DATA SCIENCE OVERVIEW

(Data Science Tools and Methods)

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Created: 2021-08-24 Di 16:34

TABLE OF CONTENTS

YOU ARE LIKE PYTHAGORAS

WHAT WILL YOU LEARN?

- How and why data science is so popular
- What skills you need to do data science
- Which problems data science can solve
- What data scientists do all the time

HOW POPULAR IS DATA SCIENCE?

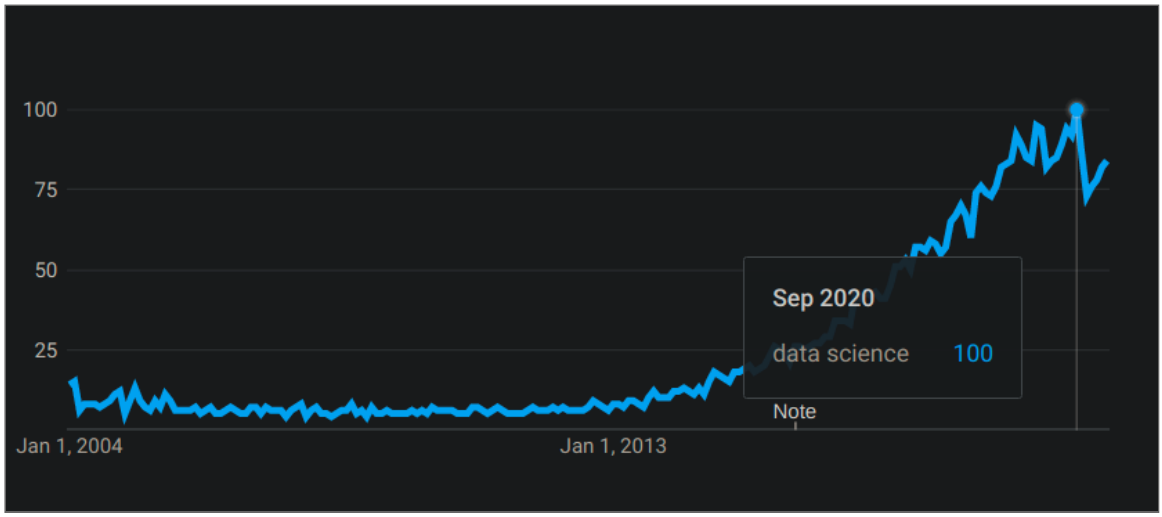
How would you try to find out?

WAYS TO EXPLORE POPULARITY

- Search (how?)
- Find relevant models (how?)
- Generate primary data (how?)
- Use secondary data (instead of?)

Any issues with these methods?

WORLDWIDE SEARCHES 2004-2021



How would you explain this curve?

THE DEFINITION OF SEXY

»The best data scientists are product and process innovators and sometimes, developers of new data-discovery tools. That is the definition of sexy.«

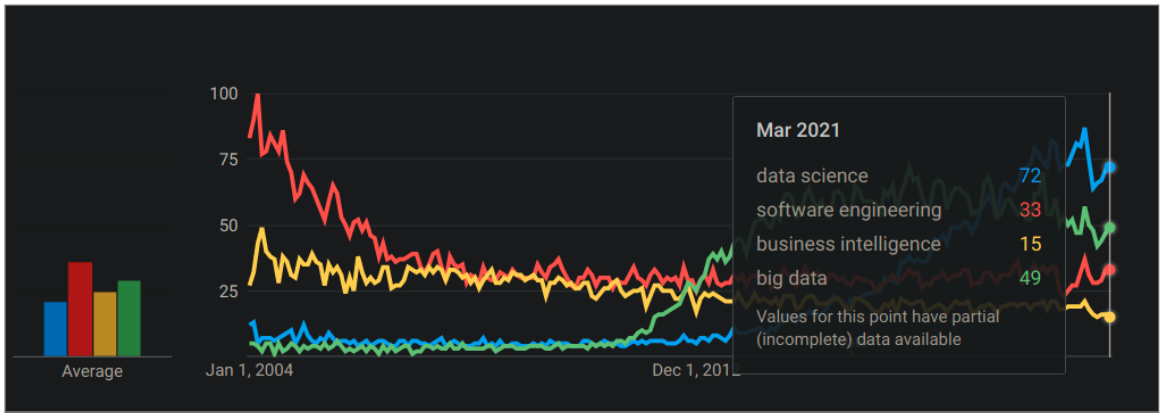
*Gil Press (**Forbes, 09/27/12**)*

POPULARITY CONTEST

Which one is most searched:

