Big Data Infrastructures

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Fall 2018

Lecture 1 - Class Introduction

Outline

- Introduction to Big Data
- Class overview

Instant Quiz

- **Foreign-Key?**
- **Normal Forms?**
- **Two-Phase Commit?**
- **ACID? BASE?**
- **CAP?**
- **Hadoop? Yarn? Spark?**

Big Data & Me

- My lab @ unifr: eXascale Infolab (http://exascale.info/)
  - Previously: M.I.T. (Stonebraker's lab), EPFL (Best PhD Award), U.C. Berkeley
  - Industry also (IBM Watson Research, HP, Microsoft Research Asia, Microsoft CISL, Scigility, Dashcom)
  - Teach Big Data at Swiss Joint MSc in CS, U. Lucern, Royal Institute of Tech. (Sweden), IIMT, EPFL, HEC Lausanne

→ How to store and manage Big Data

- 2M € ERC, SNF, Haslerstiftung, H2020
- Verisign, SAP, Microsoft, Amazon, Google, ArmaSuisse

eXascale Infolab

Course Assistants

- Several labs and exercises will be given by Ph.D. students and Senior Researchers

eXascale Infolab

Goals of the Class

- Study new principles of data management
  - Data properties, data independence, scale-out, etc.
- Study key DBMS design issues
  - Transactions, parallel data processing, etc.
  - Consistency, Availability, network Partition
- Hands on some current, *hot* Big Data topics
  - Get exposed to recent trends / technologies / start-ups
- Ensure that
  - You are comfortable using a DBMS
  - You have an idea about (distributed) data management
  - You know a bit about current research topics in data management
  - You know a bit about the current market and industry trends

Exascale Data Deluge

- Web companies
  - Google
  - Ebay
  - Yahoo
- Science
  - Biology
  - Astronomy
  - Remote Sensing
- Financial services, retail companies, governments, etc.

New data formats

New machines

Peta & exa-scale datasets

Obsolescence of traditional information infrastructures

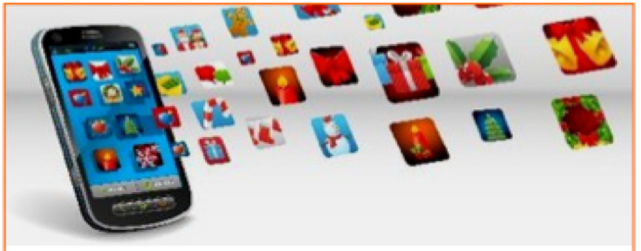
Big data can generate significant financial value across sectors

US health care

- $300 billion value per year
- ~0.7 percent annual productivity growth

Europe public sector administration

- €250 billion value per year
- ~0.5 percent annual productivity growth



Global personal location data

- $100 billion+ revenue for service providers
- Up to $700 billion value to end users

US retail

- 60+% increase in net margin possible
- 0.5–1.0 percent annual productivity growth

Manufacturing

- Up to 50 percent decrease in product development, assembly costs
- Up to 7 percent reduction in working capital

SOURCE: McKinsey Global Institute analysis

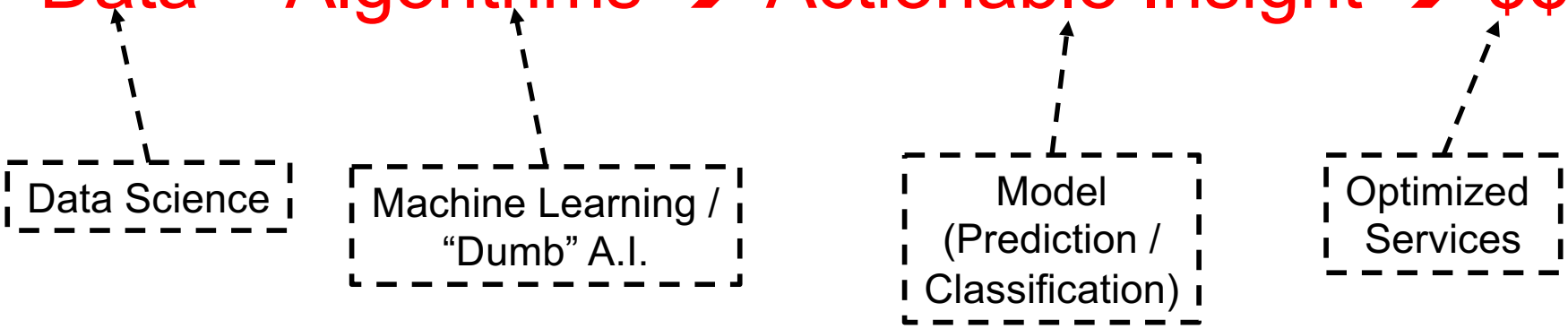
Big Data as a New Class of Asset

- The Age of Big Data (NYTimes Feb. 11, 2012) http://www.nytimes.com/2012/02/12/sunday-review/big-datas-impact-in-the-world.html

  "Welcome to the Age of Big Data. The new megarich of Silicon Valley, first at Google and now Facebook, are masters at harnessing the data of the Web — online searches, posts and messages — with Internet advertising. At the World Economic Forum last month in Davos, Switzerland, Big Data was a marquee topic. A report by the forum, "Big Data, Big Impact," declared data a new class of economic asset, like currency or gold."

