Aalto University
School of Science

Introduction to Big Data Platforms

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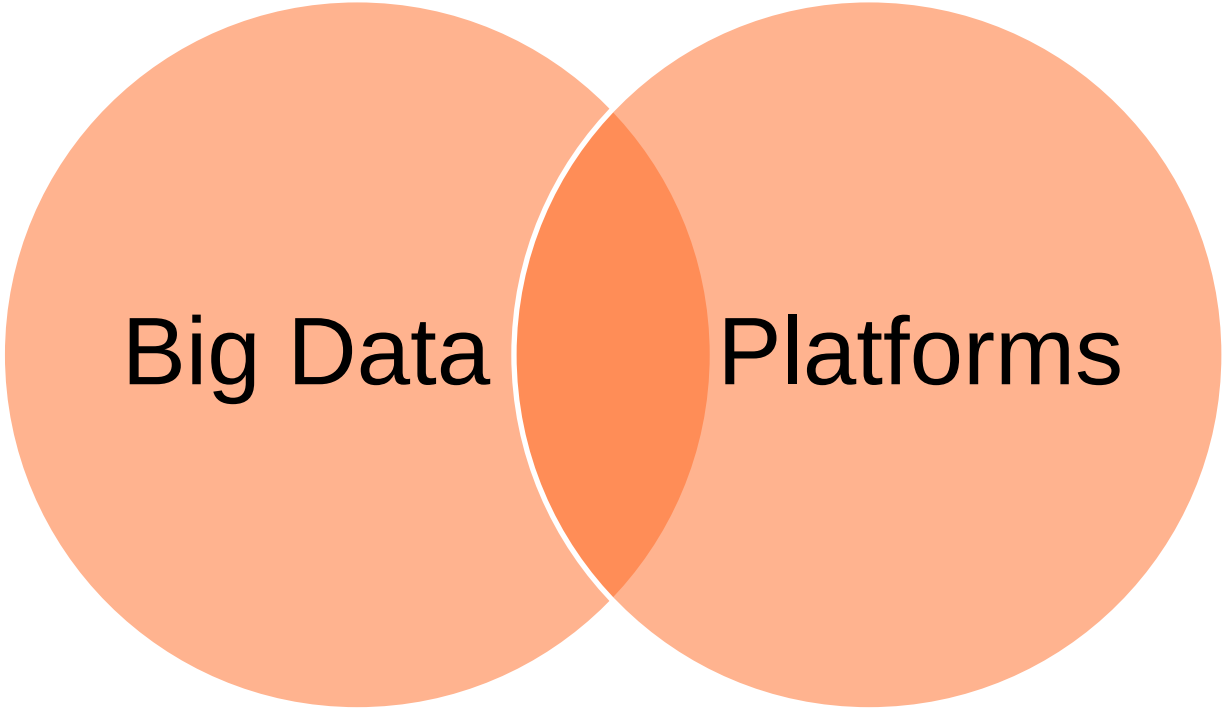
Learning objectives

- **Understand “big data” and “platforms” in big data platforms**
- **Capture high-level views of big data platforms and understand the role of big data platforms**
- **Understand key aspects in studying big data platforms**

What are they?



Data: facts, responses, events, measurement, etc.

amazon_reviews_multilingual_US_v1_00.tsv (3.63 GB)

Detail | Compact | Column | 10 of 15 columns

marketplace	customer_id	review_id	product_id	product_parent	product_title	product_c
US	53096384	R63J84G1LOX6R	1563890119	763187671	The Sandman Vol. 1: Preludes and Nocturnes	Books
US	53096399	R1BALOA11Z06MT	1559947608	381720534	The 22 Immutable Laws of Marketing	Books
US	53096332	R1LLAY5W5PZUS4	0671701800	860650224	Contact	Books
US	53096335	R3R9VTJ82FXECQ	0425132153	624269601	Good Omens	Books
US	51747709	R1P5J3FNBWTFXY	0517122707	161411385	A Confederacy	Books

Source: https://www.kaggle.com/cynthiarempel/amazon-us-customer-reviews-dataset

Row	unique_key	case_number	date	block	iucr	primary_type
1	7638368	HS442861	2010-08-03 12:10:00 UTC	007XX E 111TH ST	1305	CRIMINAL DAMAGE
2	7658504	HS461920	2010-07-26 05:00:00 UTC	061XX S MELVINA AVE	1305	CRIMINAL DAMAGE
3	7699434	HS447549	2010-08-05 06:12:00 UTC	036XX S ARCHER AVE	2210	LIQUOR LAW VIOLATION
4	7717246	HS524769	2010-09-20 02:30:00 UTC	057XX W AINSLIE ST	2851	PUBLIC PEACE VIOLATION
5	7721499	HS528767	2010-09-22 06:00:00 UTC	031XX S ASHLAND AVE	1121	DECEPTIVE PRACTICE
6	7734397	HS541125	2010-09-29 03:00:00 UTC	132XX S BALTIMORE AVE	1152	DECEPTIVE PRACTICE

Source: Chicago Crime, BigQuery

Sensor	PM2.5 µg/m³
Median 7 Sens.	23
(+) #20890	25
(+) #26221	23
(+) #31206	13
(+) #31454	28
(+) #34144	20
(+) #43411	1
(+) #59291	36

Source: https://maps.sensor.community/#8/52.917/8.817

Is it big ?

