TRƯỜNG ĐẠI HỌC BÁCH KHOA HÀ NỘI
HANOI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Introduction to big data management and processing

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Slides by Dr. Viet-Trung Tran
School of Information and Communication Technology

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Abous this course

Tên học phần:	**Lưu trữ và xử lý dữ liệu lớn** **(Big data storage and processing)**
Mã số học phần:	IT4043E
Khối lượng:	3(3-1-0-6) – Lý thuyết: 45 tiết – BTL: 15 tiết – Thí nghiệm: 0 tiết
Slide và nhóm	– Trên Microsoft Teams

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Syllabus

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

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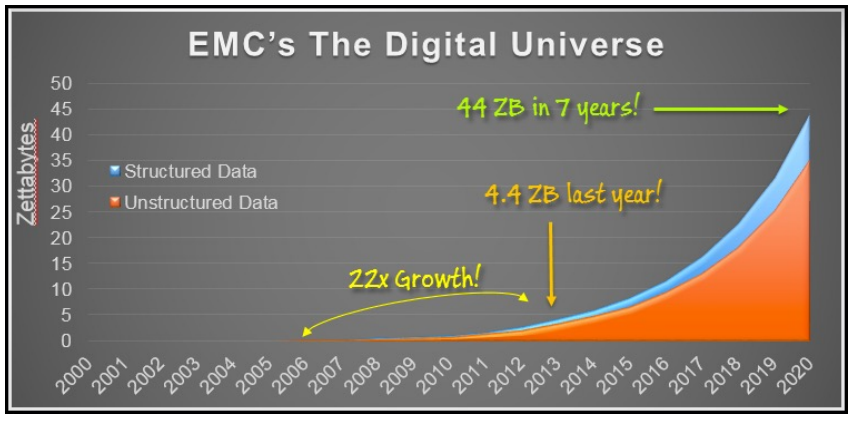
How big is big data?