Data is the new Oil

- Data + Algorithms ➔ Actionable Insight ➔ $$



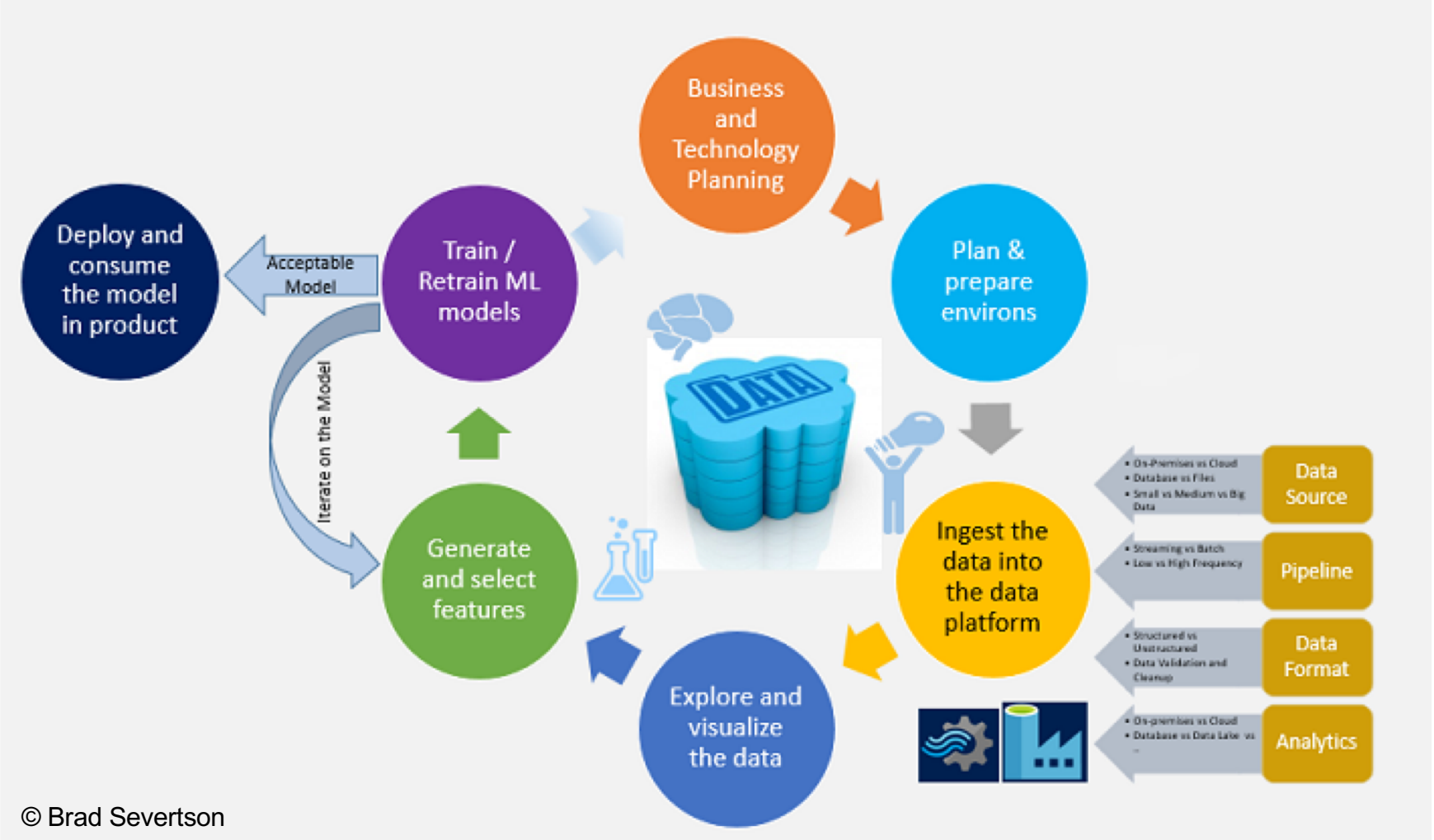
The 3-Vs of Big Data

- Volume
  - Amount of data
- Velocity
  - speed of data in and out
- Variety
  - range of data types and sources
- [Gartner 2012] *"Big Data are high-volume, high-velocity, and/or high-variety information assets that require new forms of processing to enable enhanced decision making, insight discovery and process optimization"*

What can you do with the data

- Reporting
  - Post Hoc
  - Real time
- Monitoring (fine-grained)
- Exploration
- Finding Patterns
- Root Cause Analysis
- Closed-loop Control
- Model construction
- Prediction
- …

Data Science Lifecycle

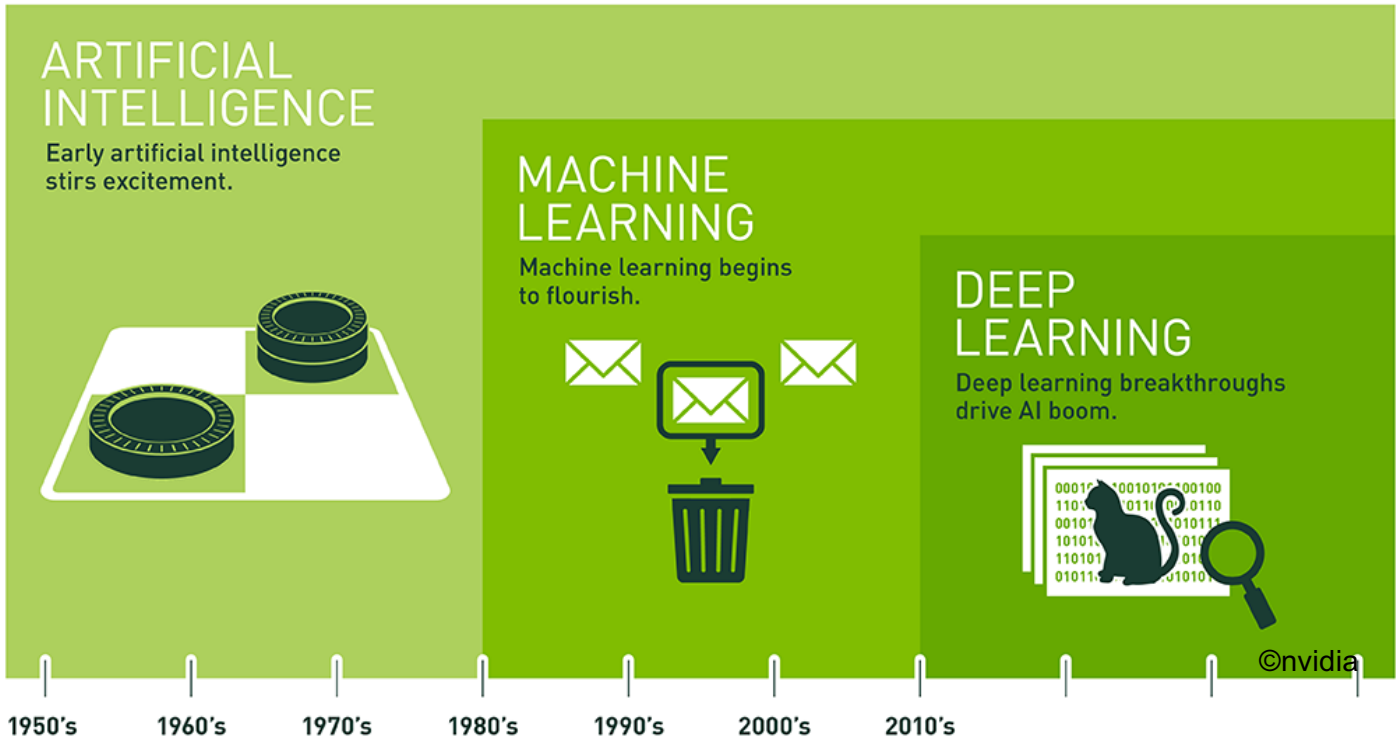


Three Generations of Models

- Descriptive models (yesterday)
- Predictive models (today)
- Prescriptive models (tomorrow)

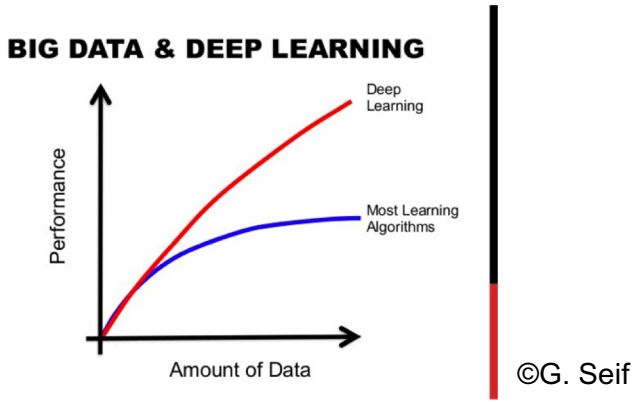
Current Model Development

- Today, models are dominated by **Deep Learning** techniques that are pushed by leading American and Chinese IT companies