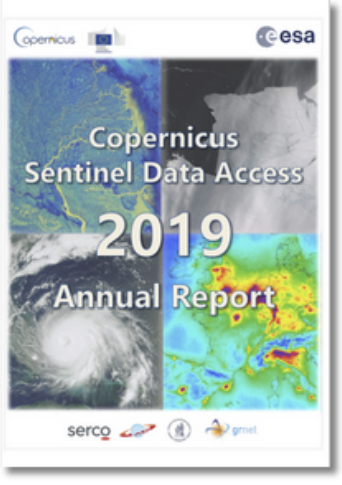
From earth observation/remote sensing

Annual Report 2019 — annual reports archive

This report for 2019 follows directly on from the 2018 report, and analyses the uptake of Copernicus Sentinel data and the performance of the Sentinel Data Access System during the period 1 December 2018 to 30 November 2019 (referred to as Y2019).

By the end of the reporting period, the Sentinel Data Access System was supporting over 280,000 registered users, a daily publication rate of over 30,500 products/day, and an average daily download volume of 214 TiB. A total of 254 million products had been downloaded by users since the start of data access operations, consisting of a total data volume of 158.4 PiB. Over half of these downloads - 128 million - occurred during Y2019 alone. The report provides the detailed statistics behind these numbers, as well as examining the demographics of users, the status of agreements with collaborative and international partners, the challenges and solutions found by the Data Access Operations team in publishing and disseminating such huge volumes of data and evolving the System to cope with them, and the outlook for the future.

The 2019 Copernicus Sentinel Data Access Annual Report is available here .



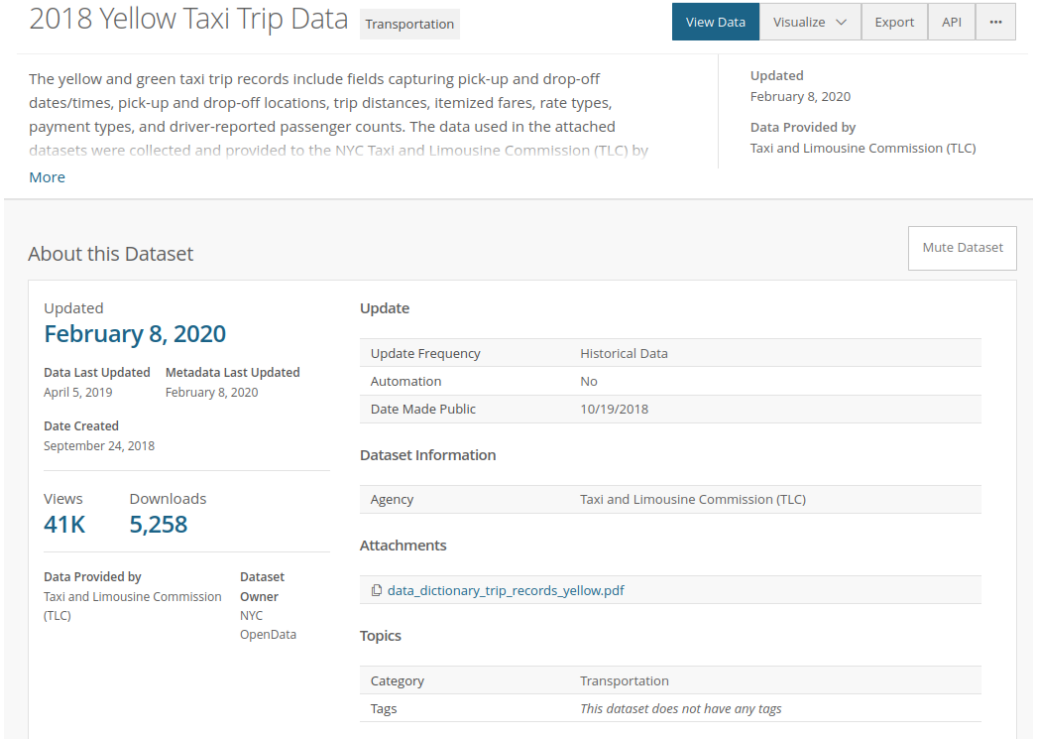
Source: https://scihub.copernicus.eu/twiki/do/view/SciHubWebPortal/AnnualReport2019

Is it big

e.g., 112M rows (2021 check)

"As of today we have 60 PB of query-able event data stored in an S3 based data lake and about 10 PB of raw data is being scanned every day using Presto."

Source: Aug, 2019
https://eng.lyft.com/presto-infrastructure-at-lyft-b10adb9db01



Snapshot from: https://data.cityofnewyork.us/Transportation/2018-Yellow-Taxi-Trip-Data/t29m-gskq

Is it big?

From a network infrastructure monitoring

5M sensors/monitoring points with
~1.4B events/day~ 72GB/day

Big Data

- **Extremely large, complex data sets**
  - they need to be handled with new techniques
- **Individual data items can be small or big**
  - e.g., simple sensor events versus high quality satellite images
- **Often characterized by V***
  - e.g., Volume, Variety, Velocity, and Veracity

Characterize big data with V*

- **Volume:**
  - big size, large data set, massive of small data
- **Variety:**
  - complex, different formats, types of data and their links
- **Velocity:**
  - generating speed, data movement speed
- **Veracity:**
  - quality is very different (timeliness, accuracy, etc.)

