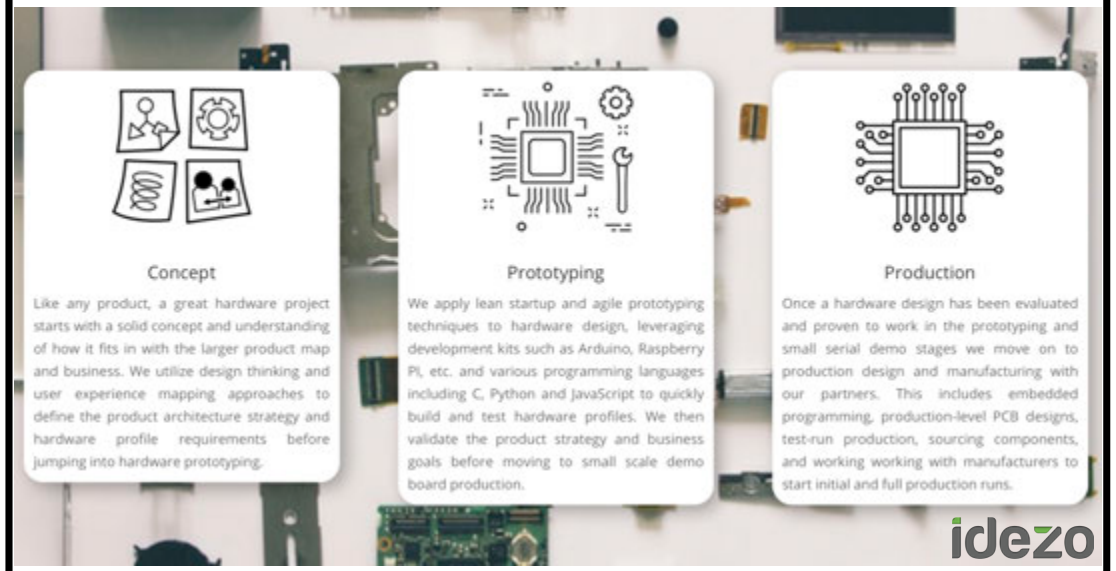
HANDS ON APPROACH TO

Data Science

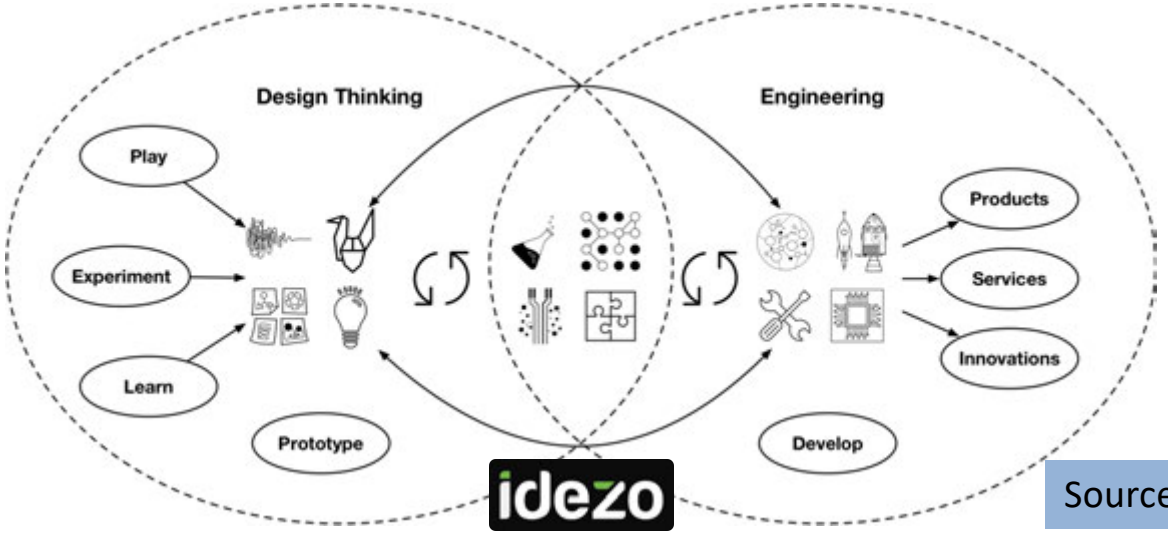
for (the)

IoT



Rob van der Willigen

HANDS ON APPROACH TO DATA SCIENCE for (the) IoT



Source: https://idezo.ch

This Data Science Course was developed for keuzevak- program of the School of Communication, Media and Information Technology (CMI, at the Hogeschool Rotterdam **(Rotterdam University of Applied Sciences, RUAS)**.
If you find errors or omissions, please contact the author, Rob van der Willigen, at r.f.van.der.willigen@hr.nl. Materials of this course and code examples used will become available at:
https://github.com/robvdw/CMIDAT01K-DATA-SCIENCE-for-IOT

Course Setup

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Lesson 01: week 02	**Discovering the IoT Data Science Domain**
Lesson 02: week 03	**Defining project requirements**
	+ Cost calculation/estimate
Lesson 03: week 04	**Learn to write code**
Lesson 04: week 05	**Data Science: How to start your own IoT Project**
Lesson 05: week 06	**IoT Platforms & MiddleWare**
Lesson 06: week 07	**Core IoT Concepts + setting-up your IoT-device**
Lesson 07: week 08	**Grading + Summary + Q & A**

Week 09/10: FEEDBACK + GRADING

DEADLINE OPLEVERING

Om voor beoordeling in aanmerking te komen lever je een ascii text file (.txt) aan met de link (URL) van jouw Git-Hub account met de IoT-repository.

De repository bevat een beschrijving van het IoT-Project waarin bewijzen
---zoals video-materiaal / code / design concept / data organisatie---
zijn opgenomen van op basis van de door jouw bedachte/geteste IoT data-pipeline/Prototype
zoals beschreven op https://github.com/robvdw/CMIDAT01K-DATA-SCIENCE-for-IOT

Deze text-file moet je uploaden via de LMS **INLEVER_MAP_OP3**

INLEVEROPDRACHT 0P03 DEADLINE 27 APRIL 2021

van de CURSUS CMIDAT01k Data Science for IoT (2020-2021).
Deadline is: 27 APRIL (vanaf 28 april kun je niet meer inleveren).

Beoordeling vindt plaats conform het beoordelingsmodel:
https://github.com/robvdw/CMIDAT01K-DATA-SCIENCE-for-IOT/blob/master/Docs/BEOORDELINGS_MODEL_DS_for_IoT_V24_npv_2020.pdf

Deze mededeling wordt als E-mail bericht wordt verstuurd (20 APRIL)
in week 10 OP3 collegejaar 2020-2021

Nota Bene! Stuur een Reply op deze E-Mail
als je voor beoordeling van de cursus: CMIDAT01k Data Science for IoT (2020-2021) **in aanmerking wilt komen.**

lesson seven

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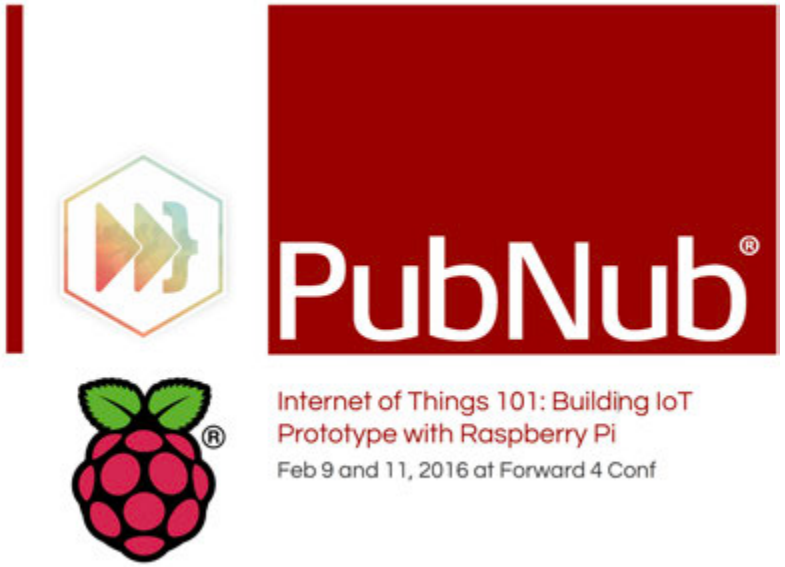

Examples of Git-Hub Repository reporting on --how to create an-- IoT-pipeline scenario + Code

Note evidence of a working prototype is NOT included!

https://docs.google.com/presentation/d/1kHjN8CIbggBIr44m2JpsRpR6IHB-Yu7b5bECC-_ntK4/edit#slide=id.p4

https://github.com/pubnub/workshop-raspberrypi

https://github.com/pubnub/workshop-raspberrypi/tree/master/projects-python/range-finder

https://github.com/pubnub/workshop-raspberrypi

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Computational Thinking Core-Concepts

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Computational thinking is a way of
solving problems,
designing systems, &
understanding human behavior
that draws on concepts
fundamental to data science.