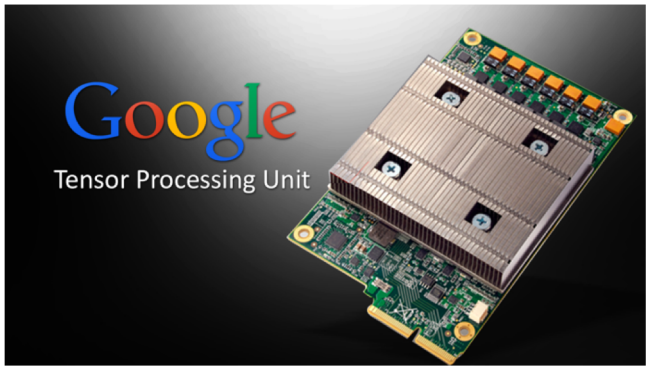


Deep Learning Feeds on Big Data

- Requires *gigantic* amounts of **annotated data** (examples)

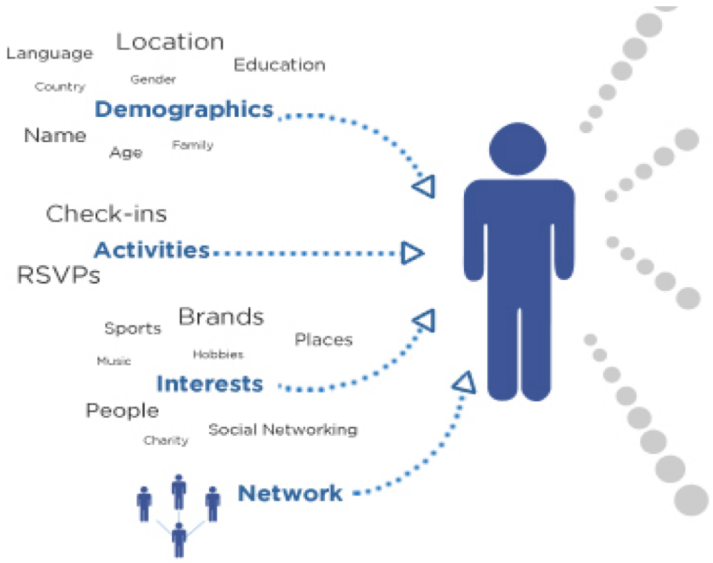


- Requires **enormous computation** (GPUs, TPUs)



Typical Big Data Success Story

- Modeling users through Big Data
  - Online ads sale / placement [e.g., Facebook]
  - Personalized Coupons [e.g., Target]
  - Product Placement [Walmart]
  - Content Generation [e.g., NetFlix]
  - Personalized learning [e.g., Duolingo]
  - HR Recruiting [e.g., Gild]



More Data => Better Answers?

- Not that easy…
- More Rows: Algorithmic complexity kicks in
- More Columns: Exponentially more hypotheses

- Another formulation of the problem:
  - Given an inferential goal and a fixed computational budget, provide a guarantee that the quality of inference will increase monotonically as data accrue (without bound)

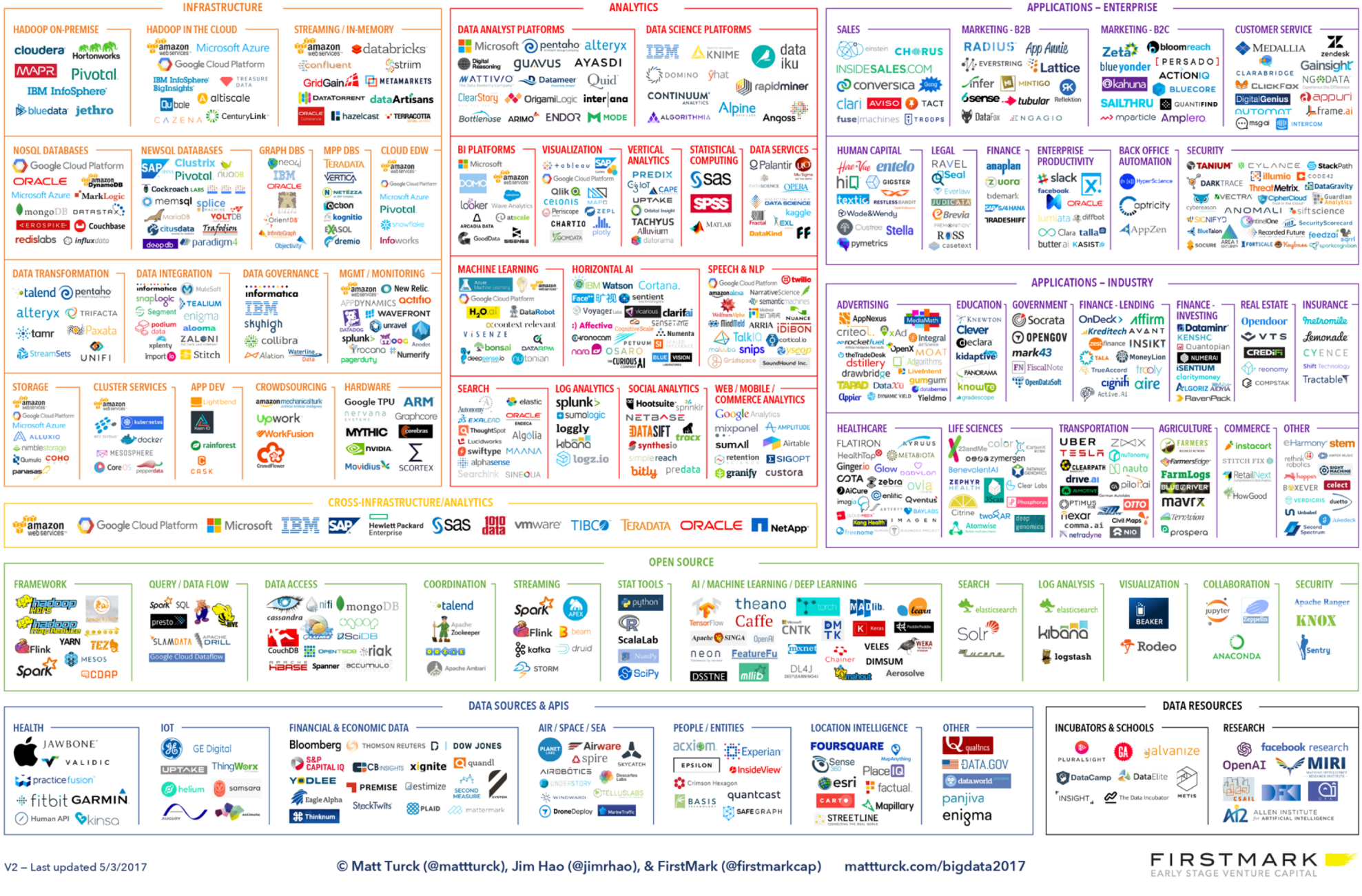
- In other words:

  => Data should be a resource, not a load

What's wrong with my old DBMS?