Why do we have big data now?

- **Social media data generated by human activities**
  - Meta/Facebook, TikTok, Twitter, Instagram, etc.
- **Internet of Things (IoT)/Machine-to-Machine (M2M)/Industry 4.0**
  - data generated from monitoring of equipment, infrastructures and environments
- **Advanced sciences data generated by advanced instruments**
  - Earth observation from satellites/telescopes (Sentinel, James Webb)
- **Personal and disease information (e.g., healthcare)**
- **Business-related customer data**
- **Asset management and lodging (e.g., cars, homes)**
- **Software systems (e.g., logs and test results)**

Why do we need to care?

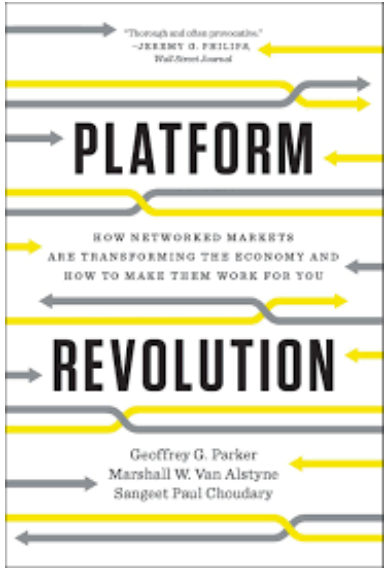
- **Because of the values of data!**
- **Top-down: Data economy**
  - more data → more insights → better decision making → more business successes
- **Bottom-up**
  - understanding → optimizing → saving cost/creating new values
- **"The Unreasonable Effectiveness of Data" principle → with more data, the same algorithm performs much better!**

Alon Halevy, Peter Norvig, and Fernando Pereira. 2009. The Unreasonable Effectiveness of Data. IEEE Intelligent Systems 24, 2 (March 2009). http://static.googleusercontent.com/media/research.google.com/en//pubs/archive/35179.pdf

What are platforms?

Example of platforms

Let us see from the business viewpoint from “Platform Revolution”:



Disruptive platforms: Airbnb, Amazon, Uber, Alibaba, Instagram, Facebook, Youtube, etc.

https://www.amazon.com/Platform-Revolution-Networked-Markets-Transforming/

The “Platform Revolution”s definition of a platform (from a business viewpoint)

“A platform is a business based on enabling value-creating **interactions** between external producers and consumers. The platform provides **an open, participative infrastructure** for these interactions and sets **governance conditions** for them. The platform’s overarching purpose: to consummate matches among users and **facilitate the exchange of** goods, services, or social currency, thereby enabling value creation for all participation”

Source: Geoffrey G. Parker, Van Alstyne, Marshall W. Van Alstyne , Sangeet Paul Choudary, *Platform Revolution: How Networked Markets Are Transforming the Economy - and How to Make Them Work for You,* March 28, 2016

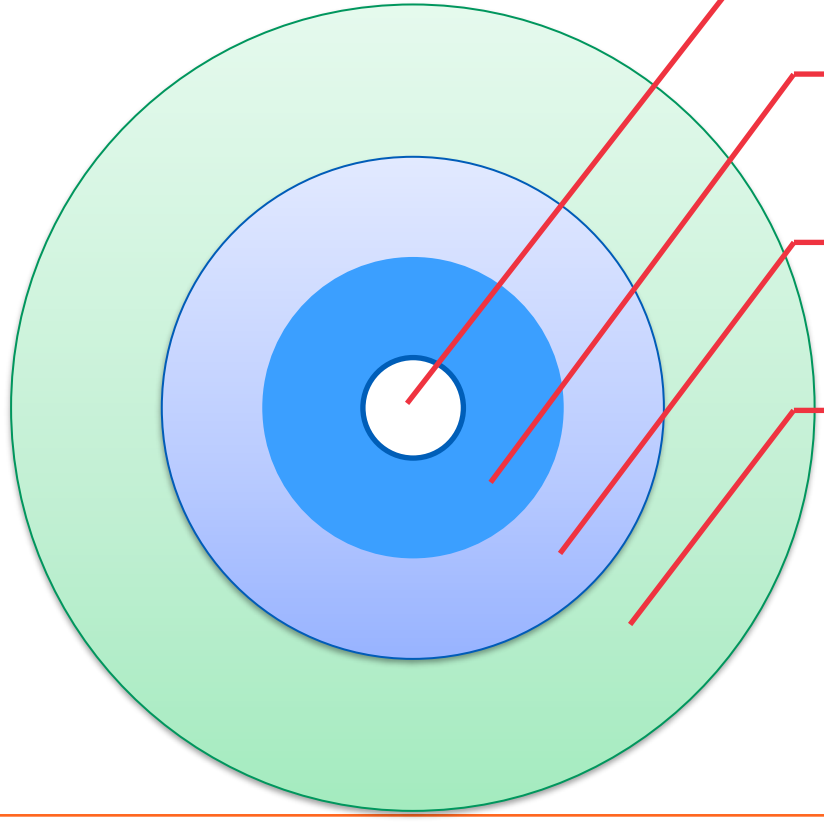
Our interpretation of platforms for big data

- **Being large-scale service platforms, e.g.**
  - On-demand computing platforms for data-centric products
  - On-demand analytics service platforms
  - On-demand data management platforms
- **Enabling interactions between big data producers and big data consumers**
  - Integration, management, analysis, optimization
- **Facilitating the exchange of big data and products centered around data**
- **Not just a database or data marketplace (even they are big!)**

Big data platforms

- **Data-centric services**
  - Data: a lot of data with different types and added continuously
  - Complex technological infrastructures
- **Extensibility**
  - allowing new services, components to be added and integrated
- **With diverse types of stakeholders**
  - Data consumers, data providers, and data integrators
  - Service consumers, service providers and service integrators
  - Regulators/auditors, etc.