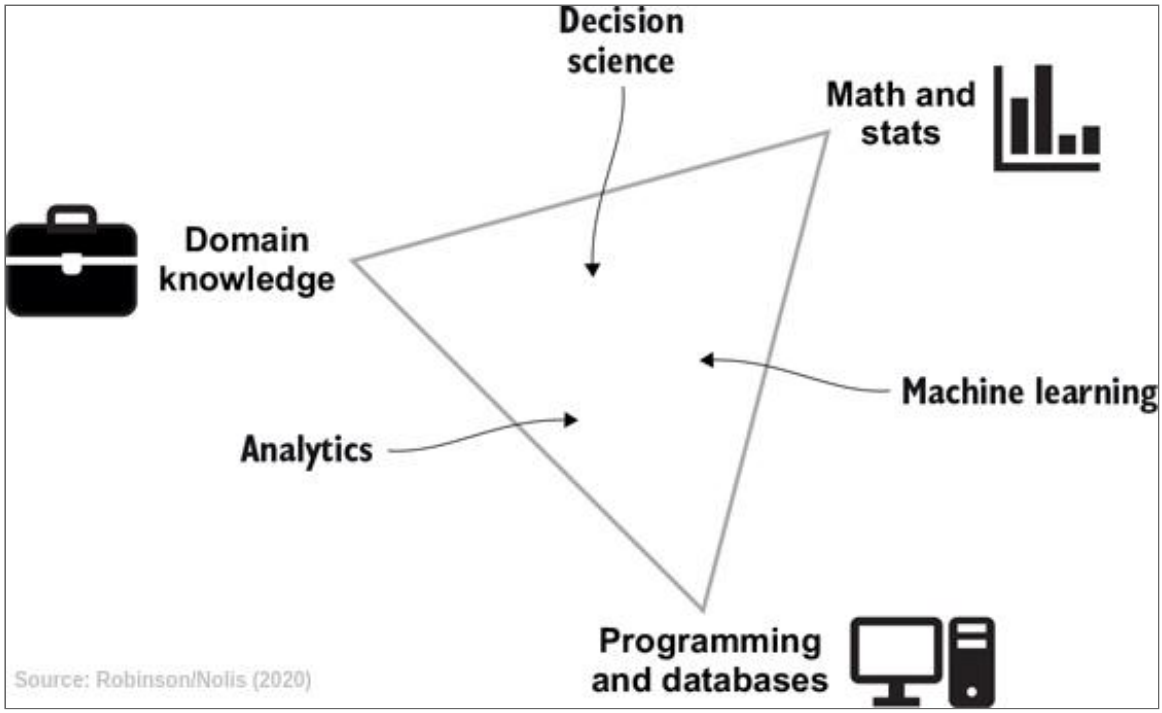
1. *Big data?*
2. *Business intelligence?*
3. *Software engineering?*
4. *Data science?*

THE WINNER IS...



How do you like the visualization?

WHAT ARE DATA SCIENCE SKILLS?



Can you give some examples?

WHAT ABOUT YOU?

Kanban: **What are your skills?**

.

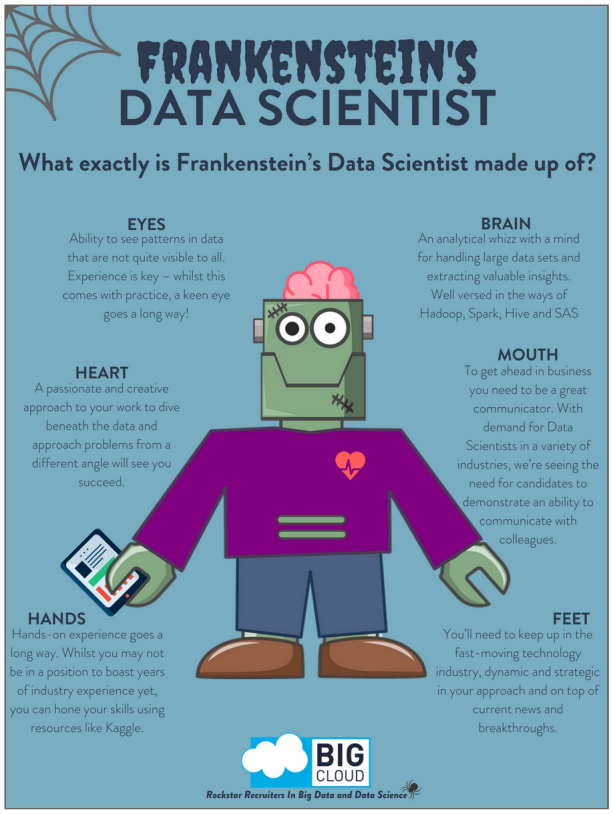
Compare: **"My IT skill stack"**[5]

WHAT ARE TECHNICAL DATA SCIENCE SKILLS?

R	Apache Spark	Apache Pig
Python	NoSQL databases	Tableau
Apache Hadoop	Cloud computing	iPython notebooks
MapReduce	D3	GitHub

Have you heard of any of these?

WHAT IS FRANKENSTEIN MADE OF?



Source: **datasciencecentral.com**

WHAT ABOUT YOU?