- Managing Big Data is hard…
  - … extremely hard
  - Traditional DBMSs are 30 years old, were not meant for Big Data
    - One user, one CPU, one type of queries
    - Obsolete physical model (n-ary storage, B-trees, etc.)
    - Impractical logical guarantees (transactions, ACID)

BIG DATA LANDSCAPE 2017

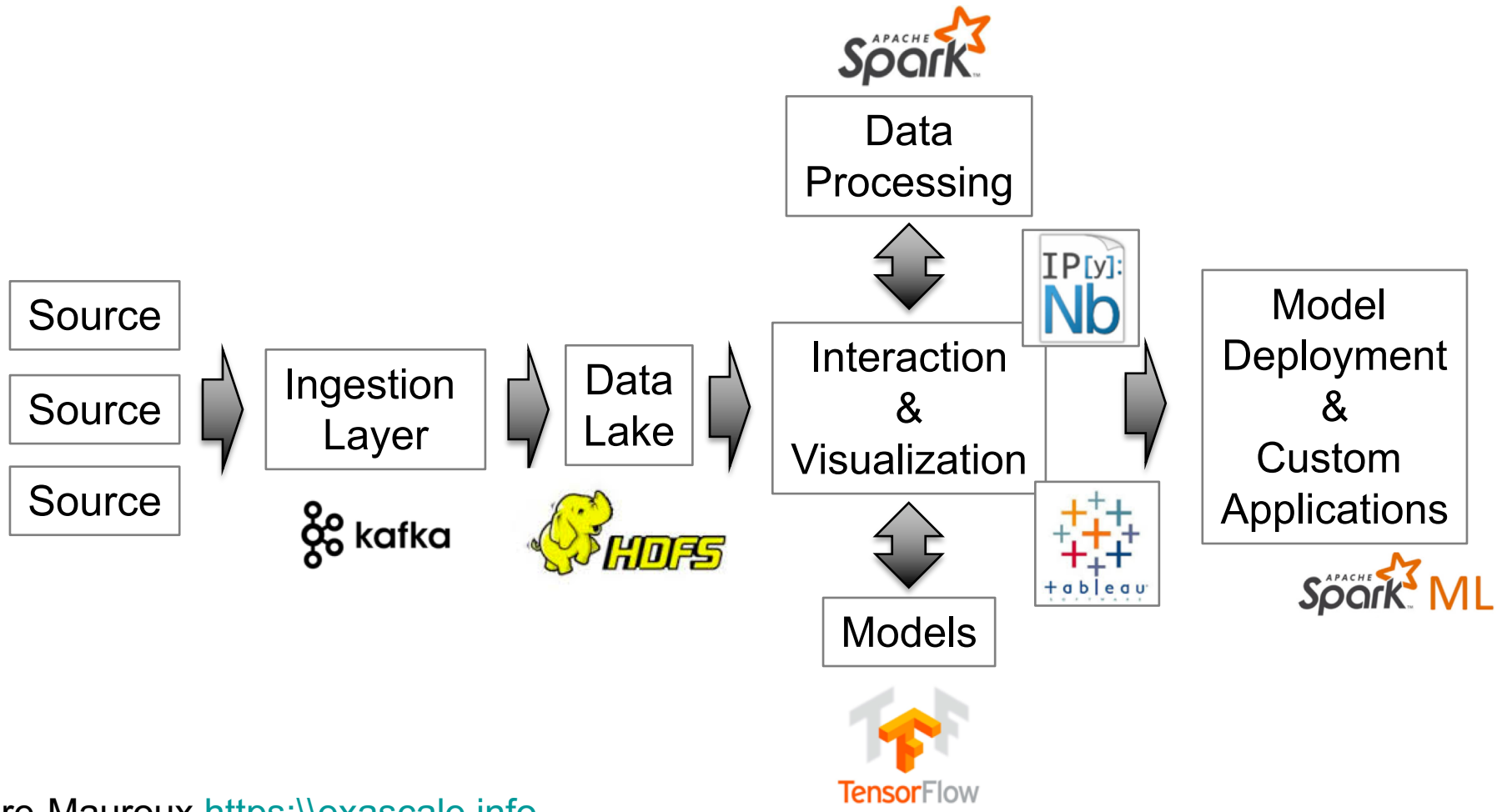


V2 – Last updated 5/3/2017

 mattturck.com/bigdata2017

FIRSTMARK
EARLY STAGE VENTURE CAPITAL

Data Science Infrastructure (circa 2018)