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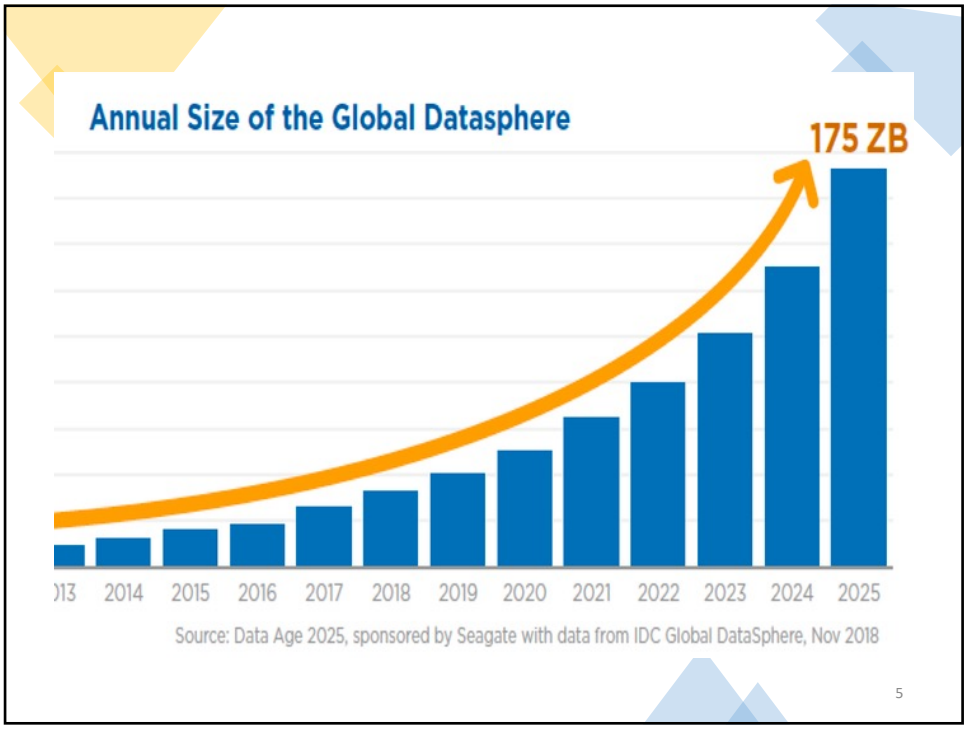
Annual Size of the Global Datasphere
175 ZB
013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025
Source: Data Age 2025, sponsored by Seagate with data from IDC Global DataSphere, Nov 2018
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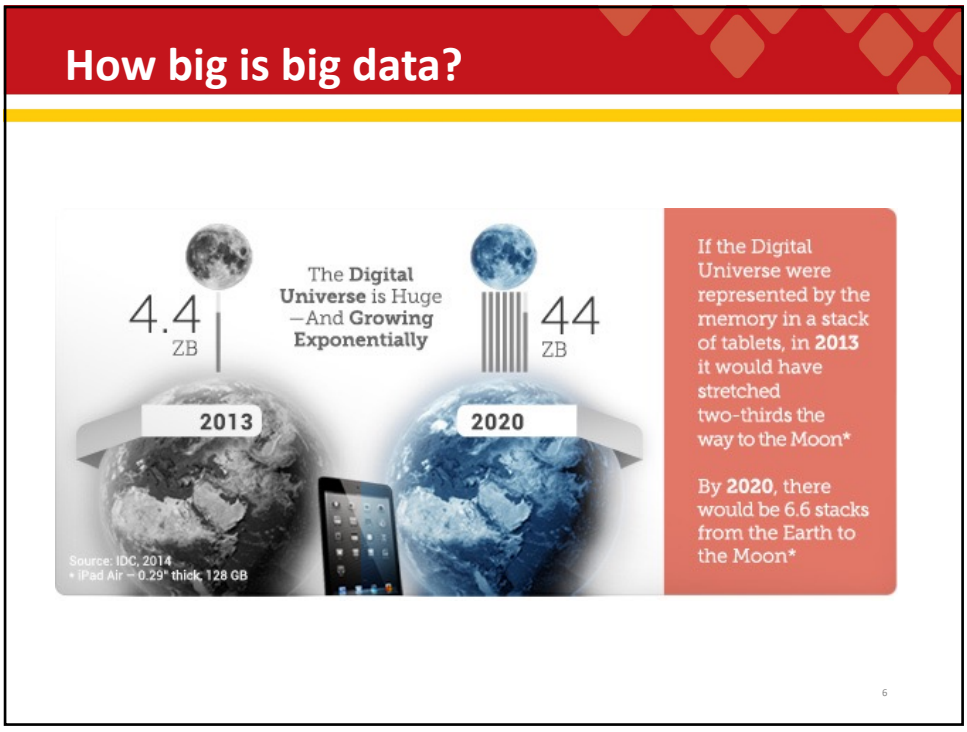
How big is big data?
4.4 ZB
The Digital Universe is Huge —And Growing Exponentially
44 ZB
2013
2020
Source: IDC, 2014
* iPad Air = 0.29" thick, 128 GB
If the Digital Universe were represented by the memory in a stack of tablets, in 2013 it would have stretched two-thirds the way to the Moon*
By 2020, there would be 6.6 stacks from the Earth to the Moon*
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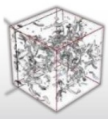
Data science: The 4th paradigm for scientific discovery

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



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*

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Big data in 2008

http://www.wired.com/wired/issue/16-07 September 2008

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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

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Big data today

The amount of information generated during the first day of a baby's life today is equivalent to 70 times the information contained in the Library of Congress

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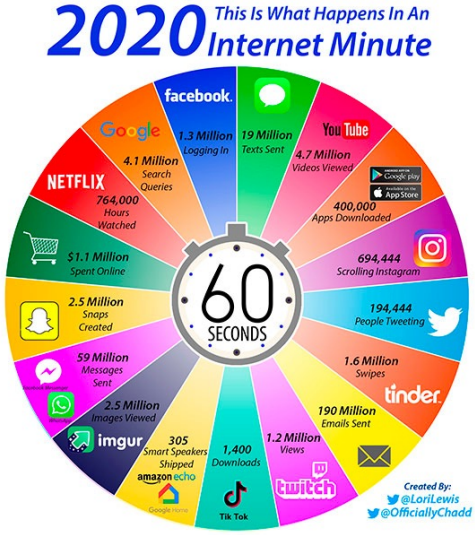
Big data's numbers