Big data platforms: Onion architecture



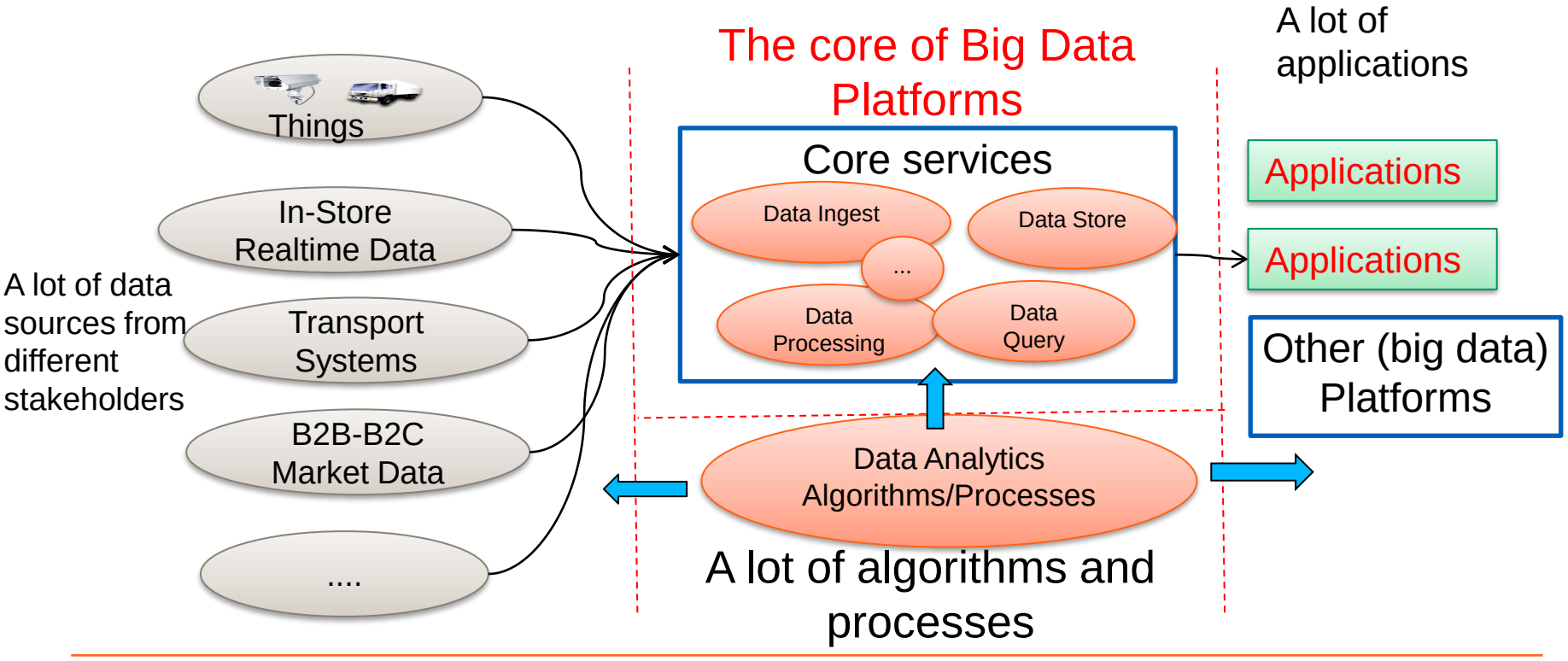
Data-centric Virtualized Infrastructures

Middleware Platforms: building, deploying, operating and scaling reliable big data services and applications

Big data services & applications

Big data platforms consumers and producers: Sensors, Things, Equipment, Industrial Processes, People