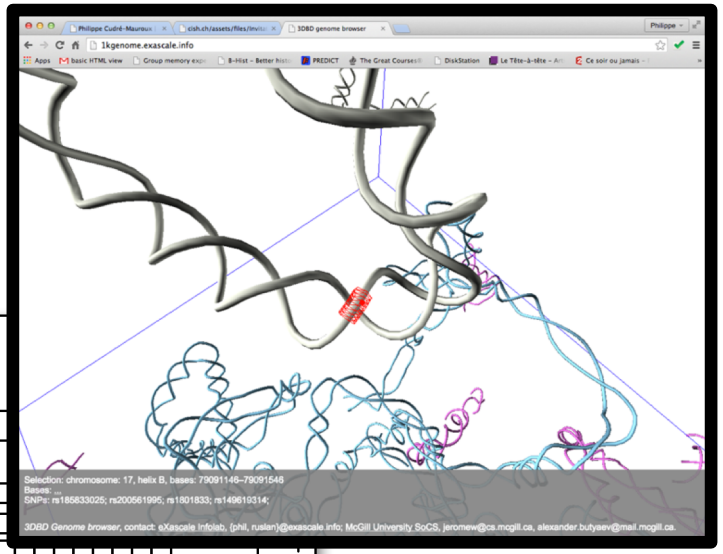


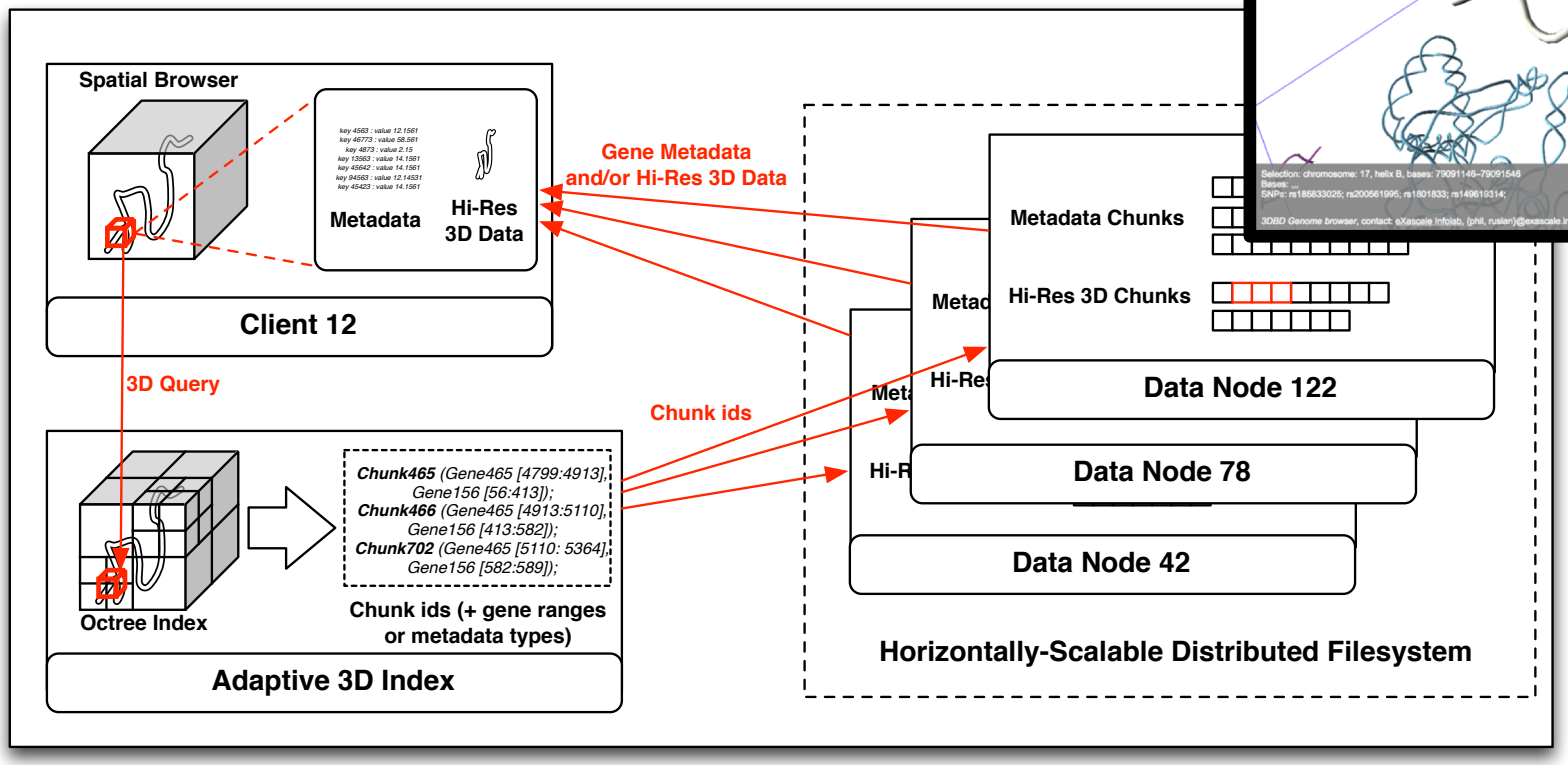
Three Examples from XI

- Three examples from the eXascale Infolab:
  - Volume: 3D Genome Browser
  - Velocity: Detecting anomalies in real-time in smart-cities
  - Variety: Integrating Log Data on Azure

Volume

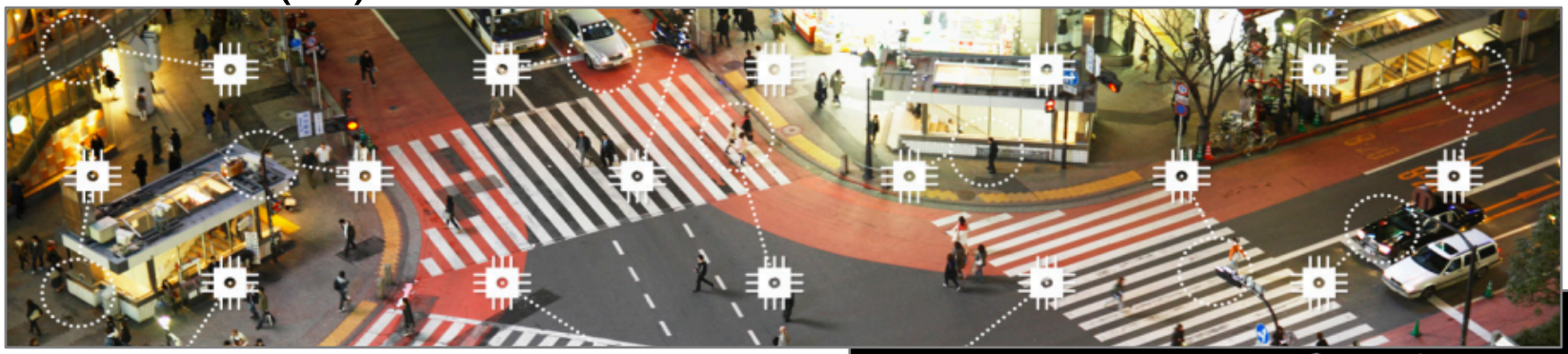
The 3D Genome Browser
- Graceful scale-out
- Very low latency



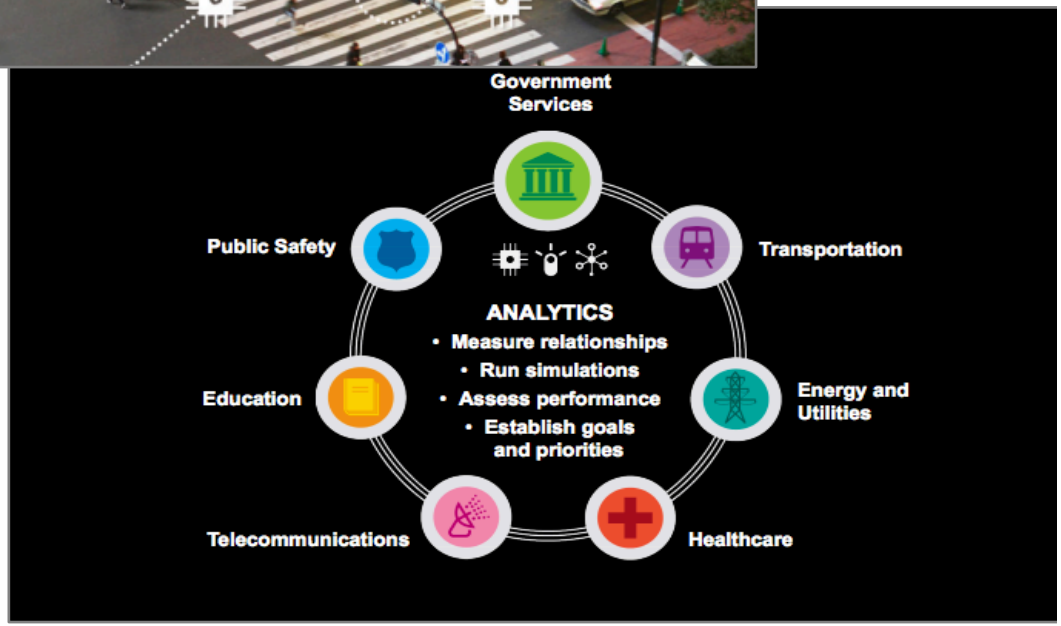


Velocity

- Smart(er) Cities!