Viewpoint | Jeannette M. Wing

Computational Thinking

It represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use.

Computational thinking builds on the power and limits of computing processes, whether they are executed by a human or by a machine. Computational methods and models give us the courage to solve problems and design systems that no one of us would be capable of tackling alone. Computational thinking confronts the riddle of machine intelligence: What can humans do better than computers? and What can computers do better than humans? Most fundamentally it addresses the question: What is computable? Today, we know only parts of the answers to such questions.

Computational thinking is a fundamental skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability. Just as the printing press facilitated the spread of the three Rs, what is appropriately incestuous about this vision is that computing and computers facilitate the spread of computational thinking.

Computational thinking involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science. Computational thinking includes a range of mental tools that reflect the breadth of the field of computer science.

Having to solve a particular problem, we might ask: How difficult is it to solve? and What's the best way to solve it? Computer science rests on solid theoretical underpinnings to answer such questions precisely. Stating the difficulty of a problem accounts for the underlying power of the machine—the computing device that will run the solution. We must consider the machine's instruction set, its resource constraints, and its operating environment.

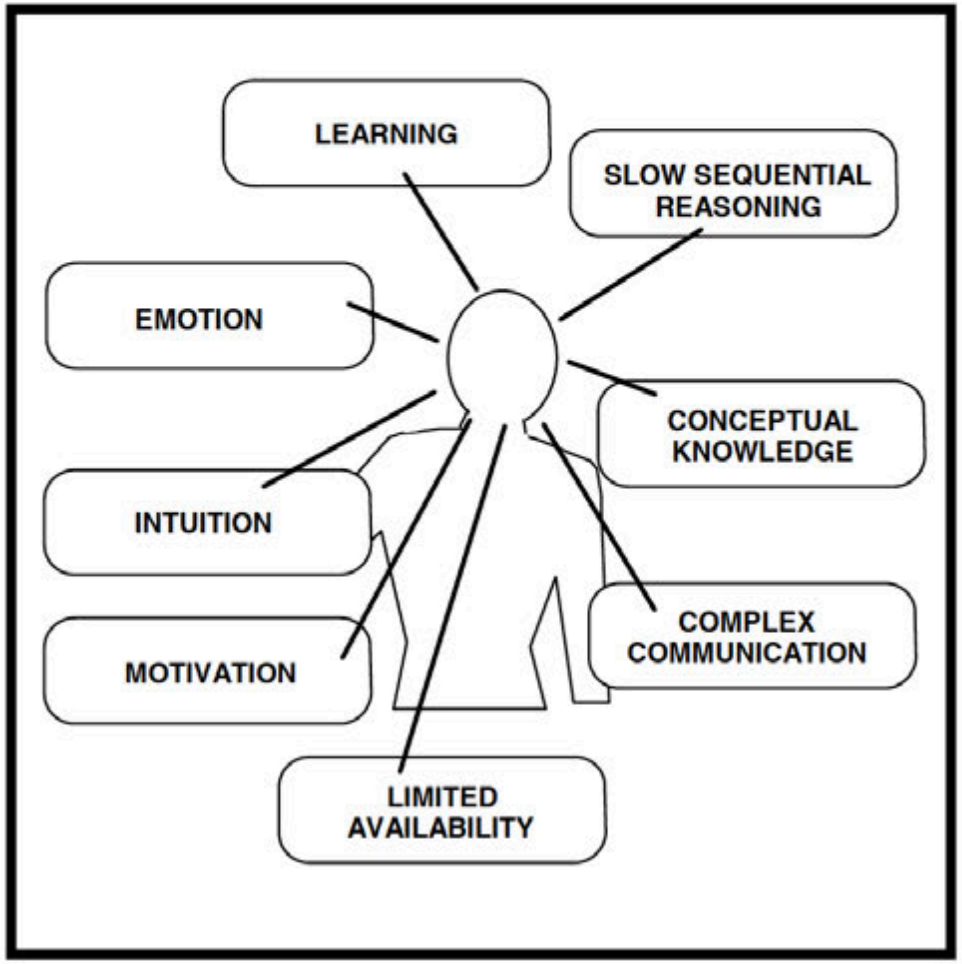
In solving a problem efficiently, we might further ask whether an approximate solution is good enough, whether we can use randomization to our advantage, and whether false positives or false negatives are allowed. Computational thinking is reformulating a seemingly difficult problem into one we know how to solve, perhaps by reduction, embedding, transformation, or simulation.

Computational thinking is thinking recursively. It is parallel processing. It is interpreting code as data and data as code. It is type checking as the generalization of dimensional analysis. It is recognizing both the virtues and the dangers of aliasing, or giving someone or something more than one name. It is recognizing both the cost and power of indirect addressing and procedure call. It is judging a program not just for correctness and efficiency but for aesthetics, and a system's design for simplicity and elegance.

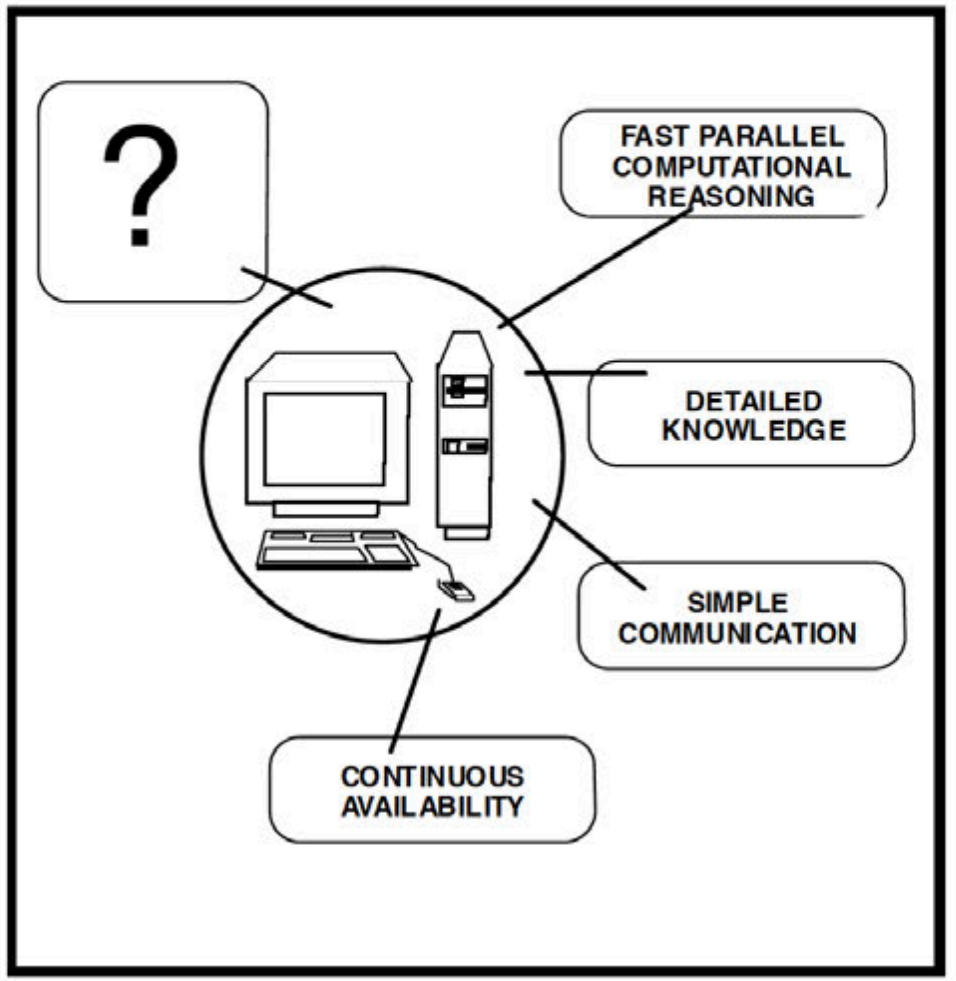
Computational thinking is using abstraction and decomposition when attacking a large complex task or designing a large complex system. It is separation of concerns. It is choosing an appropriate representation for a problem or modeling the relevant aspects of a problem to make it tractable. It is using invariants to describe a system's behavior succinctly and declaratively. It is having the confidence we can safely use, modify, and influence a large complex system without understanding its every detail. It is

Human versus Computer

Humans are pattern-driven



Computers are data-driven



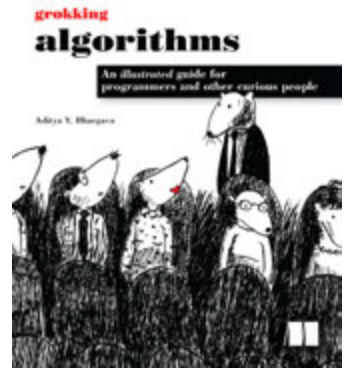
Wat is an algorithm?

No knowledge of *semantics* is needed to apply an algorithm for adding two natural numbers.

It is essential to understand what **an algorithm** does, and in particular which problems it is ment to solve.