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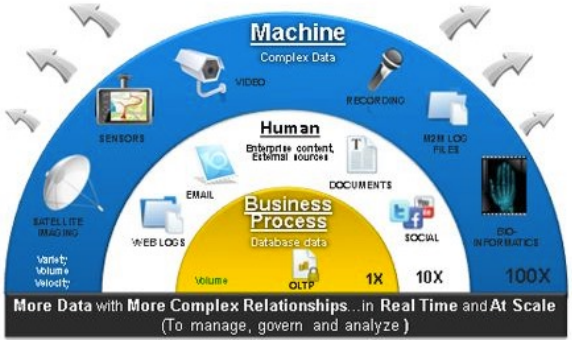
Big data sources

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



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Data is the new oil

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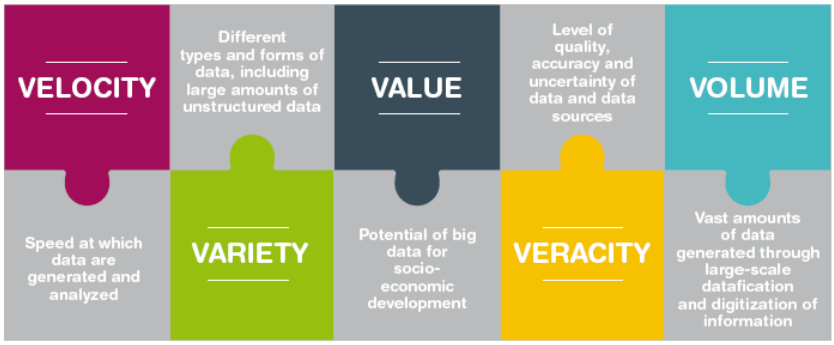
Big data 5'V



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)

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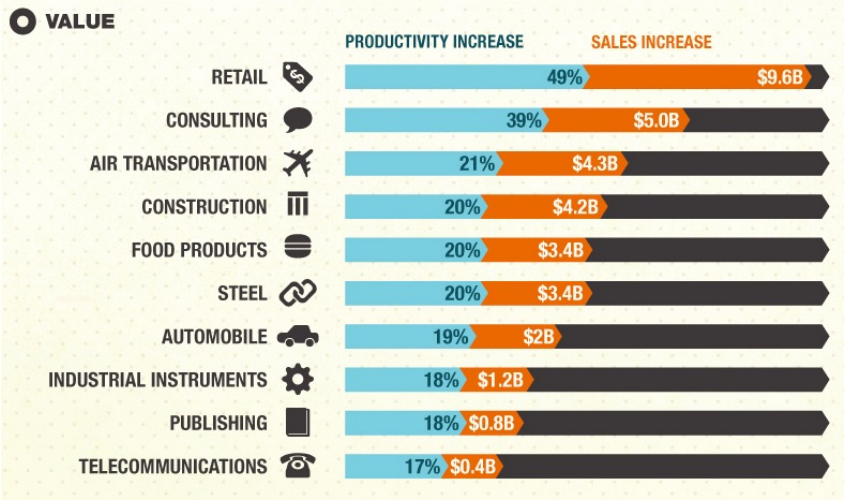
Big data – big value



source: wipro.com

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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.

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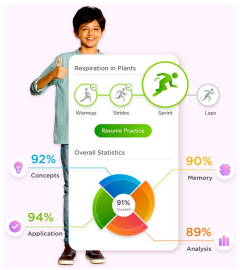
Edtech

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



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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.

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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.

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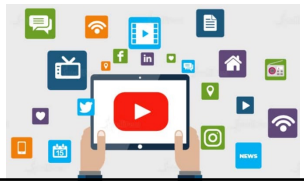
Big Data in media and entertainment industry

- 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.