  - Electricity provisioning
  - Water Networks



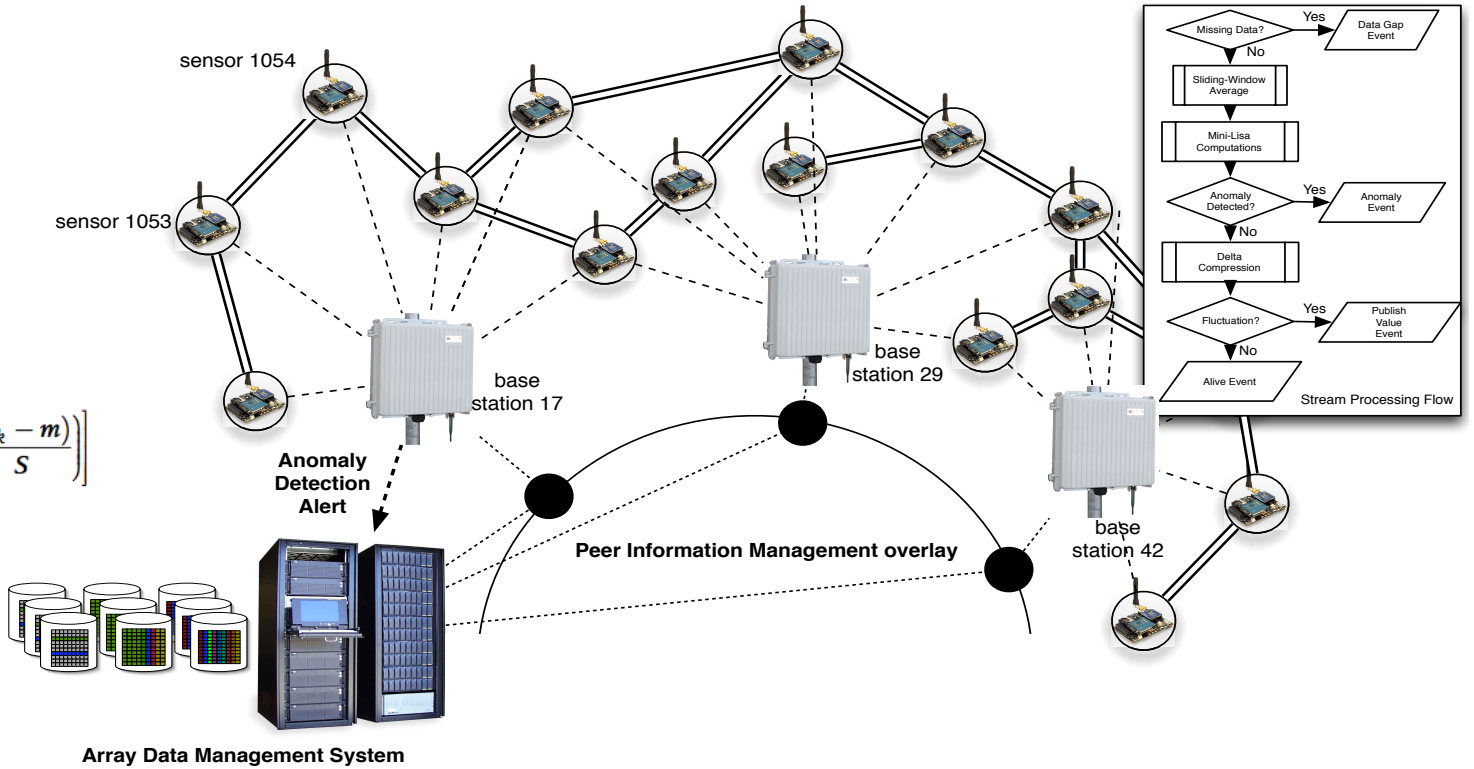
Velocity

- Detecting leaks / pipe bursts / contamination in real-time for water distribution networks

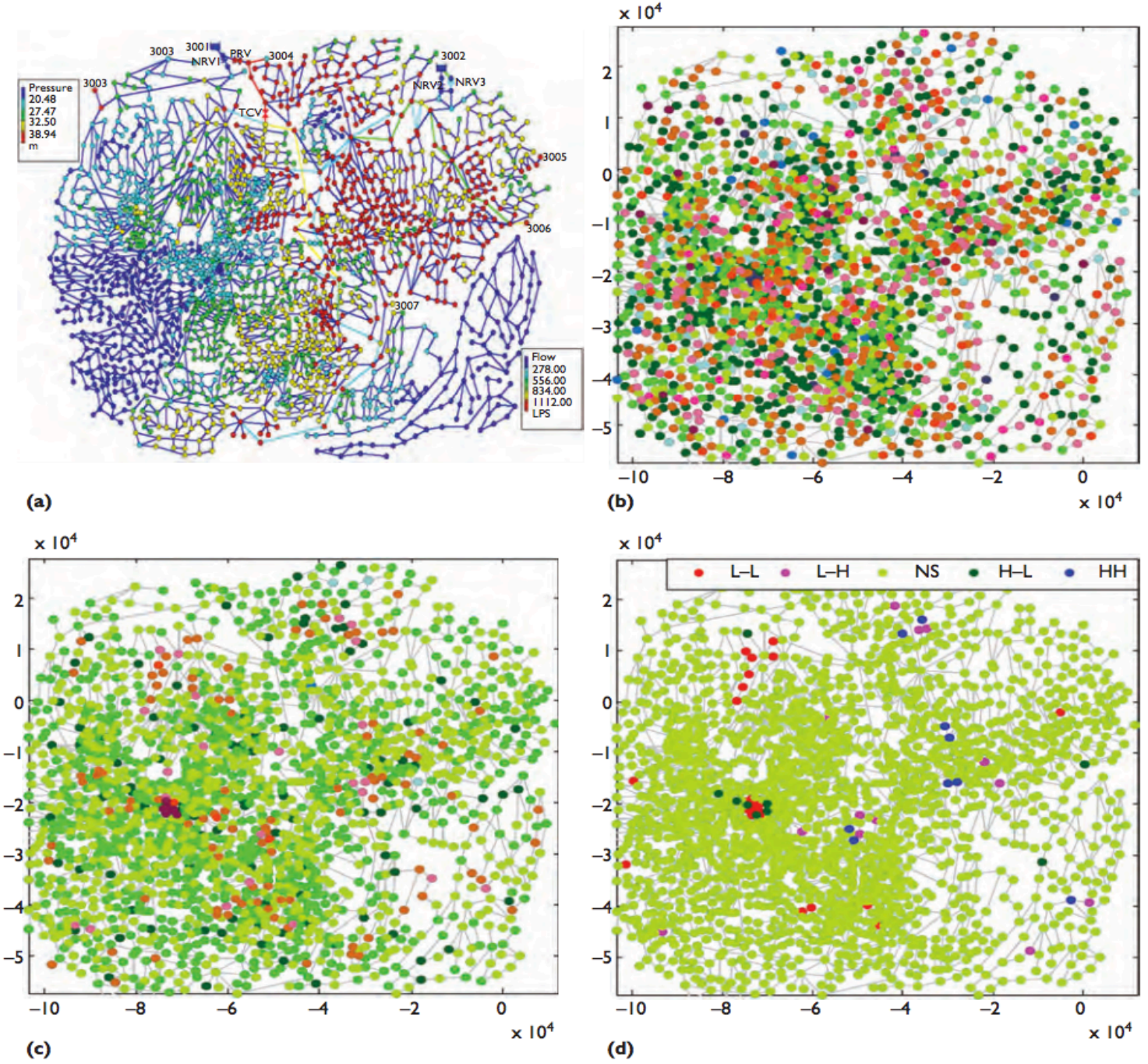
Data at each Vertex!