Algorithm

Step by step process or recipe describing *how to solve a problem* and/or *complete a task*, which will always give the correct result



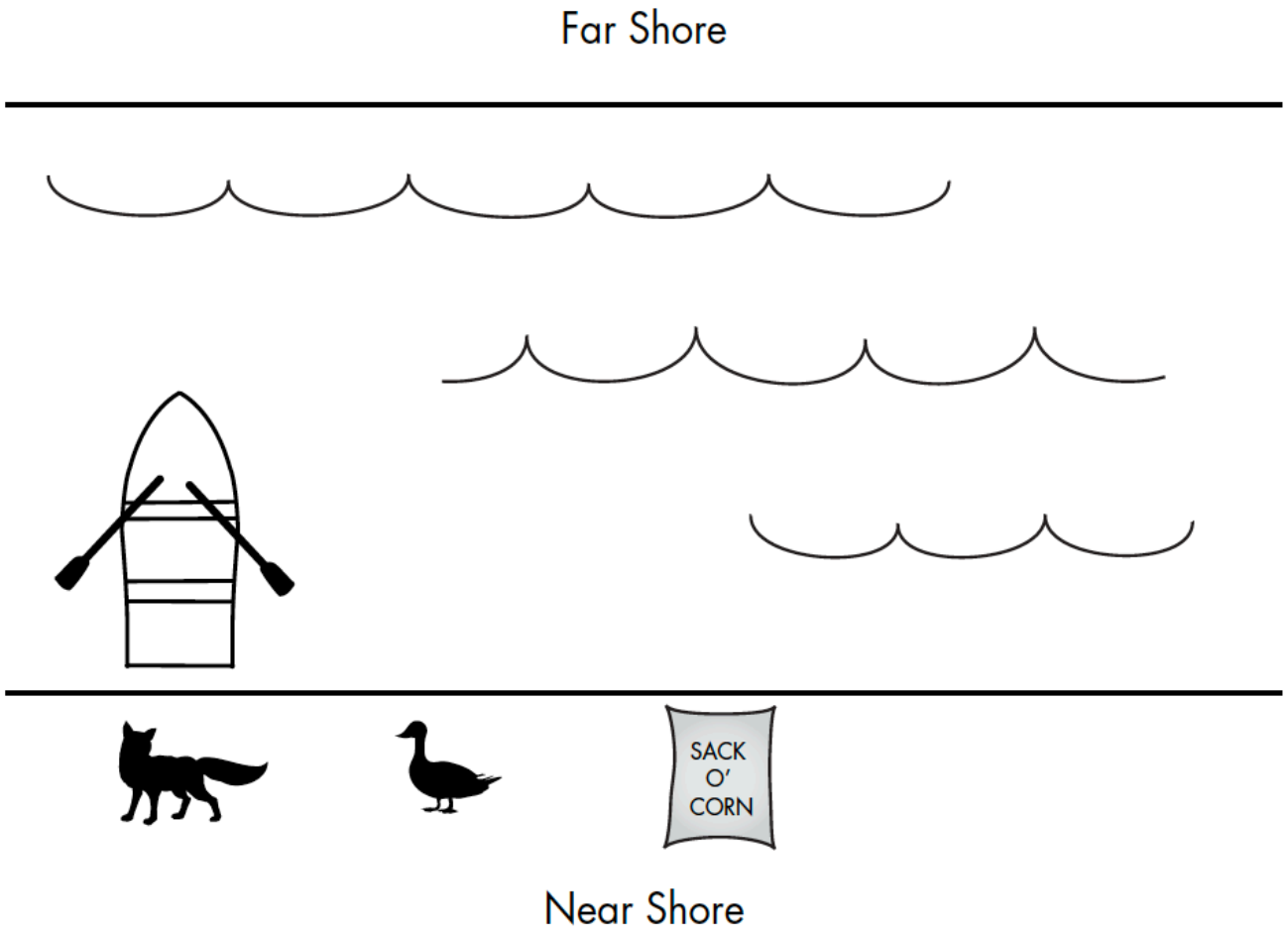
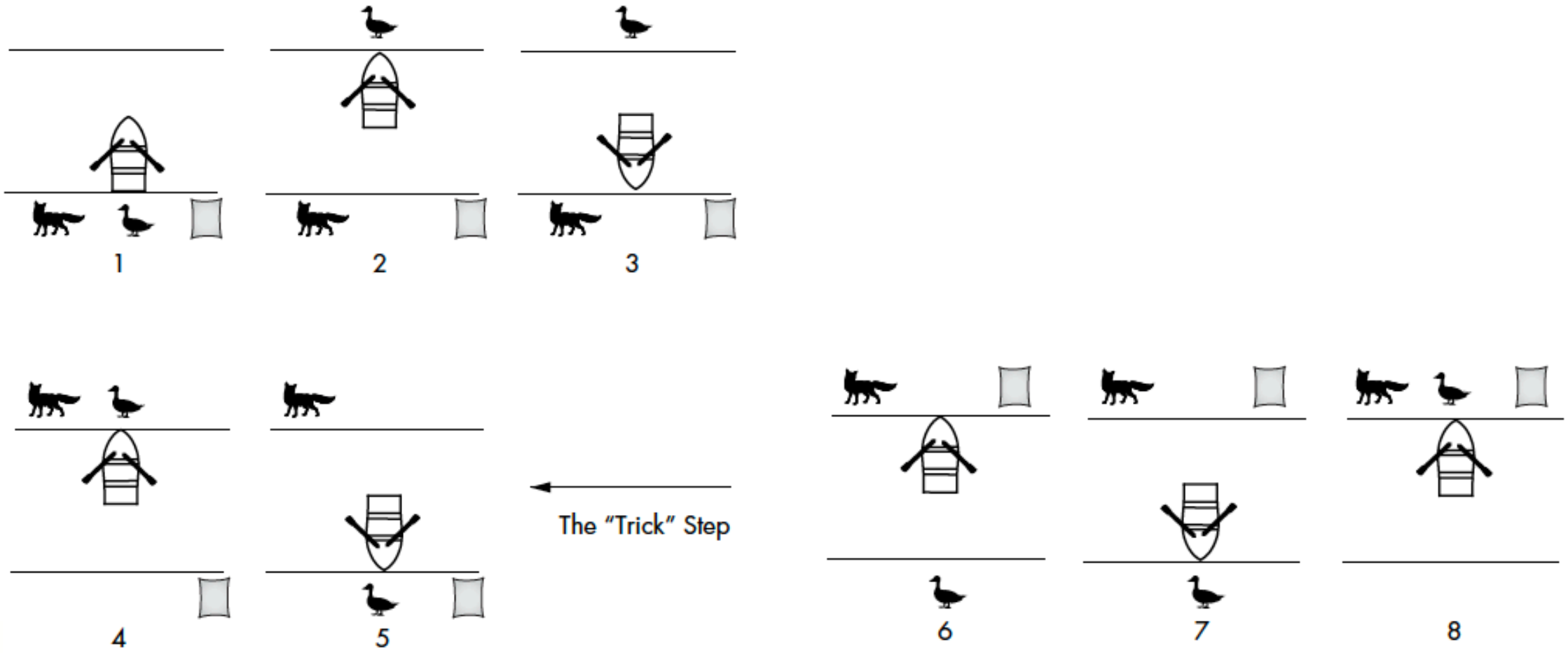
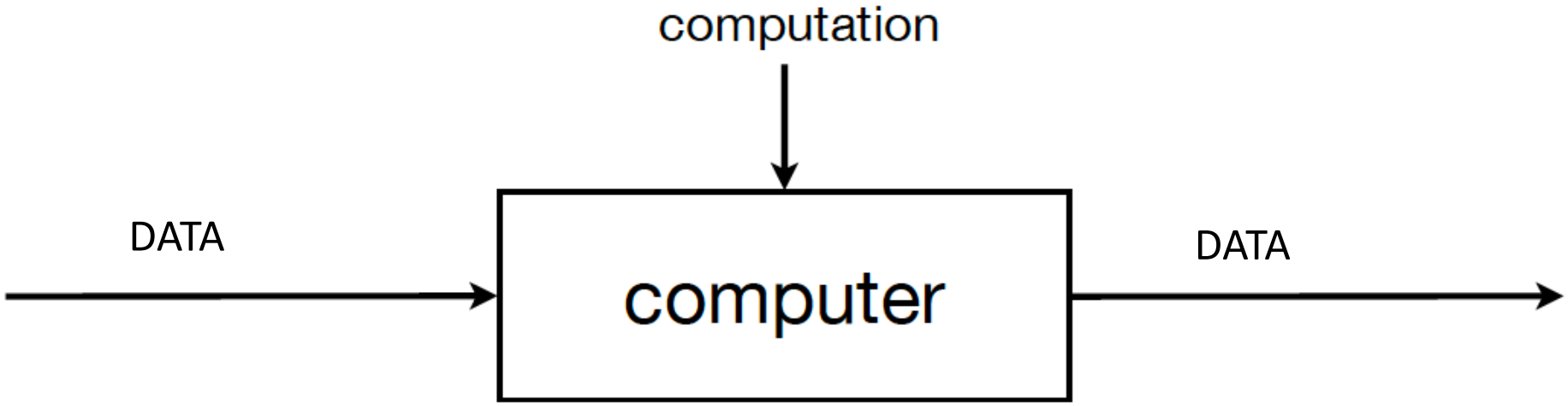


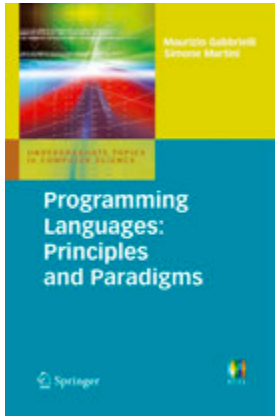
Figure 1-1: The fox, the goose, and the sack of corn. The boat can carry one item at a time. The fox cannot be left on the same shore as the goose, and the goose cannot be left on the same shore as the sack of corn.