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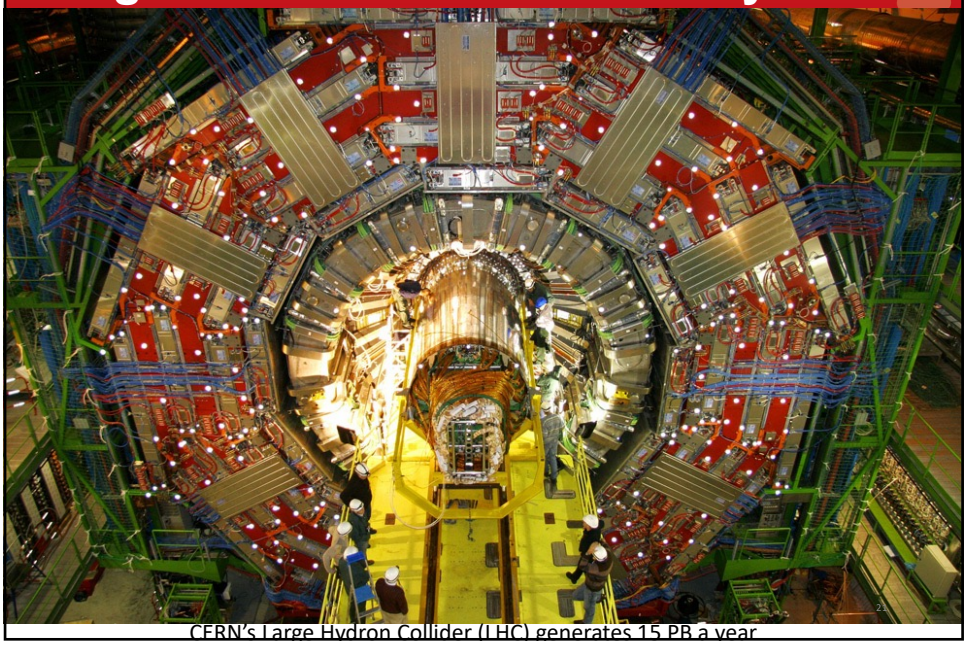
Big data in scientific discovery



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

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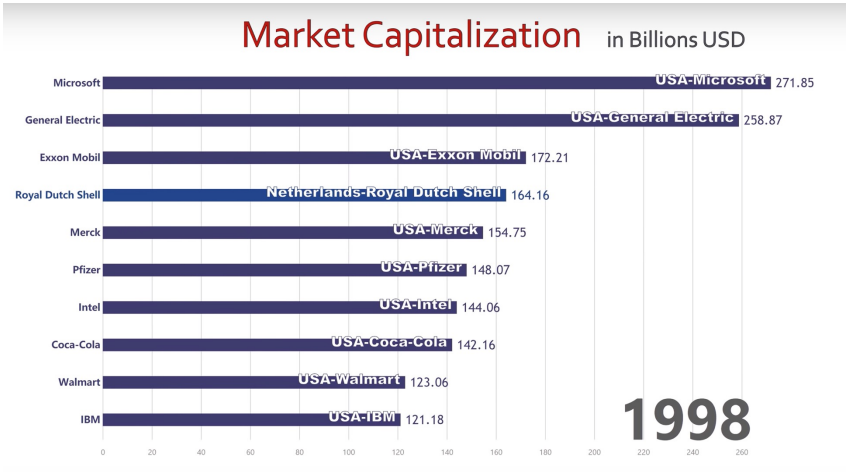
Top 10 Company Market Cap Ranking History (1998-2018)



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

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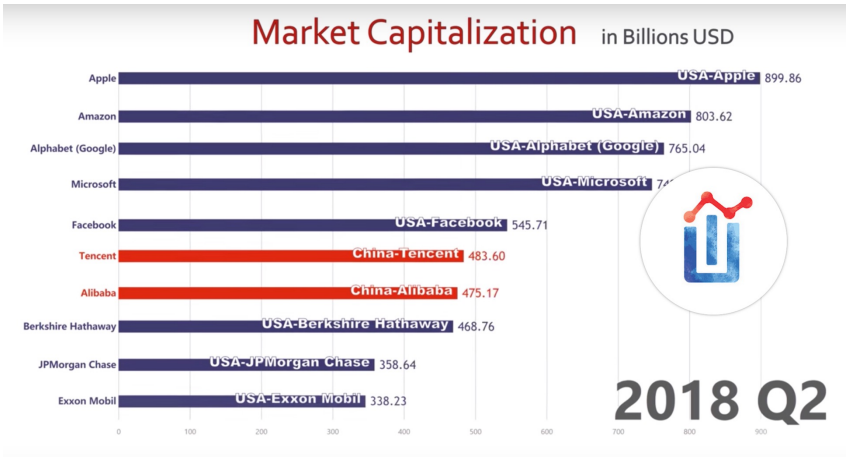
Top 10 Company Market Cap Ranking History (1998-2018)