- Spatial + temporal statistical processing (mini-Lisas)
- Stream processing (Storm) + Array processing (SciDB)

$$LISA(v_a) = \left(\frac{v_a - m}{S}\right)\left[\sum_{k=1}^{K}\left(\frac{1}{K}\right)\left(\frac{(v_k - m)}{S}\right)\right]$$



Results (anomalies Detected)



Variety

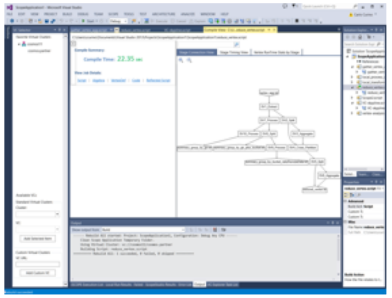
Microsoft's own Metadata Lake…

Example 1: Job pipeline analysis

- *User: "I need help with my ML experiment processing Clicklogs"*
- *Ops / Engineer:*

Dig through many tables (from cooked logs)

+

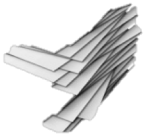


Write ad-hoc analytics

+

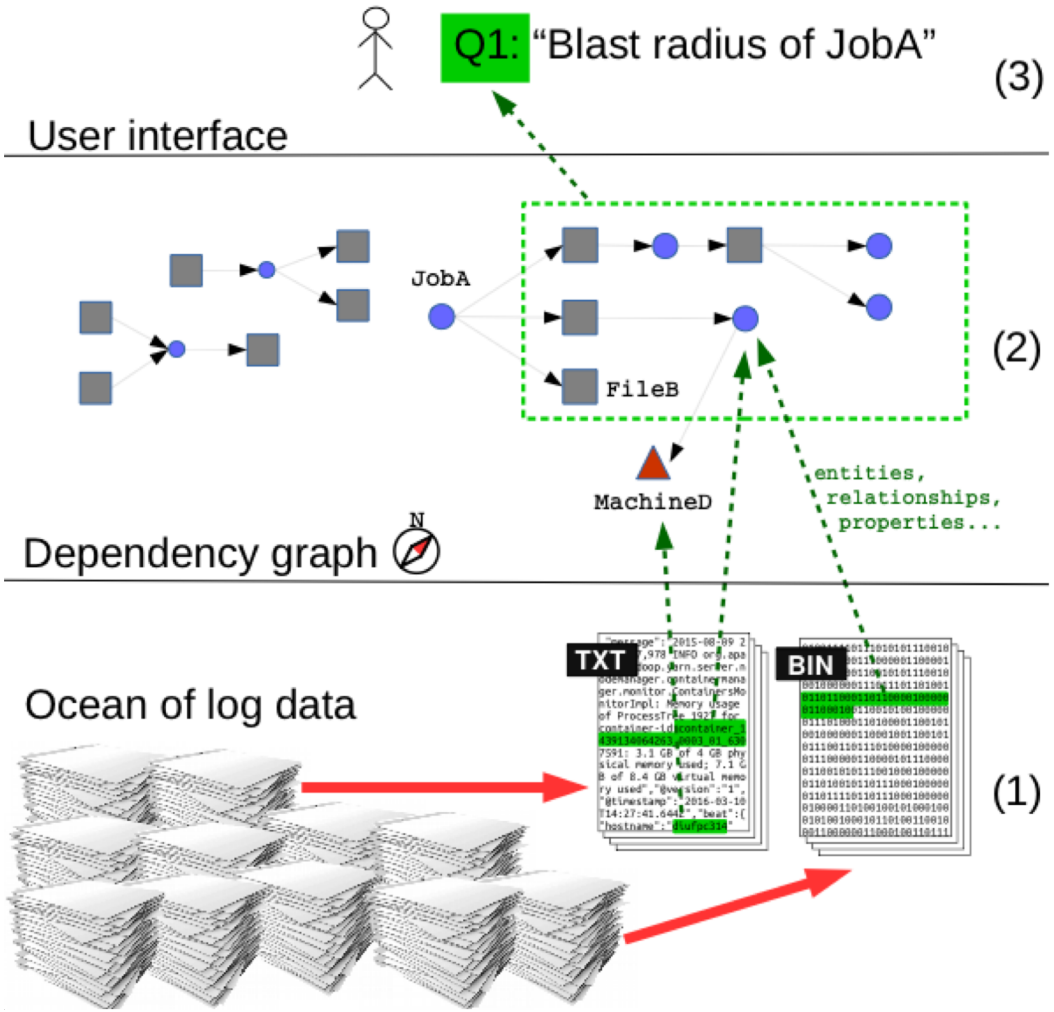
Wait 50 min (drink coffee)

=



Manual inspect Job exec plan (XML blobs)