Algorithm 3:
Step-by-step solution to the fox, goose, and corn problem



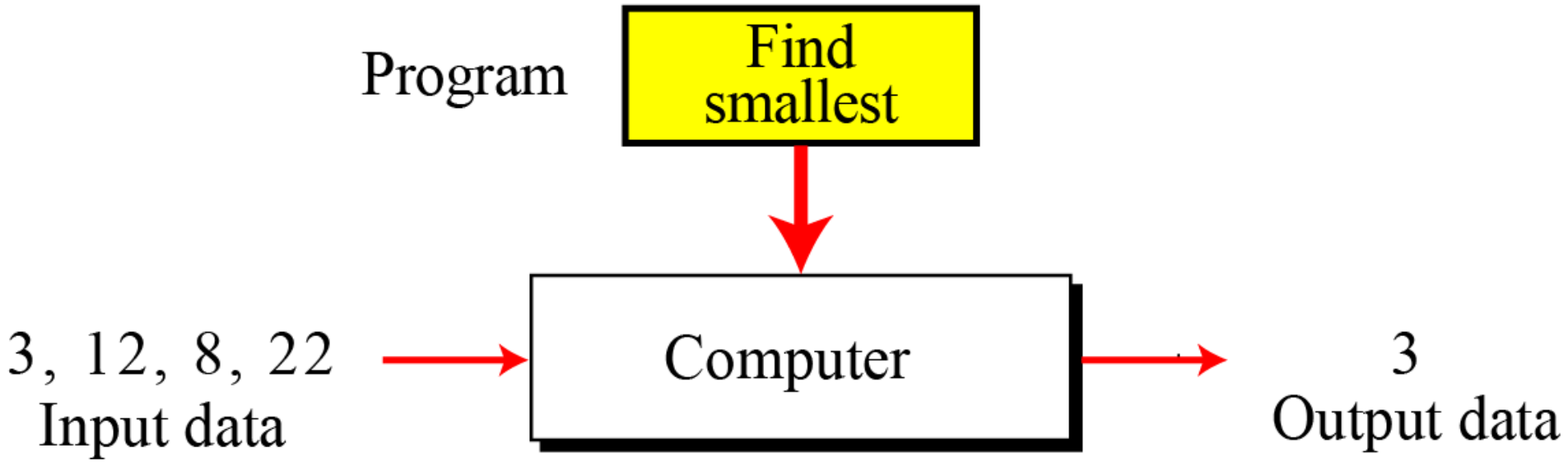
What is a Computer?





A computer is a programmable machine that receives input, stores and manipulates data, and provides output in a useful format.

Computers act as a Computational Data Processor



Modern computer acts as a *black box* that accepts input data, processes the data, and creates output data.

Command Line Terminal (interface)

What Is the Command Line?

The command-line interface, sometimes referred to as the CLI,

is a tool into which you can type text commands to perform specific tasks—in contrast to the mouse's pointing and clicking on menus and buttons.

Since you can directly control the computer by typing, many tasks can be performed more quickly, and some tasks can be automated with special commands that loop through and perform the same action on many files—saving you, potentially, loads of time in the process.

Software

Software is a generic term, which is used to describe a group of computer programs & procedures which perform some task on a computer (system).

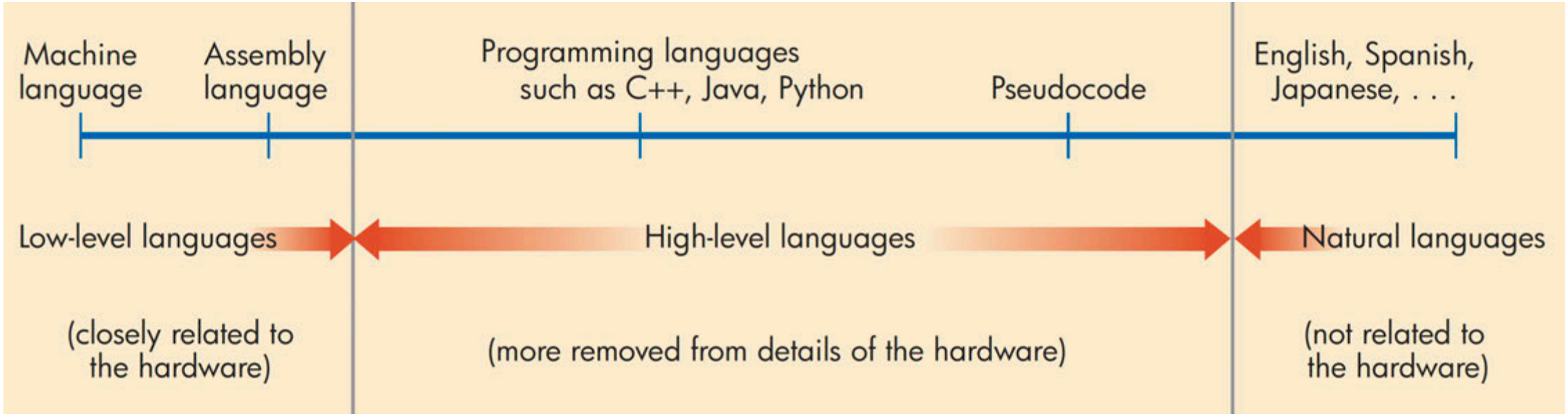
It is an ordered sequence of instructions given for changing the state of the computer hardware, in a certain predefined manner.

Coding

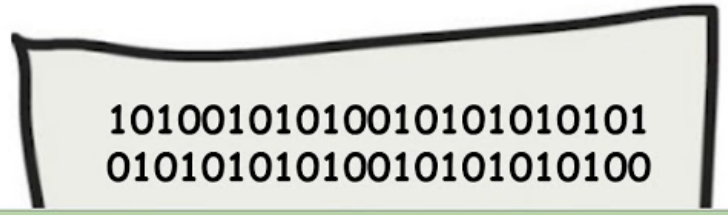
Anyone interested in developing software, such as a source-code, game, or IoT pipeline, must start by learning a programming language & decide which (source-code) Editor/Debugger to use.