Big data platforms: system of systems view



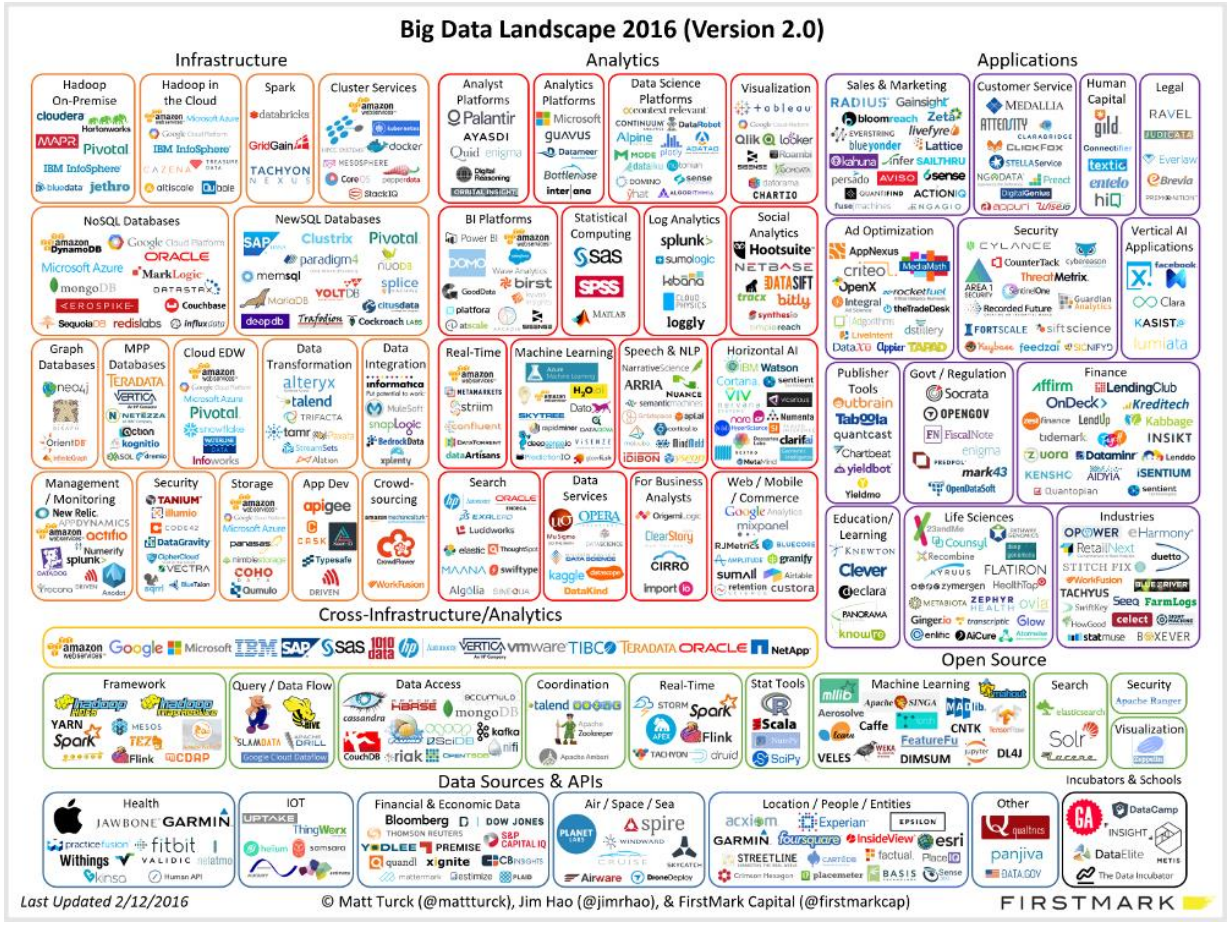
Why are big data platforms important?

- **Foundations and backbones for various "hot" areas, especially in data-driven economy**
  - Machine Learning/AI
    - *Data management, feature storage, data preparation pipelines, …*
  - Data Science
    - *Data and data management, computational models, statistics and algorithm*
  - Enterprise computing
    - *360-degree analytics of customers*
  - Industrial IoT/Manufacturing/Predictive maintenance
    - *Monitor machines and optimizing machines through real-time and predictions*
  - Smart cities

Highly relevant to industries & businesses

- **Wide range application domains**
  - Business, healthcare, manufacturing, sustainability, and science
- **Examples of key industries for infrastructural and platform services for big data**
  - Amazon, Microsoft, Google, IBM, Alibaba, Huawei, etc.
  - Gartner Data Management Solutions for Analytics "https://www.gartner.com/reviews/market/data-warehouse-solutions"
- **Big data and large-scale data analytics are fundamental in most companies/organizations doing digital business**