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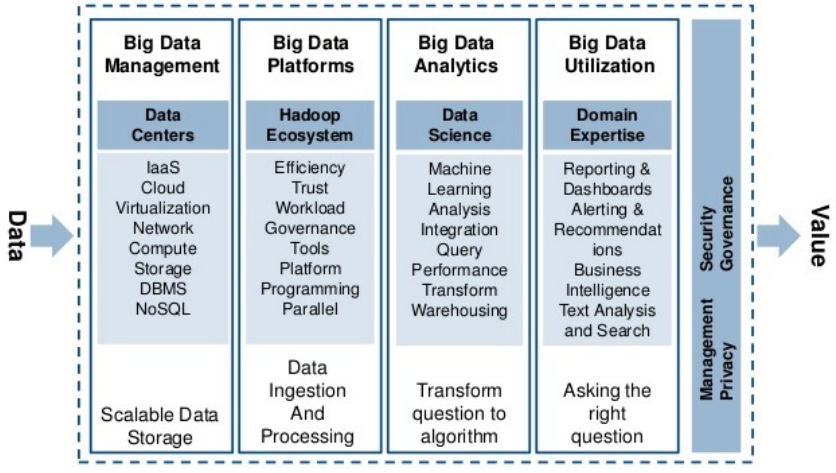
Big data technology stack



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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.

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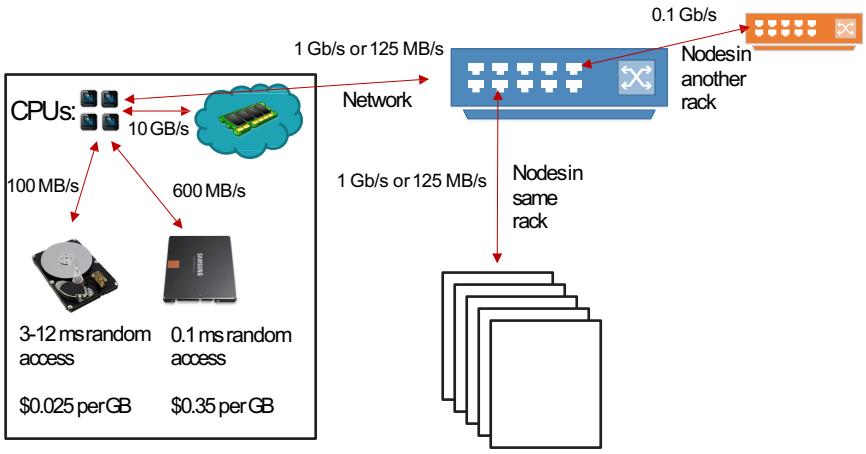
Data I/O landscape



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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

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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

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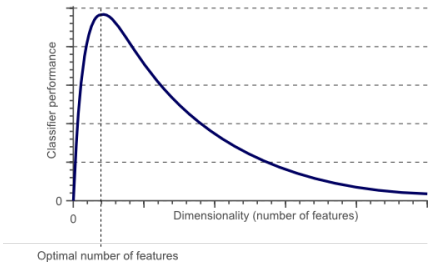
Eg. Curse of dimensionality

- 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.

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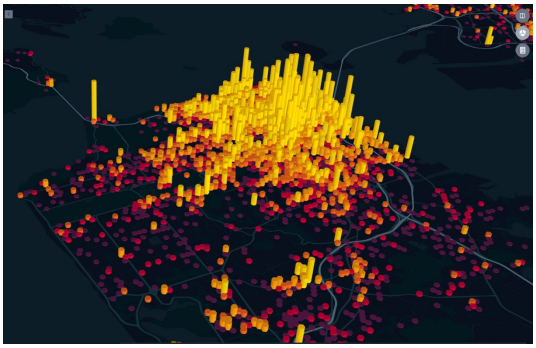
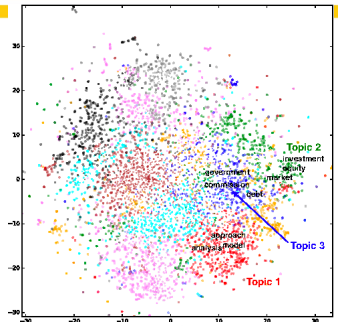
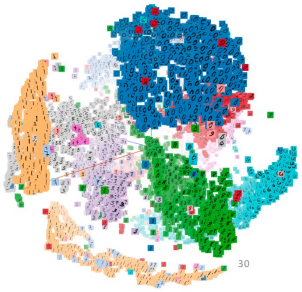
Utilization and interpretability of big data