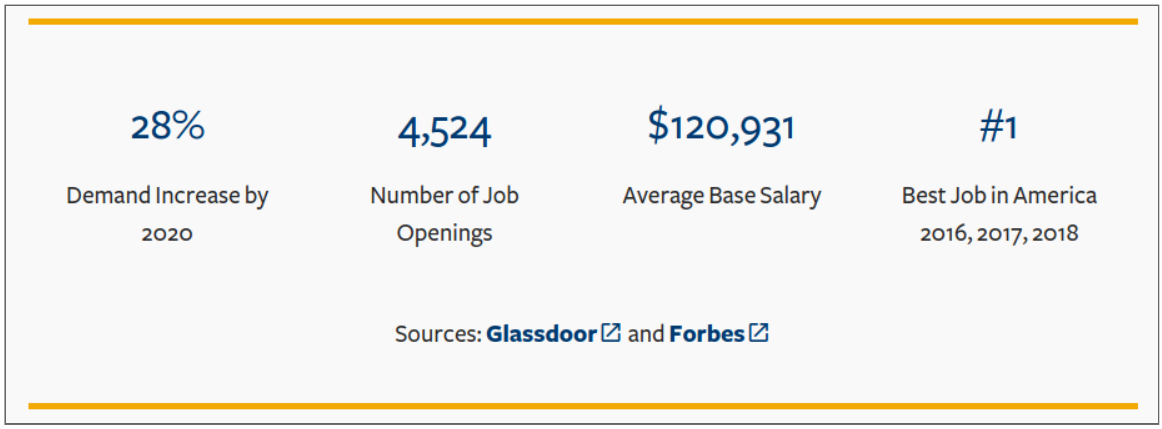
Do you have a "brain for numbers"?
Do you prefer people or stories?

.

WHAT DO METAPHORS DO?

Metaphors are models.

WHAT'S THE (US) JOB MARKET FOR DATA SCIENTISTS LIKE?



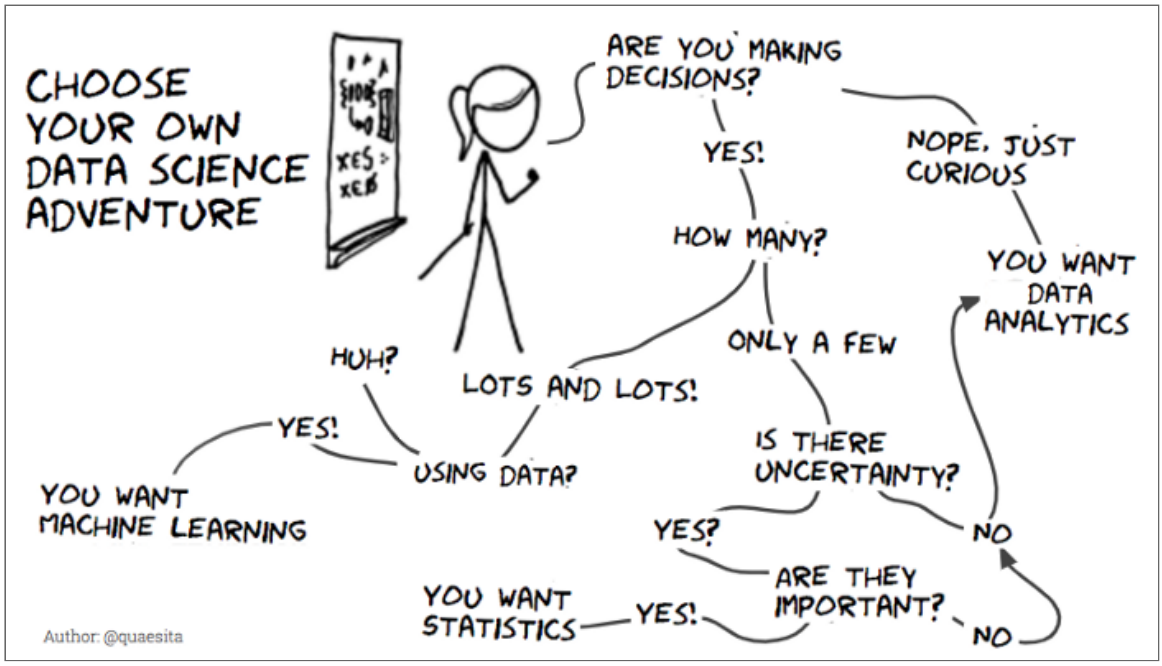
Challenge: search a job portal for "data scientist".

JOB PROFILES (DATACAMP)

Data Engineer	Data Analyst	Data Scientist	Machine Learning Scientist
Store and maintain data	Visualize and describe data	Gain insights from data	Predict with data
SQL + Java/Scala/Python	SQL + BI Tools + Spreadsheets	Python/R	Python/R