https://www.computerhope.com/issues/ch000675.htm

Coding-paradigma's

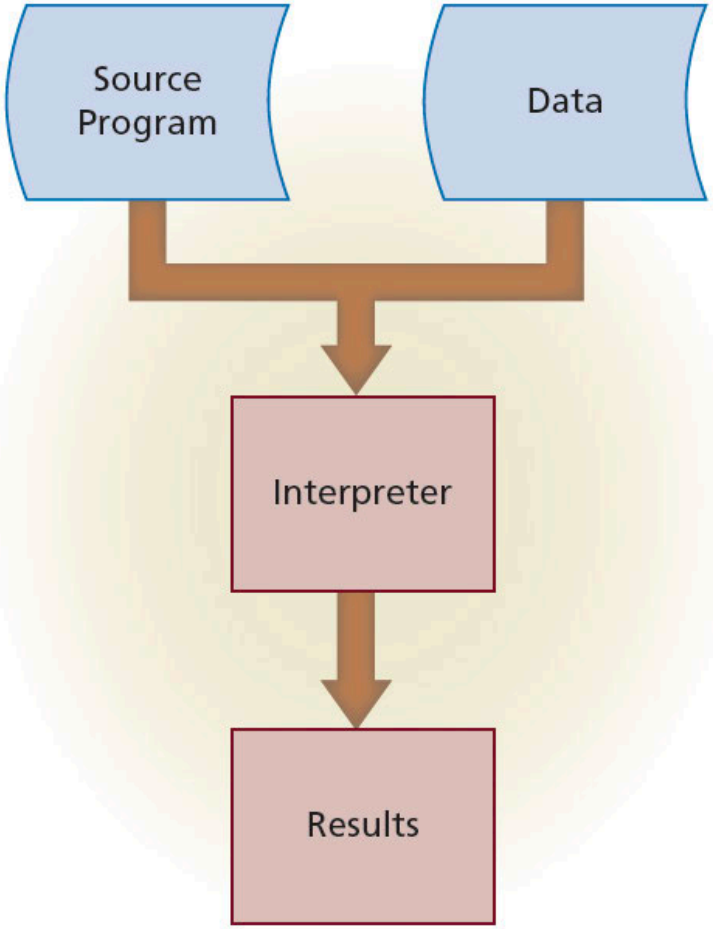


High vs low level Languages

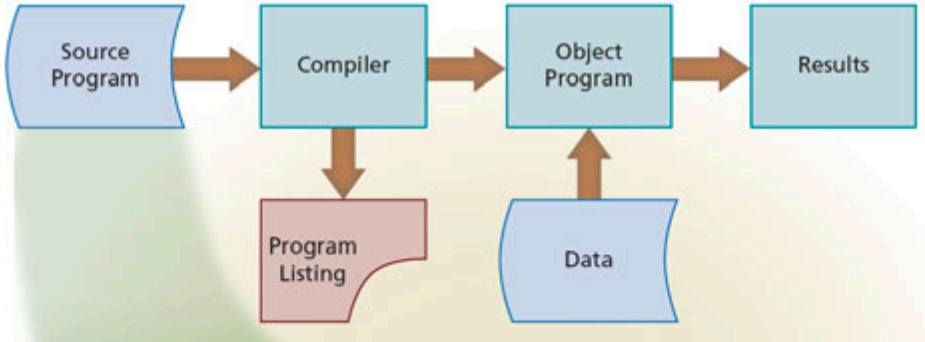


High-level language	Low-level language
Easy for humans to read, write and modify	Hard for humans to read, write and modify
Programs run slower as they make worse use of the CPU and are not very memory efficient	Direct control over the CPU means memory use is more efficient and programs run faster
No understanding of how hardware components work is needed	Good understanding of how the different hardware components work is needed
Examples are python, java, C#, C++ etc.	Examples are machine code and assembly language

Script(ing) languages
Do NOT need to be Compiled



High-level Program languag
need to be Compiled




```
/* Compute Regular Time Pay                    */
rt_pay = rt_hrs * pay_rate;

/* Compute Overtime Pay                        */
if (ot_hrs > 0)
    ot_pay = ot_hrs * 1.5 * pay_rate;
else
    ot_pay = 0;

/* Compute Gross Pay                           */
gross = rt_pay + ot_pay;

/* Display Gross Pay                           */
printf("The gross pay is %d\n", gross);
```

Mark-up vs Programing Languages

Markup languages

Markup languages are used to control the presentation and structure of the content

Programming languages

Programming languages are used to create instructions for a machine to execute & automate tasks