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







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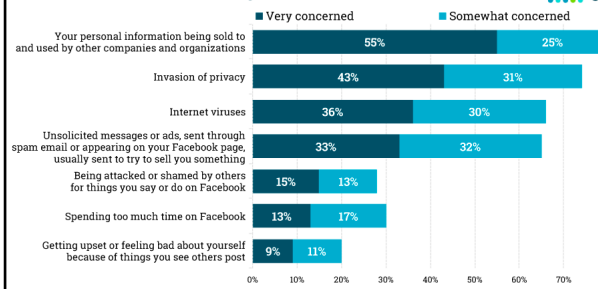
Privacy and security

FTC Settlement with Facebook

- $5,000,000,000 Unprecedented **penalty**
- New **privacy structure** at Facebook
- New tools for FTC to **monitor** Facebook

Facebook Users' Privacy Concerns



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.

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.

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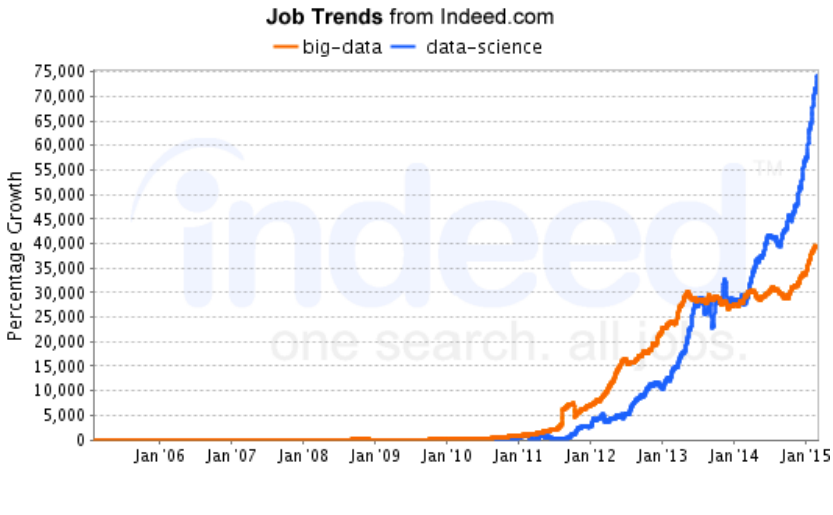
Big data job trends



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Talent shortage in big data

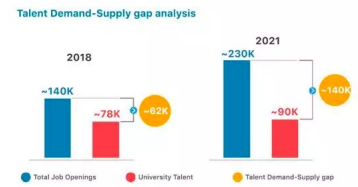

Table 2. Summary Demand Statistics

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

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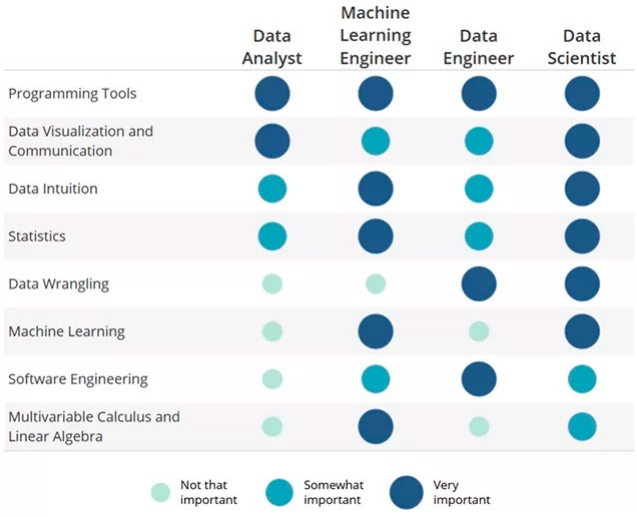
Big data skill set



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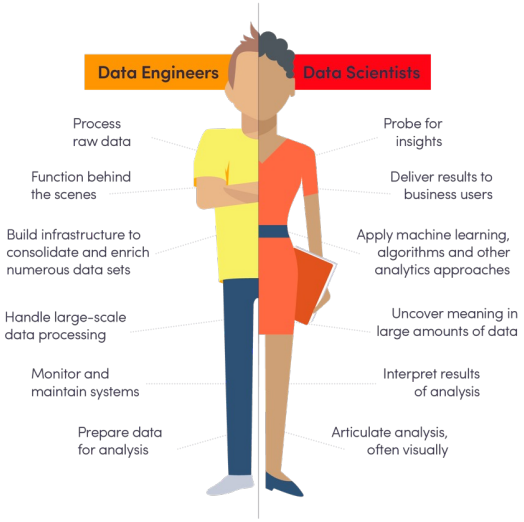
Data engineers vs. data scientists