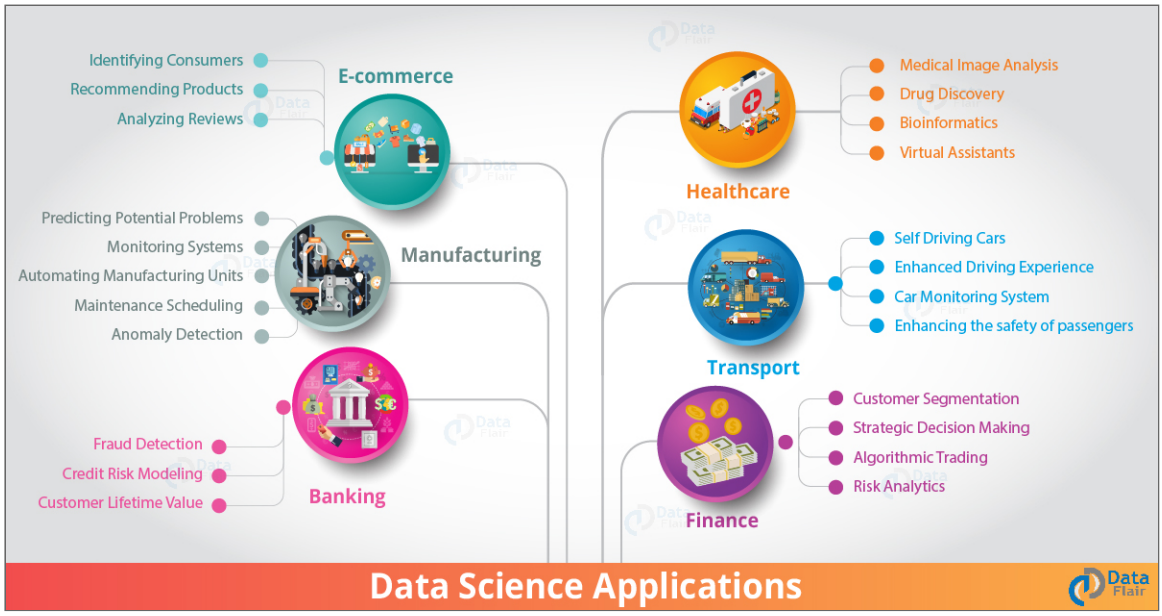
Who would you rather be?

WHAT ARE DATA SCIENCE PROBLEMS?



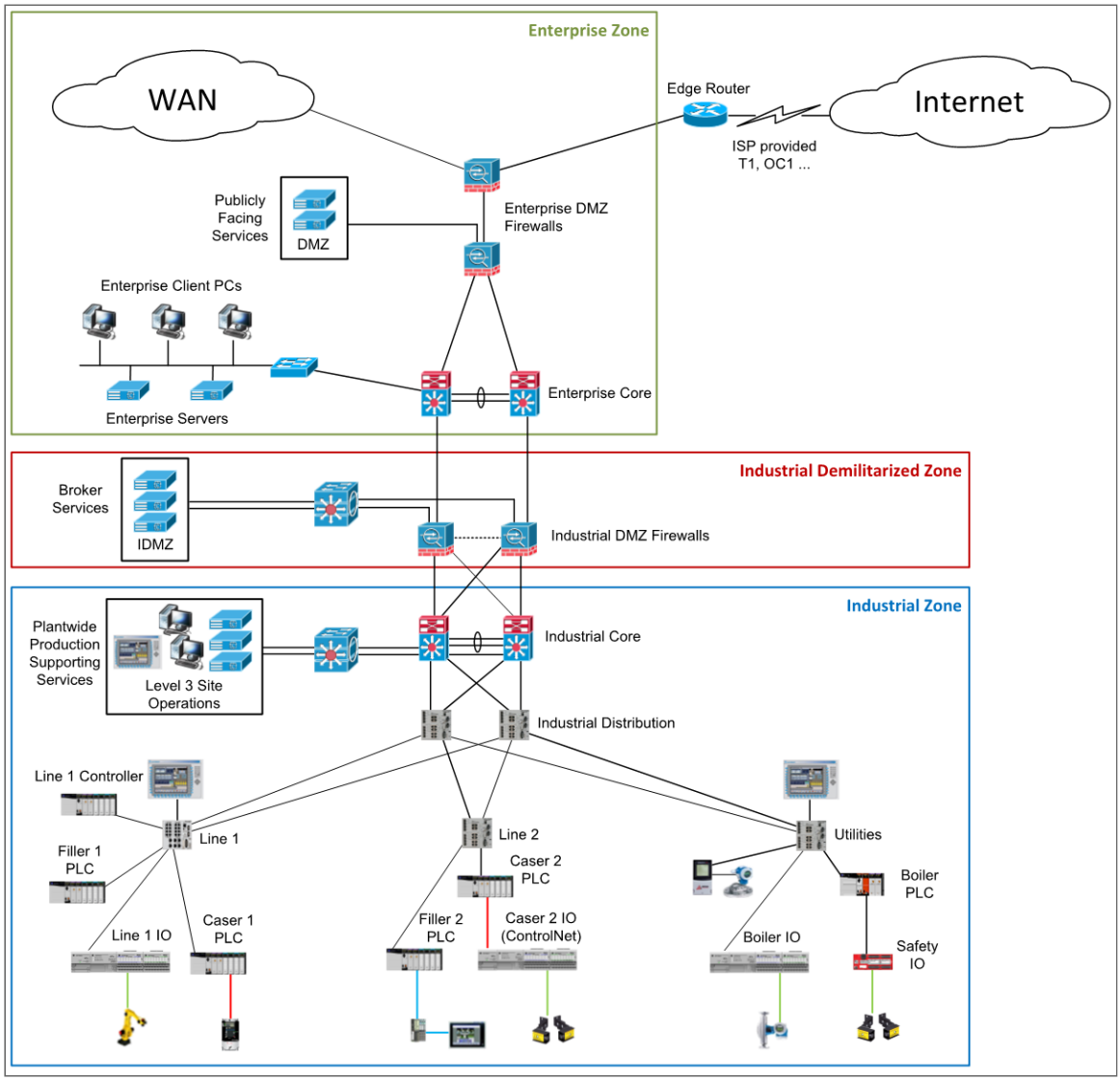
Source: Cassie Kozyrkov (**@quaesita**)