Mark-up vs Programing Languages

Markup Languages

HTML
CSS
XML

HTML defines content

CSS defines presentation

JavaScript defines behaviour

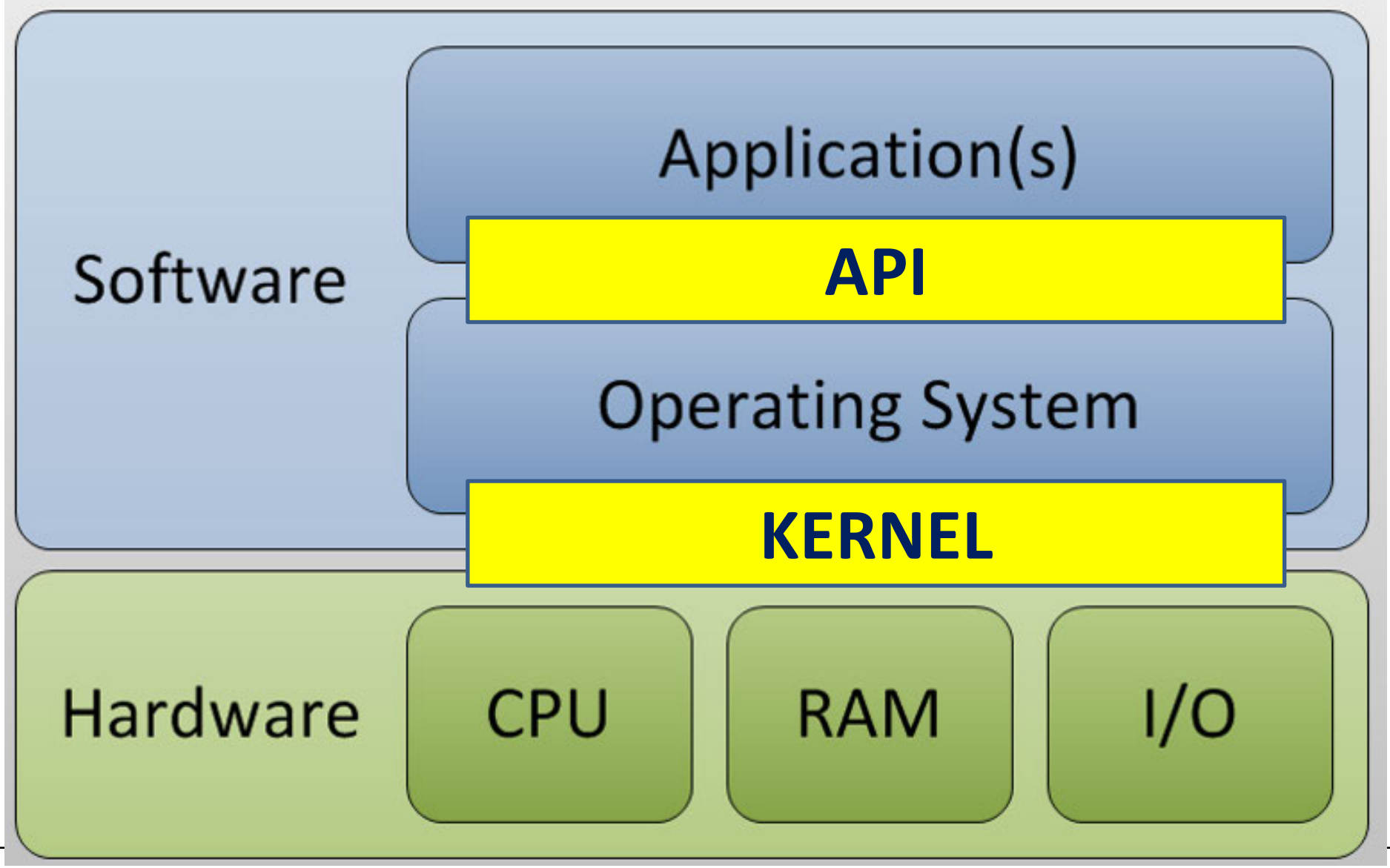
Programming languages

C
C++
C#
Java

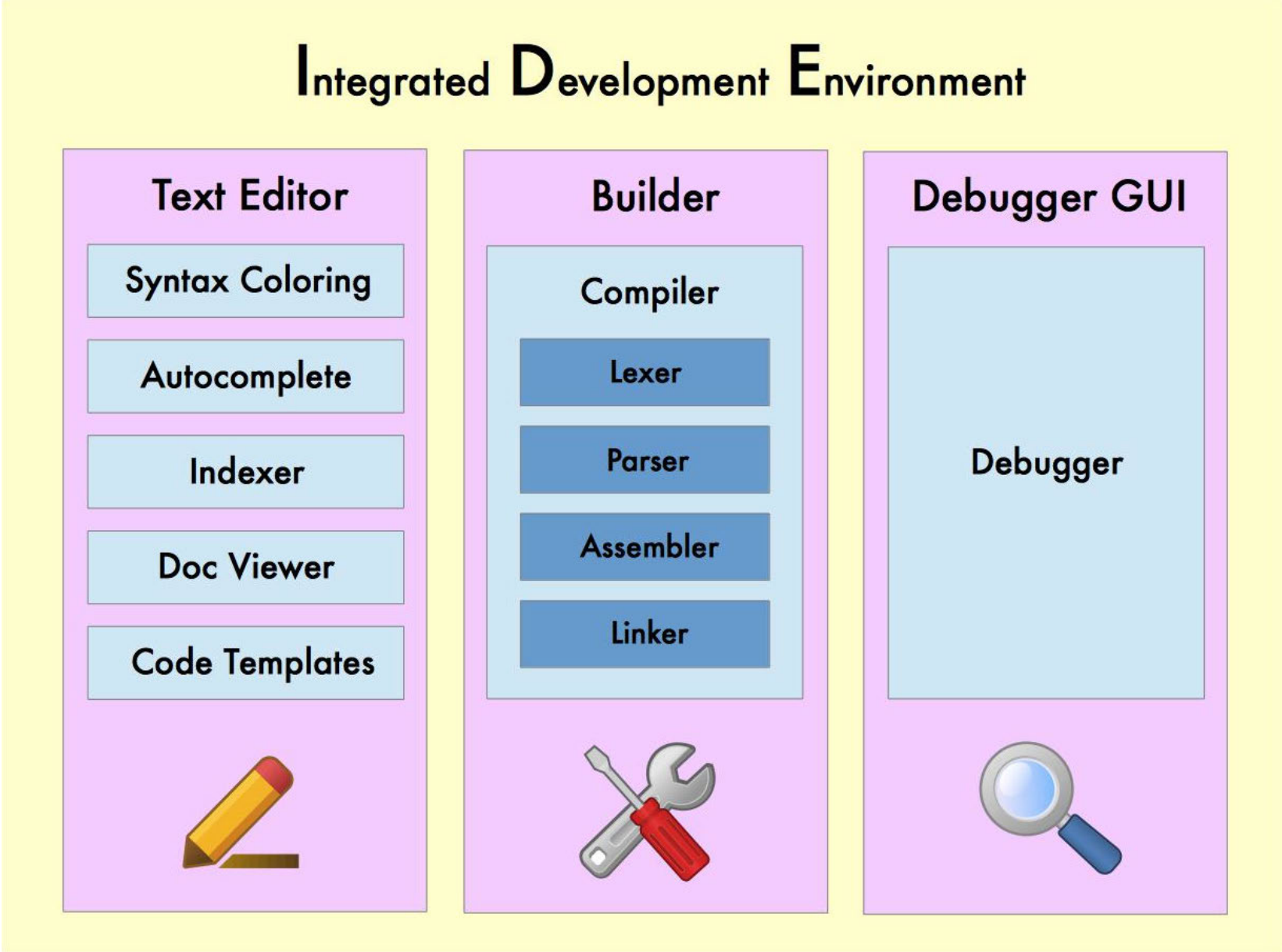
Scripting languages

JavaScript
Php
Perl
VBScript

Software vs Hardware



IDE


Integrated Development Environment
Text Editor
Syntax Coloring
Autocomplete
Indexer
Doc Viewer
Code Templates
Builder
Compiler
Lexer
Parser
Assembler
Linker
Debugger GUI
Debugger

What is (source-code) Program Software: Integrated Development Environment (IDE)?

Code editor: This feature is a text editor designed for writing and editing source code.

Source code editors are distinguished from text editors because they enhance or simplify the writing and editing of code.

Compiler/Interpreter: This tool transforms source code written in a human readable/writable language into a form executable by a computer.

Debugger: This tool is used during testing to help debug application programs.

Build automation tools: These tools automate common developer tasks.

Source-Code Editor

A source code editor is a text editor program designed specifically for editing source code of computer programs by programmers.

It may be a Standalone Application or it may be built into an Integrated Development Environment (IDE) or Web Browser.

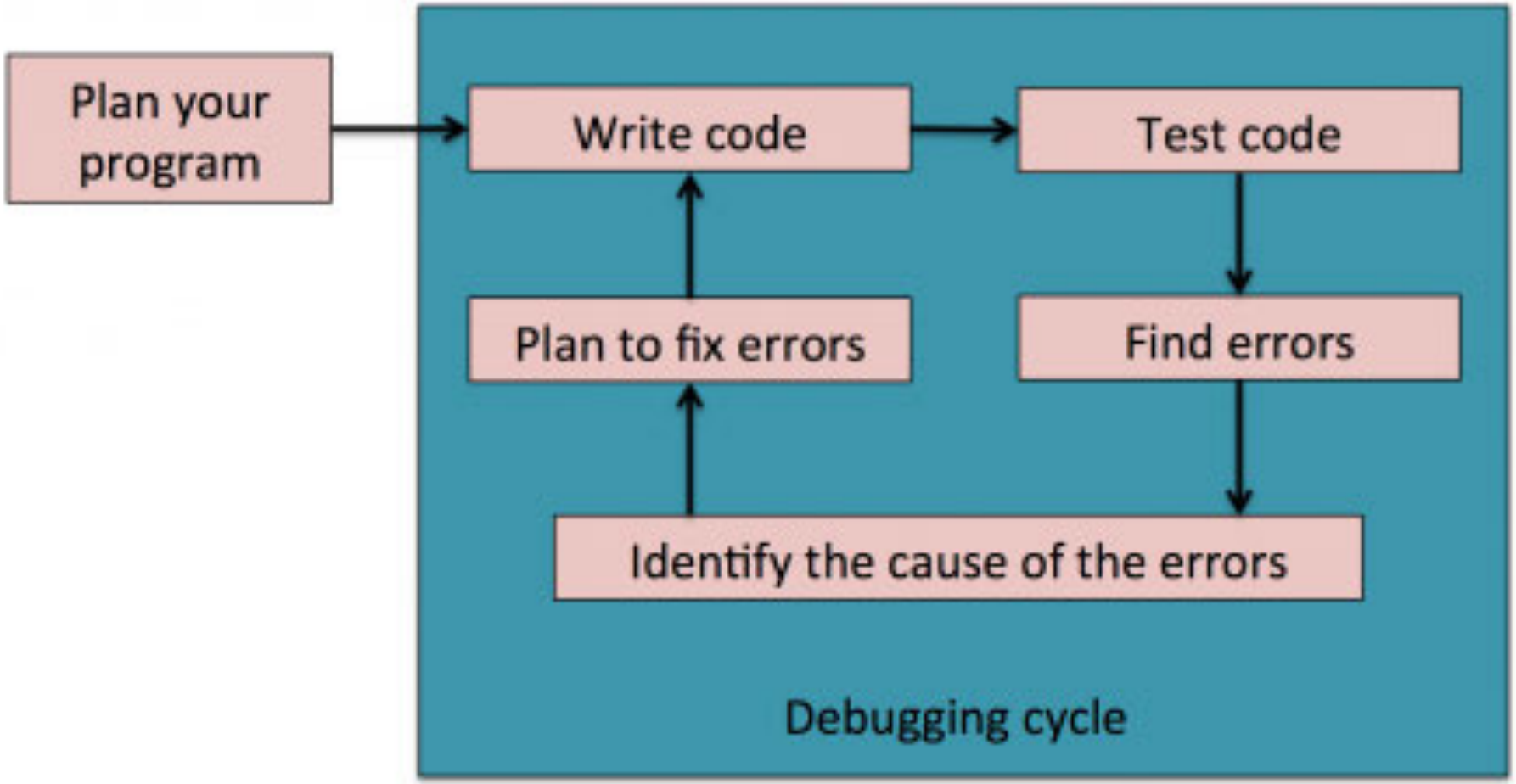
Source code editors are the most fundamental programming tool, as the fundamental job of programmers is to write and edit source code.

Debugging

Debugging is a process of analyzing a computer program source-code and removing its logical or syntactical errors.

Software which assists this process is a debugger.

Using a debugger, a software developer can step through a program's code and analyze its variable values, searching for errors.


Plan your program
Write code
Test code
Plan to fix errors
Find errors
Identify the cause of the errors
Debugging cycle

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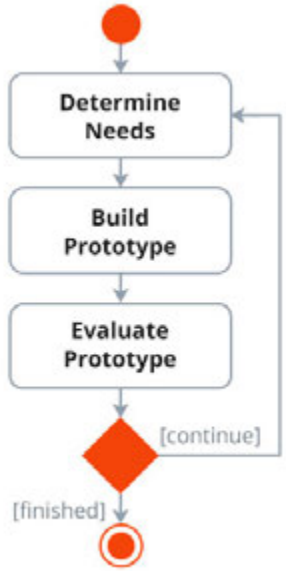
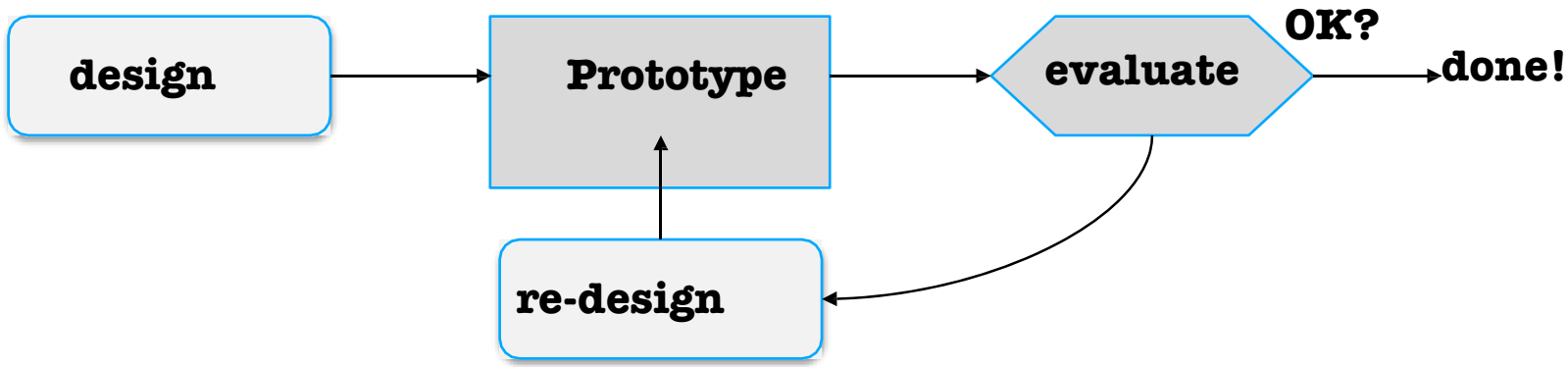
Rapid Prototyping Core-Concepts

PROTOTYPING

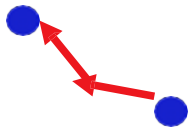
- You never get it right first time
- If at first you don"t succeed ...