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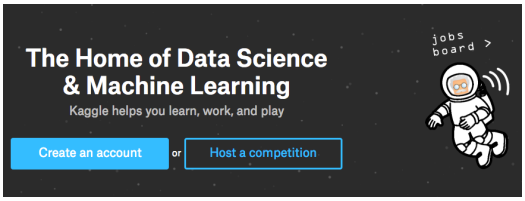
How to land big data related jobs

- 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



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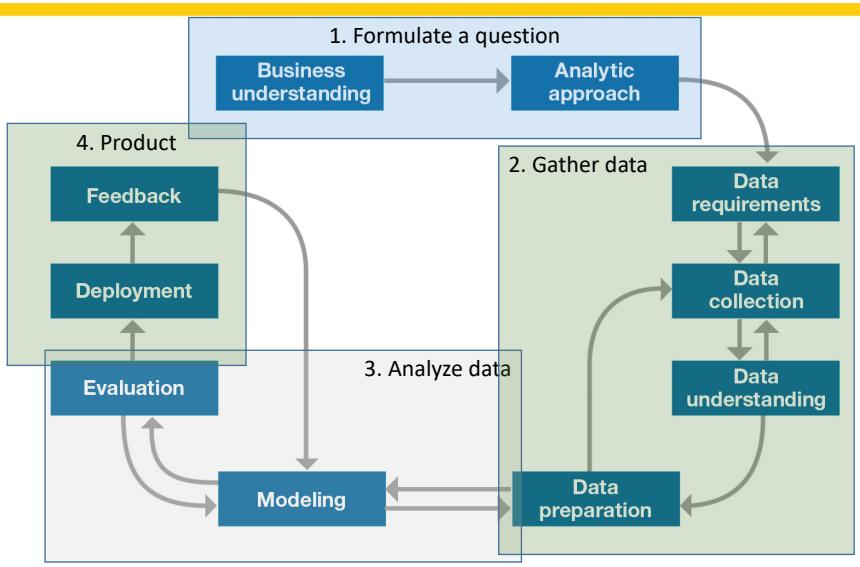
Data science method



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

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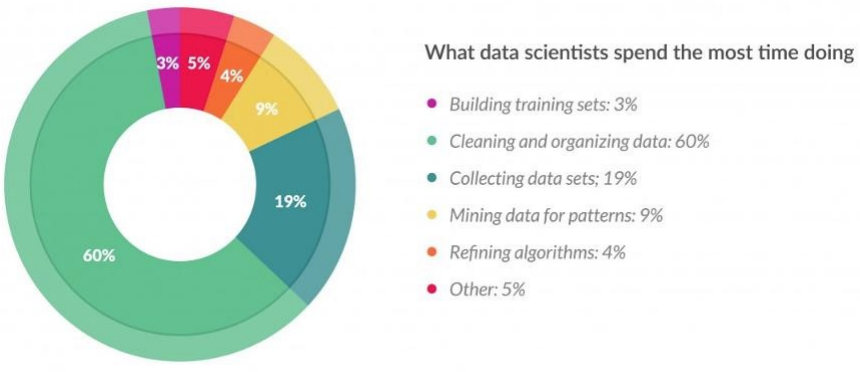
Cleaning big data: most time-consuming, least enjoyable data science task

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



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

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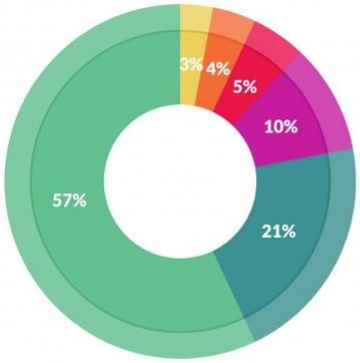
Cleaning big data: most time-consuming, least enjoyable data science task

- 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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References

[1] Tiwari, Shashank. Professional NoSQL. John Wiley & Sons, 2011.

[2] Lam, Chuck. Hadoop in action. Manning Publications Co., 2010.

[3] Miner, Donald, and Adam Shook. MapReduce design patterns: building effective algorithms and analytics for Hadoop and other systems. " O'Reilly Media, Inc.", 2012.