DATA SCIENCE APPLICATIONS



Source: **data-flair.training**

A REAL WORLD PROBLEM



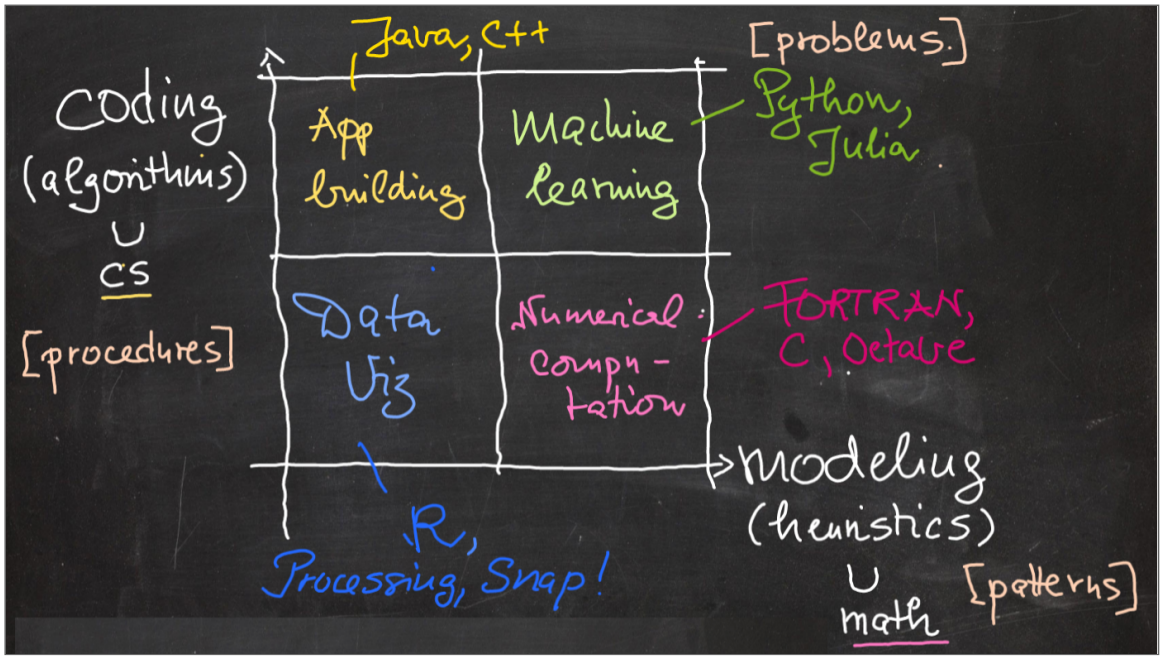
Source: **Industrial Cybersecurity (2017)**

TIME SERIES ANALYSIS & TEXT MINING

```
Jul 16 09:10:11 linux systemd-timesyncd[1219]: Synchronized to time server [2001:67c:1560:8003::c8]:123 (ntp.ubuntu.com).
Jul 16 09:11:41 linux kdeconnectd.desktop[6764]: kdeconnect.core: TCP connection done (i'm the existing device)
Jul 16 09:11:41 linux kdeconnectd.desktop[6764]: kdeconnect.core: Starting server ssl (I'm the client TCP socket)
Jul 16 09:11:41 linux kdeconnectd.desktop[6764]: kdeconnect.core: TCP connection done (i'm the existing device)
Jul 16 09:11:41 linux kdeconnectd.desktop[6764]: kdeconnect.core: Starting server ssl (I'm the client TCP socket)
Jul 16 09:11:41 linux kdeconnectd.desktop[6764]: kdeconnect.core: Socket succesfully stablished an SSL connection
Jul 16 09:11:41 linux kdeconnectd.desktop[6764]: kdeconnect.core: It is a known device "Xperia L2"
```