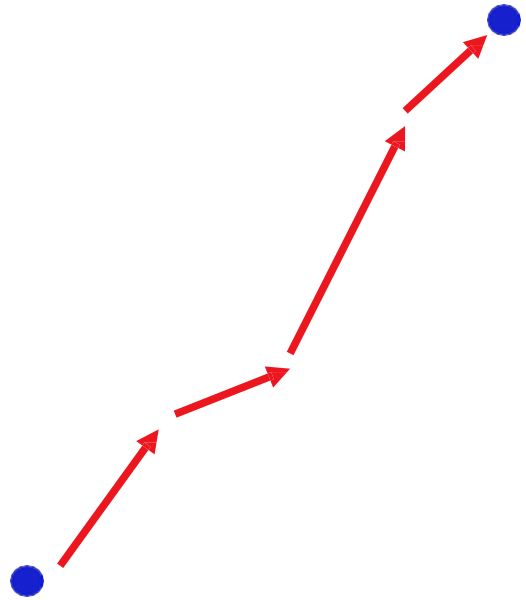




PITFALLS OF PROTOTYPING

- Moving little by little … but to where

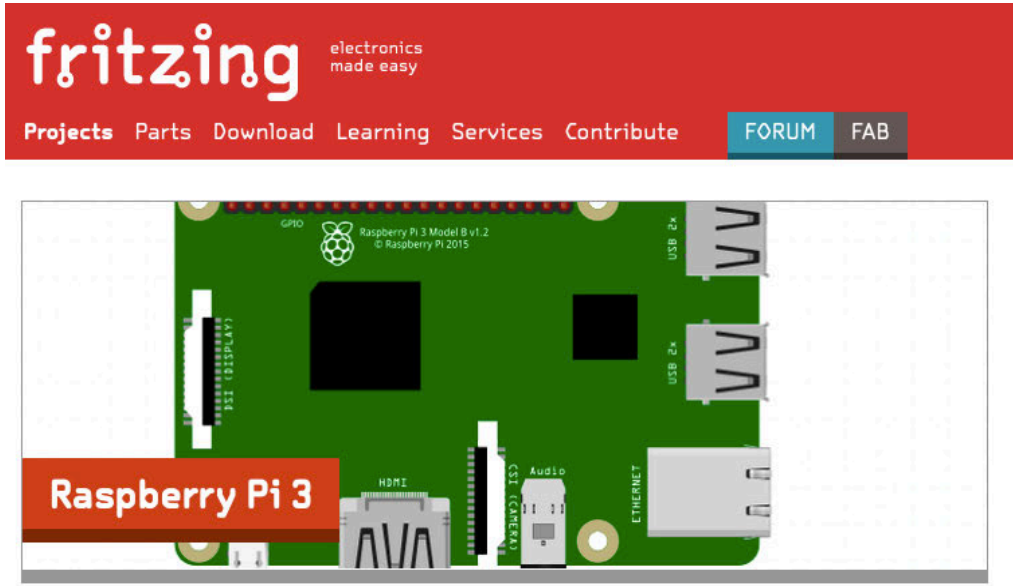




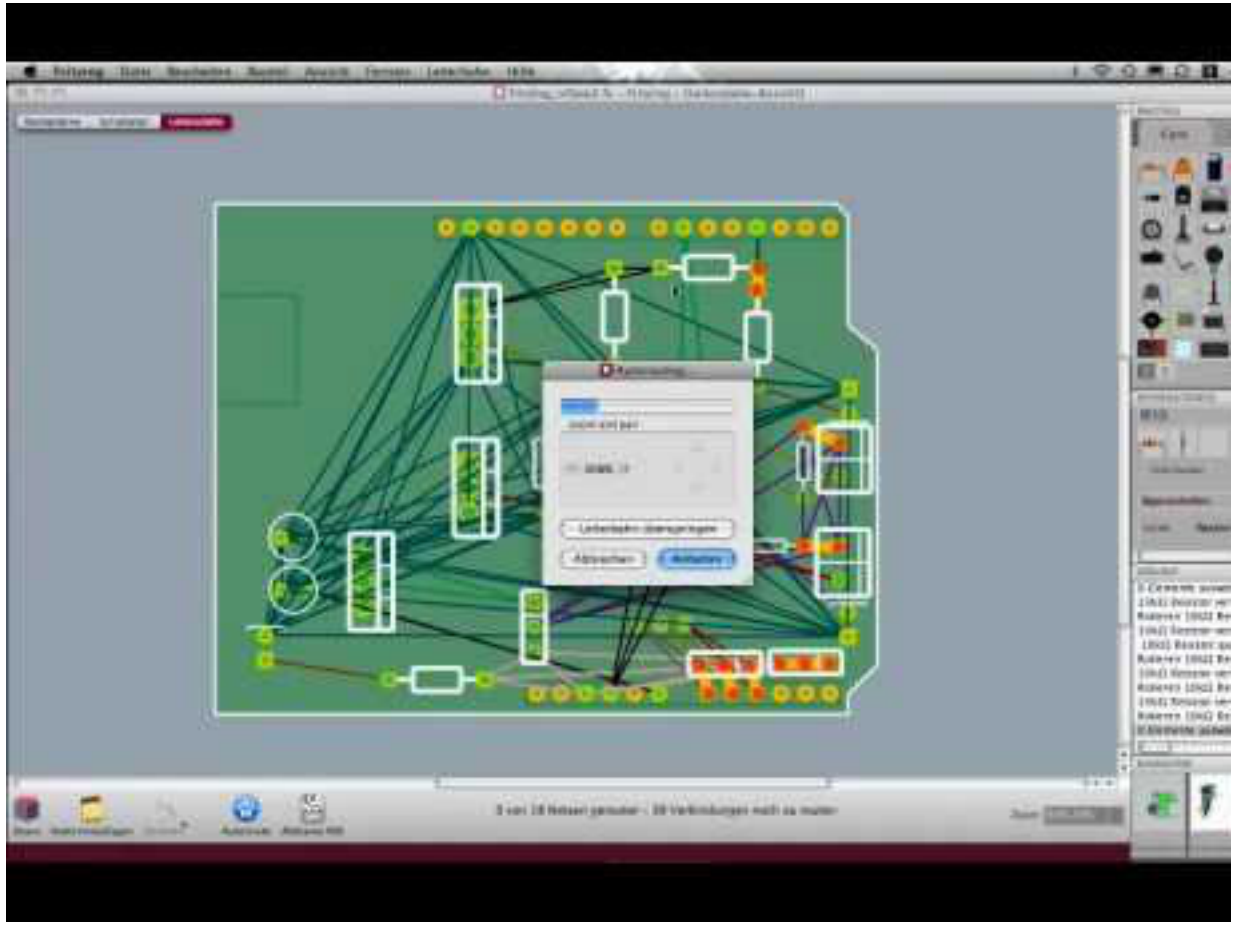
1. need a good start point
2. need to understand what is wrong

