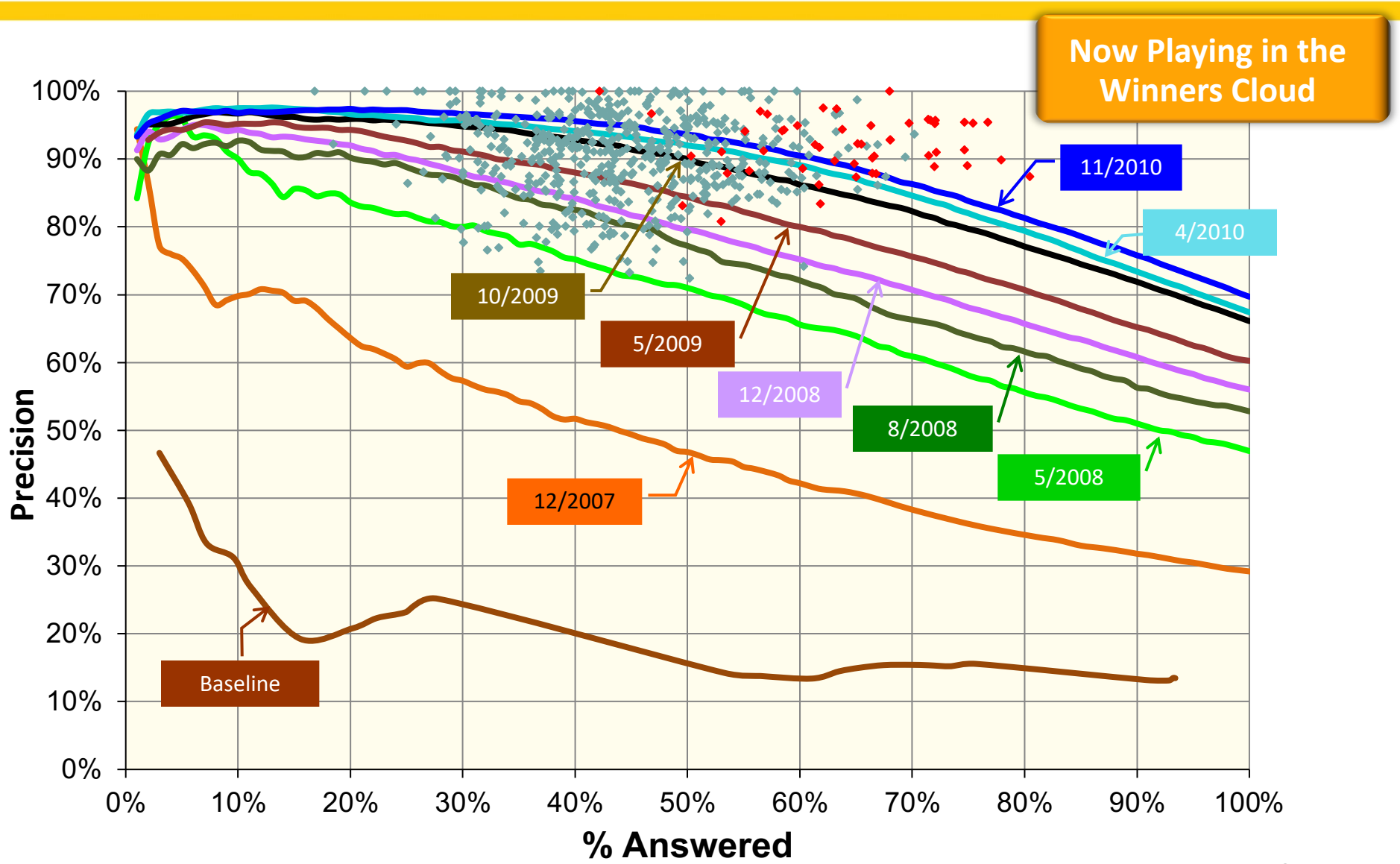


Data science method



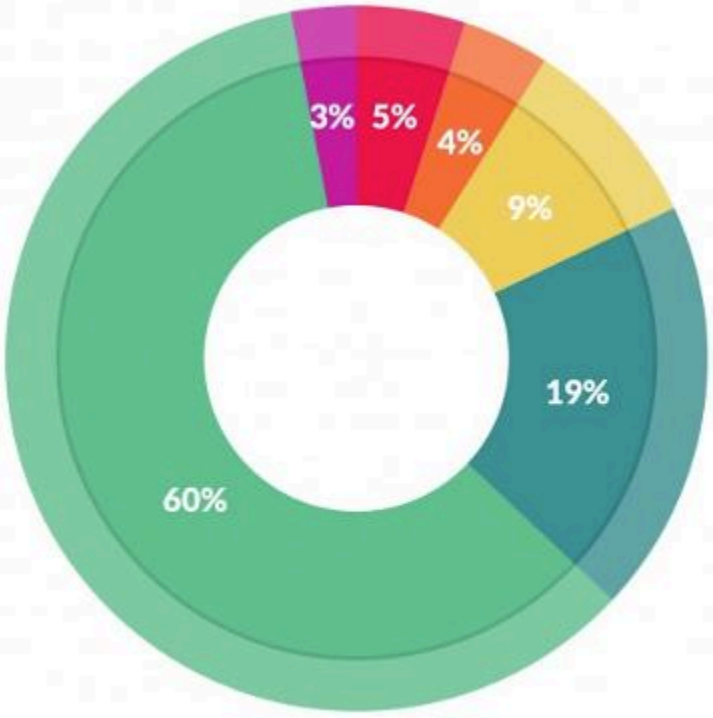
Source: *Foundational Methodology for Data Science*, IBM, 2015

DeepQA: Incremental Progress in Precision and Confidence 6/2007-11/2010



Cleaning big data: most time-consuming, least enjoyable data science task

- Data preparation accounts for about 80% of the work of data scientists



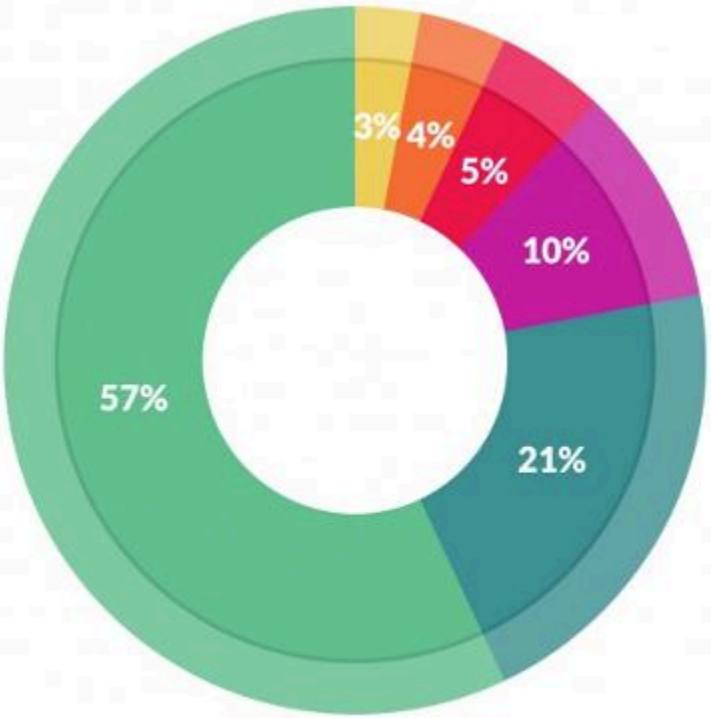
What data scientists spend the most time doing

- *Building training sets: 3%*
- *Cleaning and organizing data: 60%*
- *Collecting data sets; 19%*
- *Mining data for patterns: 9%*
- *Refining algorithms: 4%*
- *Other: 5%*

source: https://www.forbes.com/

Cleaning big data: most time-consuming, least enjoyable data science task

- 57% of data scientists regard cleaning and organizing data as the least enjoyable part of their work and 19% say this about collecting data sets.



What's the least enjoyable part of data science?

- *Building training sets: 10%*
- *Cleaning and organizing data: 57%*
- *Collecting data sets: 21%*
- *Mining data for patterns: 3%*
- *Refining algorithms: 4%*
- *Other: 5%*

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Online courses

- https://www.coursera.org/learn/nosql-database-systems
- https://who.rocq.inria.fr/Vassilis.Christophides/Big/index.htm
- https://www.coursera.org/learn/big-data-introduction?specialization=big-data
- https://www.coursera.org/learn/big-data-integration-processing?specialization=big-data
- https://www.coursera.org/learn/big-data-management?specialization=big-data
- https://www.coursera.org/learn/hadoop
- https://www.coursera.org/learn/scala-spark-big-data