Our Solution: Guider

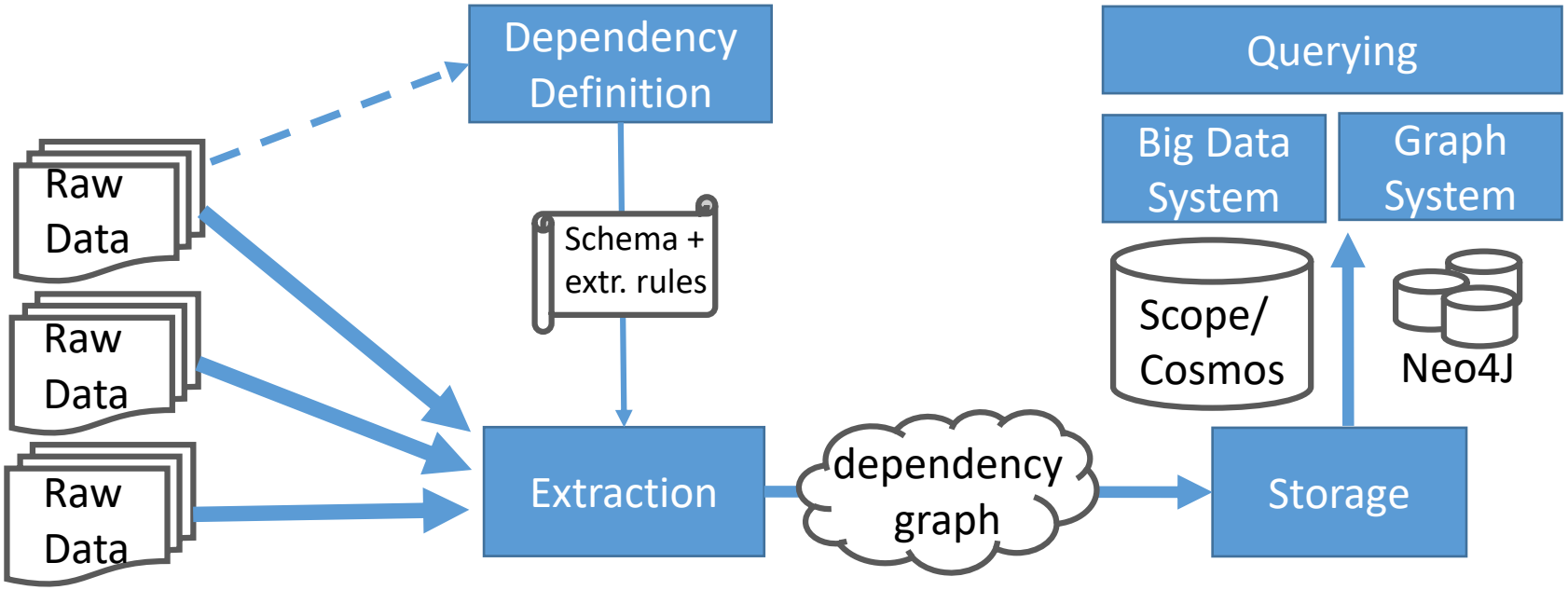


(3) User-level queries return bytes of aggregated data.

(2) Entity graph that represents a lightweight "skeleton" of the logs used for navigation

(1) Petabytes of daily logs

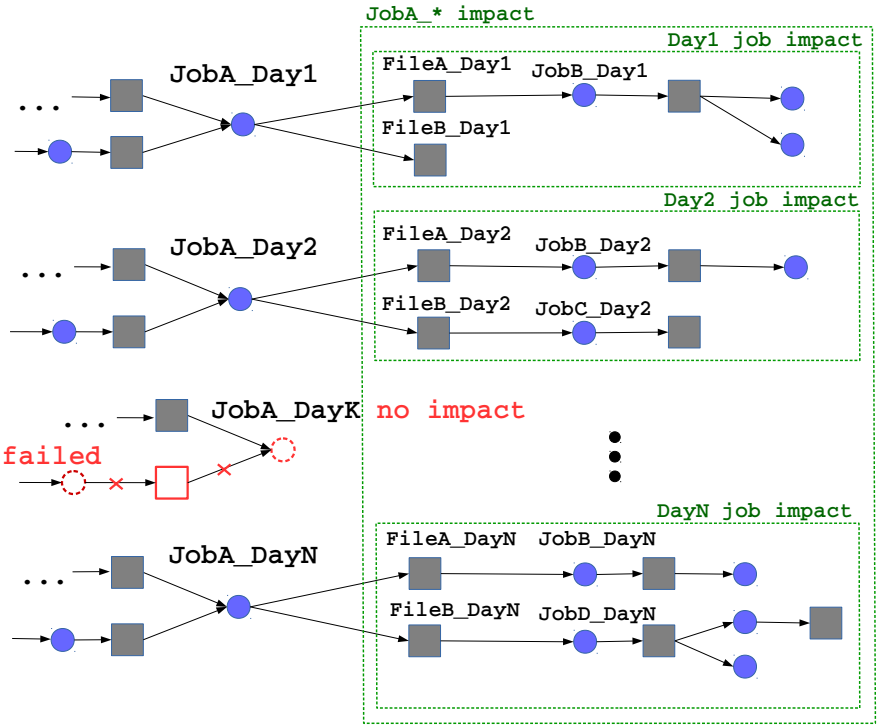
Guider Architecture



Dependency-Driven Analytics: a Compass for Uncharted Data Oceans.
Ruslan Mavlyutovm, Carlo Curino, Boris Asipovm, and Phil Cudre-Mauroux. CIDR 2017

Guider Use-Cases

1. Auditing and Compliance [in production]
2. Job Scheduling [Morpheus]
3. Global Job Ranking
4. Datacenter migration



Big Data Today in 

- Big Data is not a new technology: it's a fact;
  - Deal with it ➔ POCs and productized in most banks, insurance companies, retailers
- Largely behind US (and Asia)
- Leader in EU landscape
  - Research ☑
  - Large Companies ☑
  - SMEs ☒
  - Administrations ☒

Outline

- Introduction to Big Data
- Class overview

Class Format

- One lecture per week: Thursday, 9:15am-12am, E230
- A number of labs (on machine/laptop)
  - Not systematically every week
  - Groups of 1-2 students
  - Each group uploads their solution on Ilias by Wednesday evening (following week)
- Lectures + discussion
  - Don’t be afraid to express yourselves and ask questions

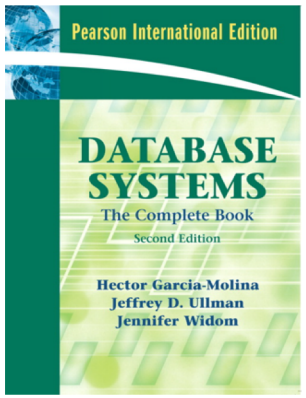
One Note About the Slides

Some slides adapted from Prof. Magda Balazinska's *fantastic* course @ UWash with her kind permission

Thanks Madga!

Readings and Notes

- Some readings are based on papers
  - Mix of old seminal papers and new papers
  - Papers will be available online on website
  - Many come from the “red book” [no need to get it but available at the Perolles 90 library]
  - Three types of readings
    - Mandatory, additional resources, and optional



- Background readings from the following book
  - **Database Systems: The Complete Book**, Garcia-Molina (available at Perolles 90)
  - Intro to databases (Stanford online course)
    (or simply some of their notes: https://cs.stanford.edu/people/widom/cs145/)
- Lecture notes (the pptx slides)
  - Posted on class website before each lecture

Tentative Menu (1/2)

- 20.09 BDI 1: intro
- 27.09 BDI 2: SQL lab (homework 1)
- 04.10 BDI 3: Storage+Indexing
- 11.10 BDI 4: Query Execution
- 18.10 BDI 5: Column Stores + Query Execution lab (homework 2)
- 25.10 BDI 6: Transactions + CAP
- 01.11 Toussaint (holiday)

Tentative Menu (2/2)

- 08.11 BDI 7: Mid-Term
- 15.11 Dies academicus (no course)
- 22.11 BDI 8: NoSQL + HDFS+HBase lab (homework 3)
- 29.11 BDI 9: GraphDB + lab (homework 4)
- 06.12 BDI 10: Hadoop+Yarn+Map/Reduce + lab (homework 5)
- 13.12 BDI 11: Logging & Recovery
- 20.12 BDI 12: Spark + lab (homework 6)

Evaluation

- Final Grade = 25% labs + 25% mid-term + 50% final exam

- Labs grade:
  - 6 “pass”: 6
  - 5 “pass”: 5.5
  - 4 “pass”: 5.0
  - 3 “pass”: 4.0
  - 2 “pass”: 3.0
  - 1 “pass”: 2.0
  - 0 “pass”: 1.0