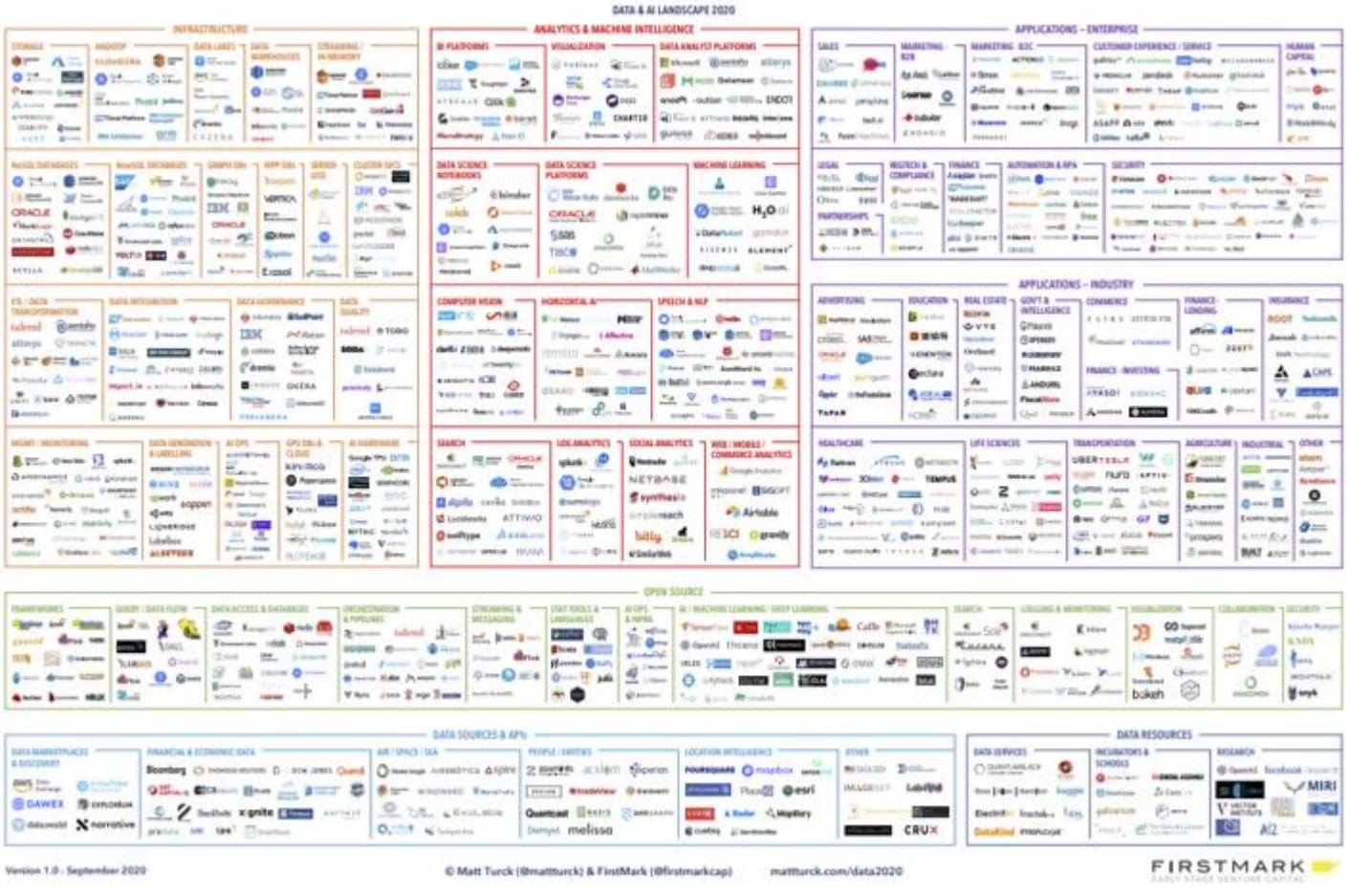
The landscape is complex for our study



Source: http://www.datameer.com/wp-content/uploads/2016/06/matt_turck_big_data_landscape_v11r.png

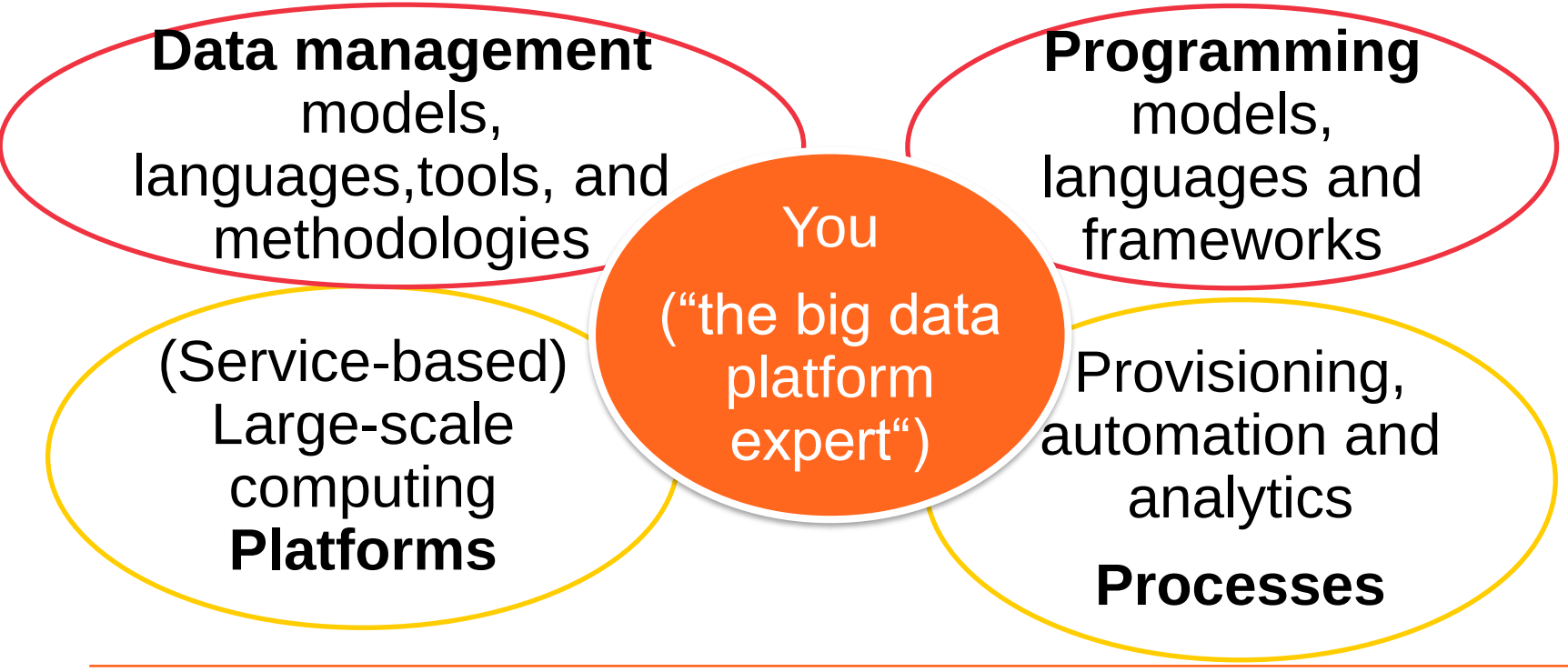
The landscape is complex for our study

the study must balance between concepts & practices!