[4] Karau, Holden. Fast Data Processing with Spark. Packt Publishing Ltd, 2013.

[5] Penchikala, Srini. Big data processing with apache spark. Lulu. com, 2018.

[6] White, Tom. Hadoop: The definitive guide. " O'Reilly Media, Inc.", 2012.

[7] Gandomi, Amir, and Murtaza Haider. "Beyond the hype: Big data concepts, methods, and analytics." International Journal of Information Management 35.2 (2015): 137-144.

[8] Cattell, Rick. "Scalable SQL and NoSQL data stores." Acm Sigmod Record 39.4 (2011): 12-27.

[9] Gessert, Felix, et al. "NoSQL database systems: a survey and decision guidance." Computer Science-Research and Development 32.3-4 (2017): 353-365.

[10] George, Lars. HBase: the definitive guide: random access to your planet-size data. " O'Reilly Media, Inc.", 2011.

[11] Sivasubramanian, Swaminathan. "Amazon dynamoDB: a seamlessly scalable non-relational database service." Proceedings of the 2012 ACM SIGMOD International Conference on Management of Data. ACM, 2012.

[12] Chan, L. "Presto: Interacting with petabytes of data at Facebook." (2013).

[13] Garg, Nishant. Apache Kafka. Packt Publishing Ltd, 2013.

[14] Karau, Holden, et al. Learning spark: lightning-fast big data analysis. " O'Reilly Media, Inc.", 2015.

[15] Iqbal, Muhammad Hussain, and Tariq Rahim Soomro. "Big data analysis: Apache storm perspective." International journal of computer trends and technology 19.1 (2015): 9-14.

[16] Toshniwal, Ankit, et al. "Storm@ twitter." Proceedings of the 2014 ACM SIGMOD international conference on Management of data. ACM, 2014.

[17] Lin, Jimmy. "The lambda and the kappa." IEEE Internet Computing 21.5 (2017): 60-66.

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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

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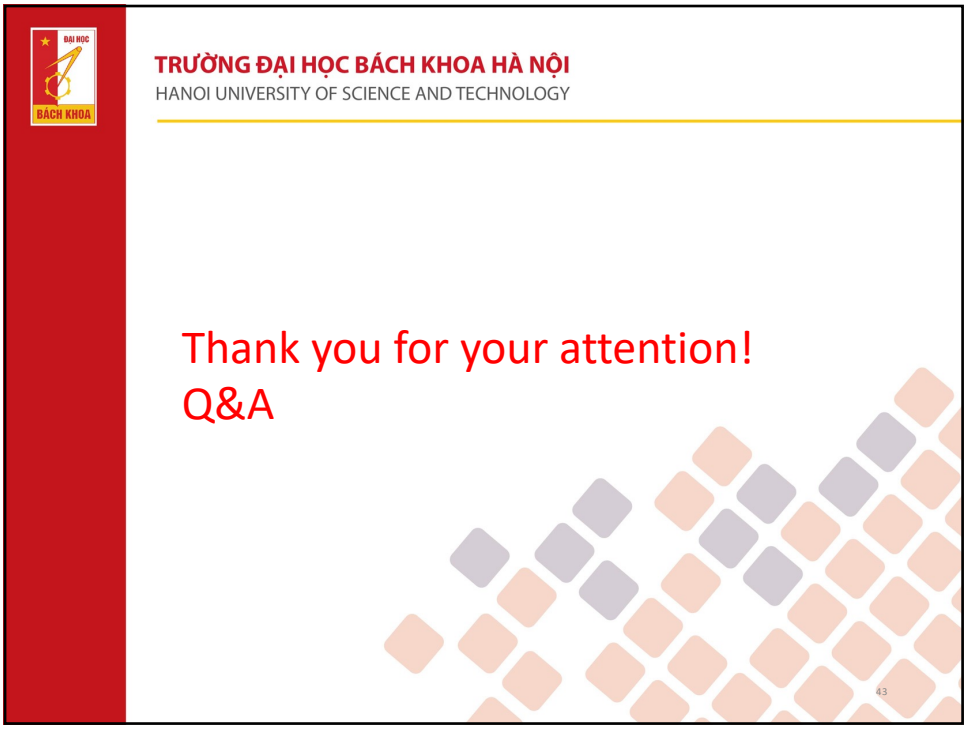

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