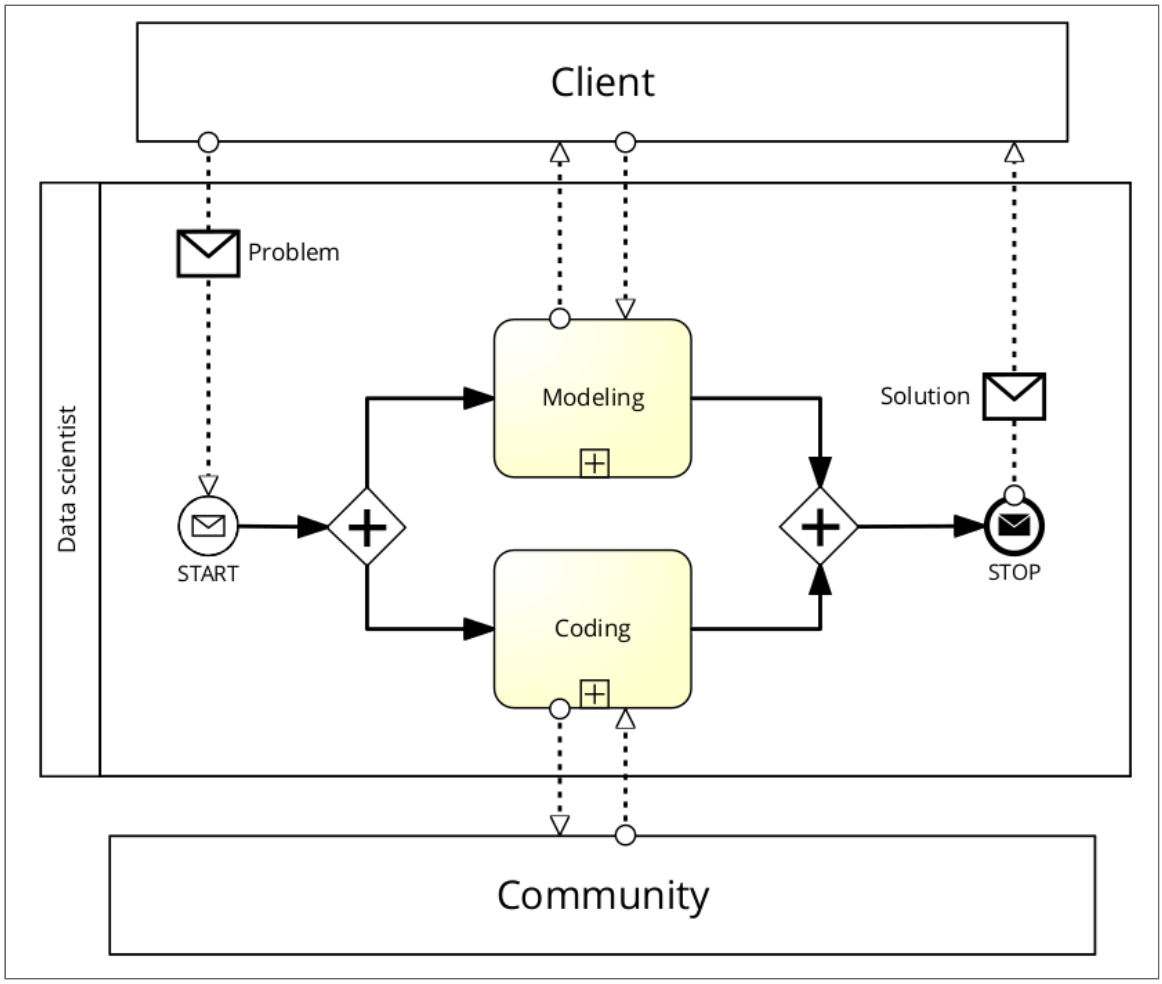
Source: Linux `/var/log/syslog` event log

WHAT IS THE DATA SCIENCE PROCESS?



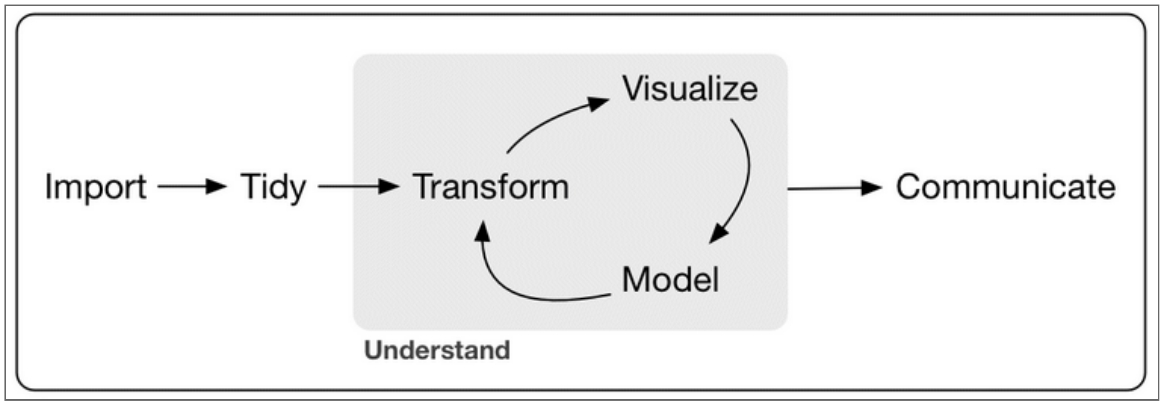
Source: **Birkenkrahe (2021)**

PROBLEM-CENTERED PROCESS



Source: **Birkenkrahe (2021)**

EDA-CENTRIC PROCESS MODEL



Source: **Wickham/Grolemund (2017)**

(***Interactive BPMN version***)