Source: http://mattturck.com/wp-content/uploads/2020/09/2020-Data-and-AI-Landscape-Matt-Turck-at-FirstMark-v1.pdf

Core principles/techniques for Big Data Platforms



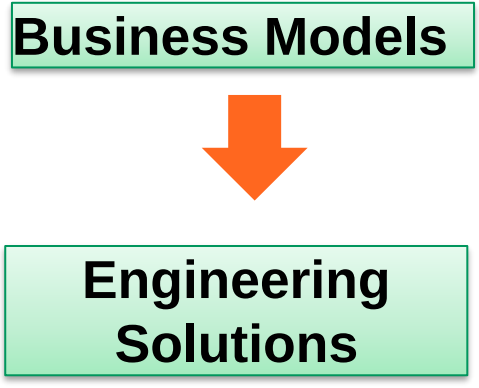
Focuses in studying big data platforms

- **Design/Development vs Operation**
- **Data-centric vs Service-centric vs Platform-centric activities**
- **High-level analytics vs low-level programming models and processes**
- **Quality and governance**

Target goals for the study

- As a user: able to program atop big data platforms
- As a provider: able to operate big data platforms
- As a designer/architect: able to design new big data platforms
- As a developer: able to develop services/applications in big data platforms

Business models vs platform engineering



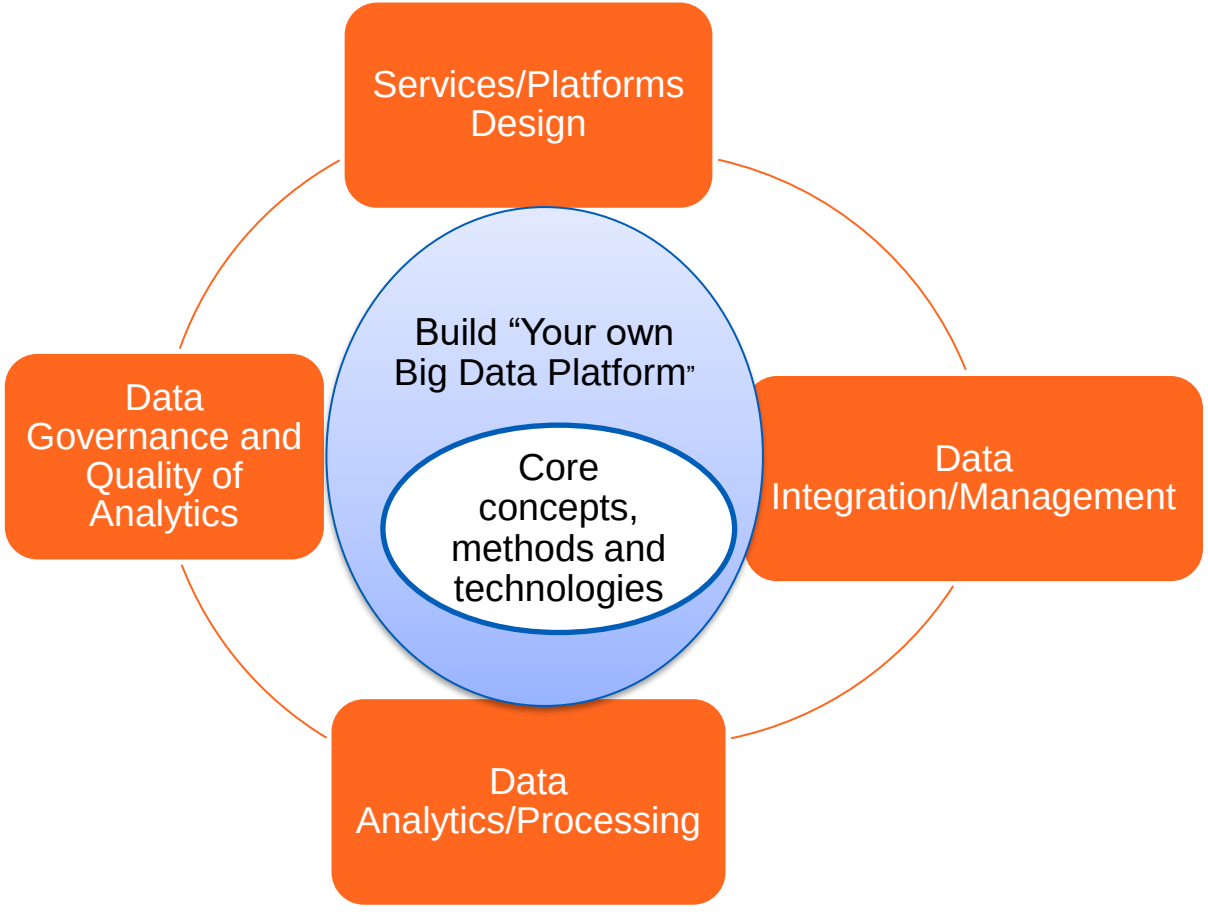
- **Distinguish between engineering and business models**
  - Engineering: design, operation and governance
  - Business models: stakeholder management, pay-per-use, pricing, tenant models
- **We mainly focus on engineering**
  - Business aspects are reflected in requirements for the engineering

Concepts/Techniques vs Technologies

- **Concepts/Techniques versus Technologies**
  - Concepts: e.g., NoSQL data models, sharding techniques, coordination for scalable datastores
  - Technologies: e.g., Cassandra, Hadoop, Apache Spark, Airflow
- **We still focus mainly on concepts/techniques**
  - Technologies can be very complex or “everything is behind an API”
  - But don’t forget key concepts and techniques
  - Implement key concepts with state-of-the-art technology in a limited but realistic scenarios

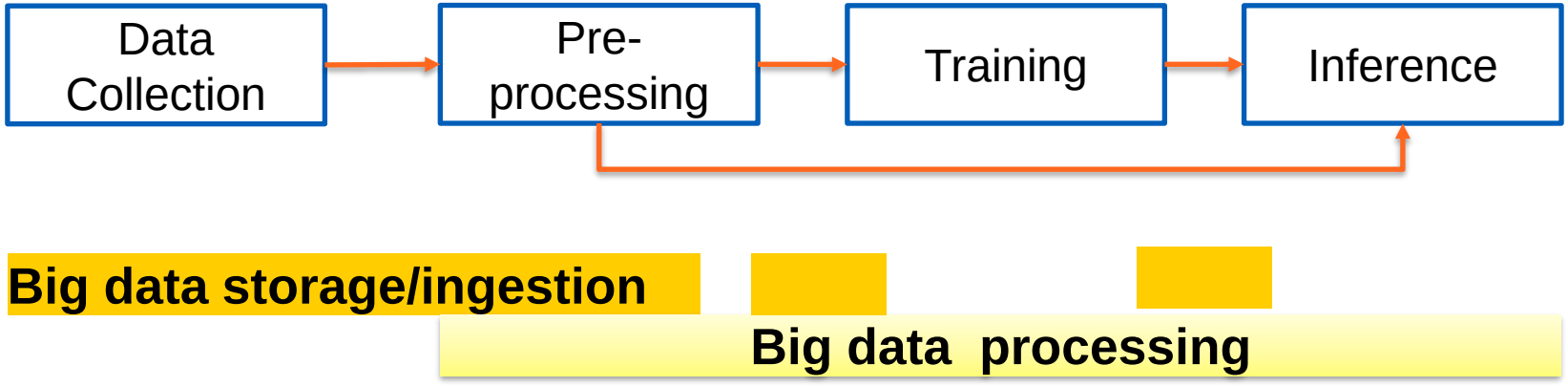
Build your story

Focus on foundations & explore your strengths/interests

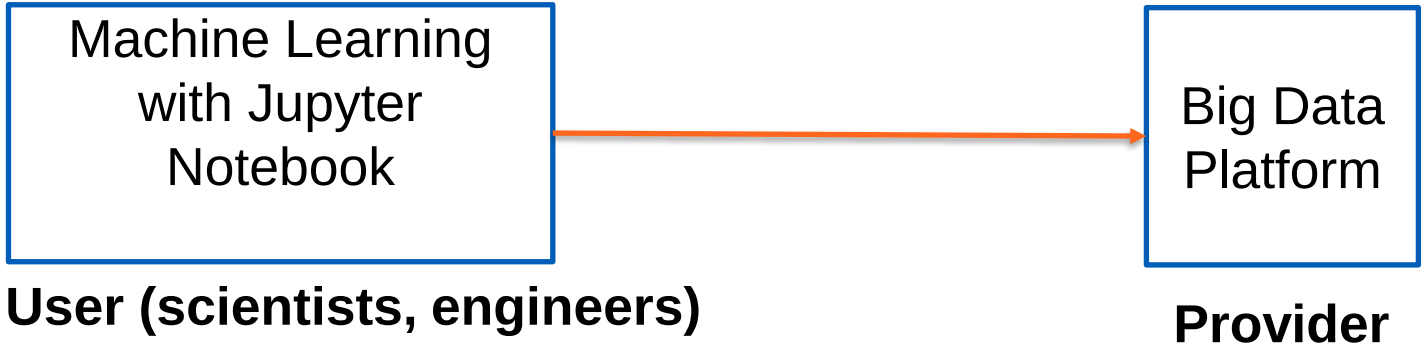


Design and implementation mainly reflect activities of platform developers/providers in the lifecycle of a big data platform based on real-world data sets and scenarios

Example of a typical big data machine learning pipeline (hot area!)



Big data processing in our story: we are not just “data scientist”



Our learning goals: tasks in systems and applications

- **Understand the user/developer needs**
- **Understand how to build platforms to support the users/developers**

Related concepts/techniques

- **Distributed systems and cloud computing**
  - Virtualized environments and cloud deployment, concurrency, consistency/availability/fault management, application protocols
- **Databases and data management**
  - Data modeling, ETL/data pipeline, data partitioning, databases
- **Algorithms and programming models**
  - Parallel/concurrent programming, workflows, streaming processing
- **Service and software engineering**
  - Service engineering & microservices

Thanks!

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