DATA SCIENCE WORKFLOW

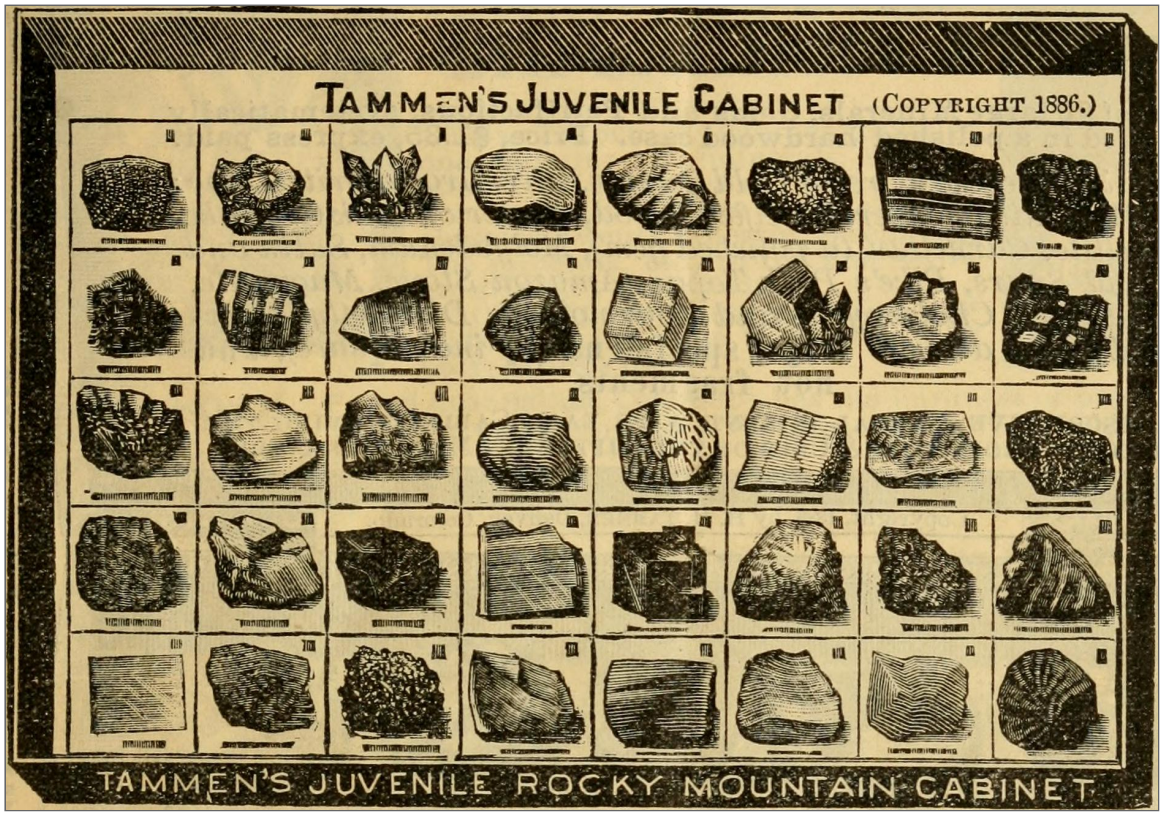
Source: **Data science for everyone** (DataCamp)

CONCEPT SUMMARY

- Data science is used for decision support, process analytics and machine learning.
- Data science makes use of domain knowledge - experience in a particular field of business.
- The job market for data science is good.
- The data science process includes modeling, visualizing, and communicating data analysis results.

Read the seminal article by ***Davenport/Patil (2012)***.

R DEMO - VISUALIZATION EXAMPLE



mtcars: Motor Trend Car Road Tests

CODE SUMMARY

`data()`	import dataset
`head()`	print first few lines of dataset
`str()`	show dataset structure
`summary()`	print statistics overview of dataset
`plot()`	create scatterplot
`lm()`	fit linear [regression] model to data
`abline()`	add straight lines through a plot

WHAT'S NEXT?

DataCamp assignment	Data collection and storage
Installing R	**Try it yourself!**
First steps in R	We'll do it together!
Weekly test	5-15 simple questions

THANK YOU! QUESTIONS?

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"YOUR TURN" (HINTS AND SOLUTIONS)

POPULARITY

Check out the seminal article by **Davenport/Patil 2012.** (At least) one answer is in there.

SKILLS

Recently, an MBA student asked me these same questions and here is my answer: "**My IT Skill Stack**". See also **Bolles and Brooks (2021)**

SOFTWARE

- **D3.js,** a JavaScript library for manipulating documents based on data. D3 helps you bring data to life using HTML, SVG, and CSS.
- **Apache Hadoop,** a "software library framework that allows for the distributed processing of large data sets across clusters of computers using simple programming models. It is designed to scale up from single servers to thousands of machines, each offering local computation and storage. Rather than rely on hardware to deliver high-availability, the library itself is designed to detect and handle failures at the application layer, so delivering a highly-available service on top of a cluster of computers, each of which may be prone to failures." (Source: Apache.org)
- **MapReduce**, "a programming paradigm that enables massive scalability across hundreds or thousands of servers in a Hadoop cluster. As the processing component, MapReduce is the heart of Apache Hadoop. The term "MapReduce" refers to two separate and distinct tasks that Hadoop programs perform. The first is the map job, which takes a set of data and converts it into another set of data, where individual elements are broken down into tuples (key/value pairs). The reduce job takes the output from a map as

input and combines those data tuples into a smaller set of tuples. As the sequence of the name MapReduce implies, the reduce job is always performed after the map job." Source: IBM. See also: **tutorialspoint**.

- **Apache Spark**, "a lightning-fast unified analytics engine for big data and machine learning. It was originally developed at UC Berkeley in 2009." Source: databricks.
- **NoSQL** "databases, purpose-built for specific data models and have flexible schemas for building modern applications. NoSQL databases are widely recognized for their ease of development, functionality, and performance at scale." Source: AWS.
- **Apache Pig**, "a platform for analyzing large data sets that consists of a high-level language for expressing data analysis programs, coupled with infrastructure for evaluating these programs. The salient property of Pig programs is that their structure is amenable to substantial parallelization, which in turns enables them to handle very large data sets. At the present time, Pig's infrastructure layer consists of a compiler that produces sequences of Map-Reduce programs, for which large-scale parallel implementations already exist (e.g., the Hadoop subproject). Pig's language layer currently consists of a textual language called Pig Latin." Source: apache.org. **Tutorialspoint**.

- **Tableau** (owned by Salesforce), commercial interactive data visualization software (SQL-based dashboards). **Tableau public**.
- **iPython notebook** (now "Jupyter Notebook"), a "interactive computational environment, in which you can combine code execution, rich text, mathematics, plots and rich media." Source: **jupyter.org**. Part of the **Anaconda** distribution. See also: Google **Colaboratory** for a (free) cloud-based version.
- **GitHub** (owned by Microsoft), "a website and cloud-based service that helps developers store and manage their code, as well as track and control changes to their code" (Source: **kinsta.com**) centered on the open-source version control software **Git**. There are many platforms like GitHub (e.g. GitLab, BitBucket, SourceForge).

Of these applications, only Git (not GitHub) is really absolutely necessary for a professional data scientist working in teams. Though a working knowledge of the principles behind all of them will be very useful (especially if they come up in interviews). Hence, no reason to be scared.

YOUR BRAIN

Other terms for what we're talking about here are: "number sense" (in maths education), or "computational thinking" (in computer science) or, more recently, "data literacy". All of these are relatively new concepts, so feel free to speculate and make up your own mind! Cp. **Devlin 2017**

FRANKENSTEIN

How do you feel about anything if doing it would turn you into a monster? What kind of monster is Frankenstein (if you didn't read the book or saw the film, I'll tell you: ugly but soulful, loveable and capable of love, too)? What is special about him as a monster in mechanical terms?

JOB MARKET

Mathematics, especially statistics, programming and databases are the skill-based disciplines that you need to master. Having said that: "mastering" could easily take not one, but several life times, and you need to begin somewhere. If you do this in earnest, you'll soon find that you start learning faster and faster the more connections with what you already know you can make.] Here is a (free) book called, incidentally, "**Foundations of Data Science**" (**Blum et al 2015, 466 p.**). It includes some geometry, graph theory, linear algebra, markov chains, and a variety of algorithms for "massive data problems" like streaming, sketching and sampling.

DECISIONS

The figure (like the underlying article) targets business decisions more than everyday decisions. For business decisions, taxonomies exist, which are generally a lot more complicated than shown here, see e.g. **Scherpereel 2006**.

PROCESS

On the surface, Wing's "Data Life Cycle" (2019) has a few more steps (and it is also not a "cycle") - it does not use the artificial (technical) term "tidy" but instead terms that can more easily be understood by practitioners outside of data science. Modeling is not addressed by Wing but instead she puts "management" at the center of the process, right between data-centric and (business) process-centric categories. Another related process model you may have heard of is the "**design thinking" process**, which plays an important role in innovation and when solving so-called "**wicked problems**".

SUMMARY

"The ability to write code" is still the "most basic, universal skill" for a data scientist - which is why learning R is the focus of this introductory course. There are many data science programs at universities now - often offered as minors or as Masters programs for people trained already in maths, computer science, or fields with obvious and current data science applications (like biology). The understanding of a data scientist as a hybrid professional has not really changed sinc