https://www.youtube.com/watch?v=JMjozqJS44M

Fritzing



https://fritzing.org/projects/raspberry-pi-3



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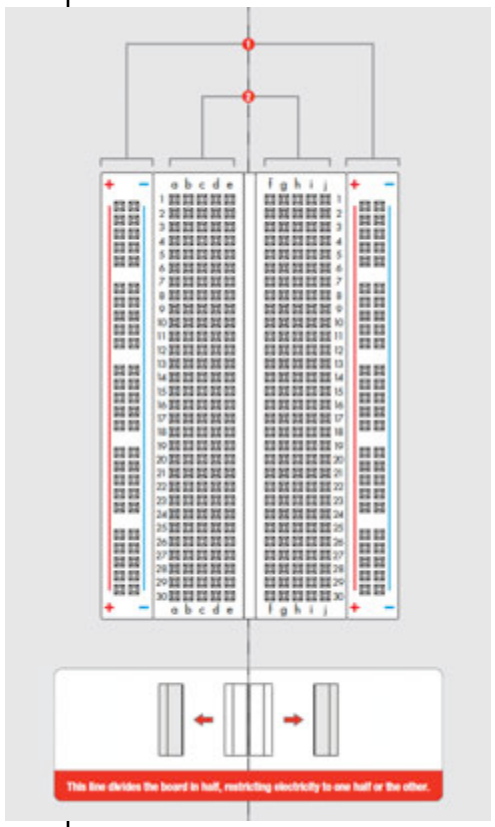
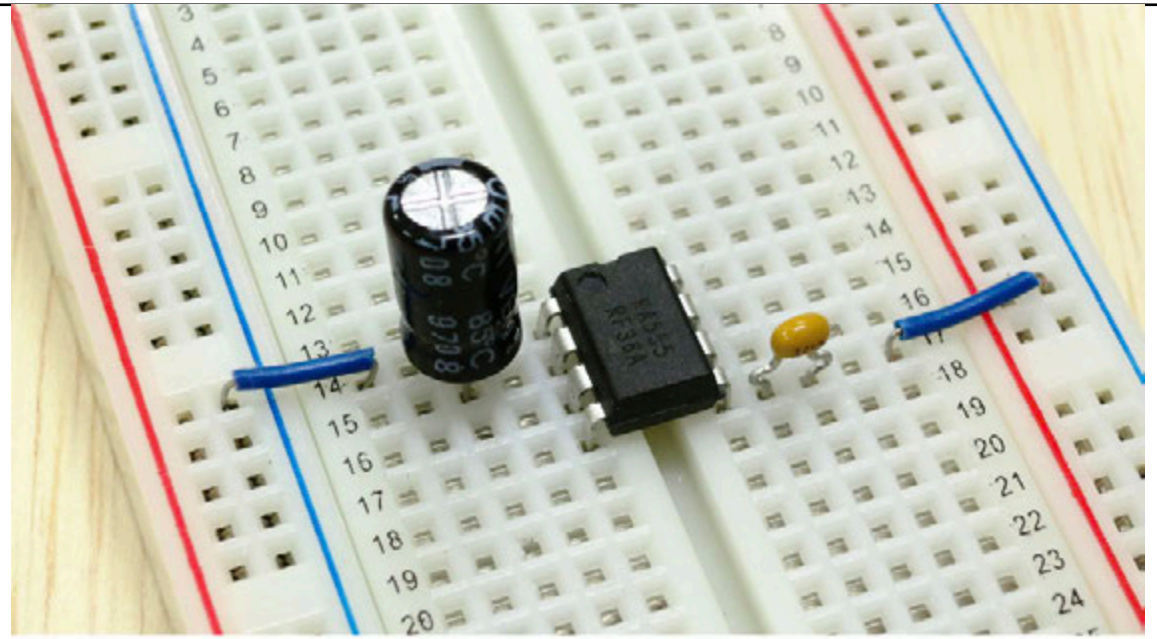
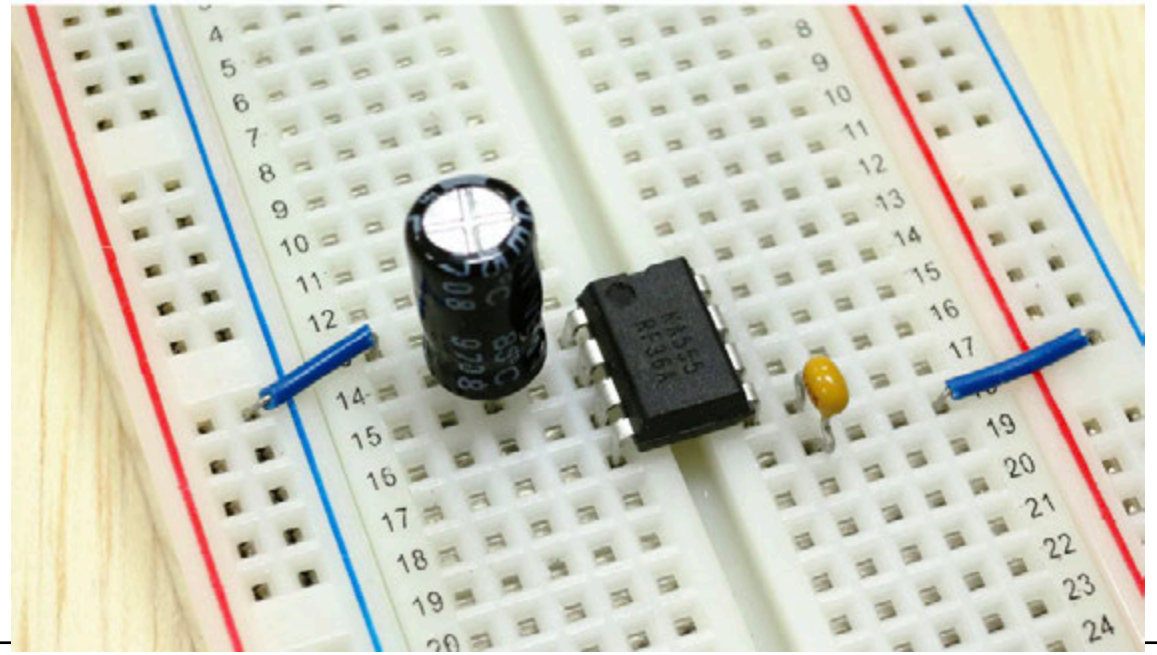
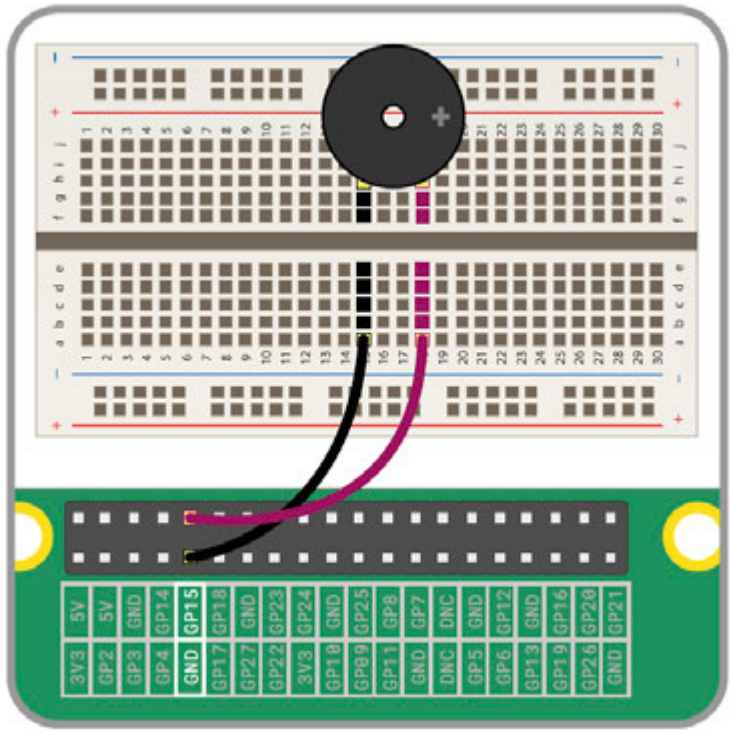
Breadboard

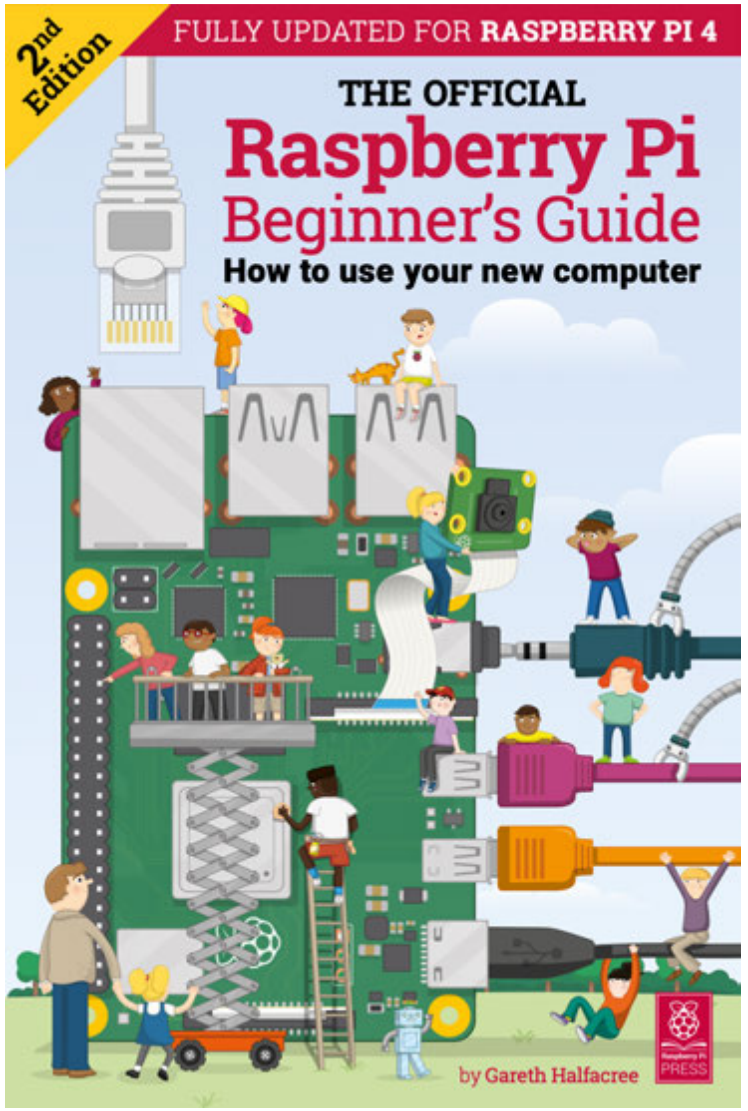






Rapid Prototyping





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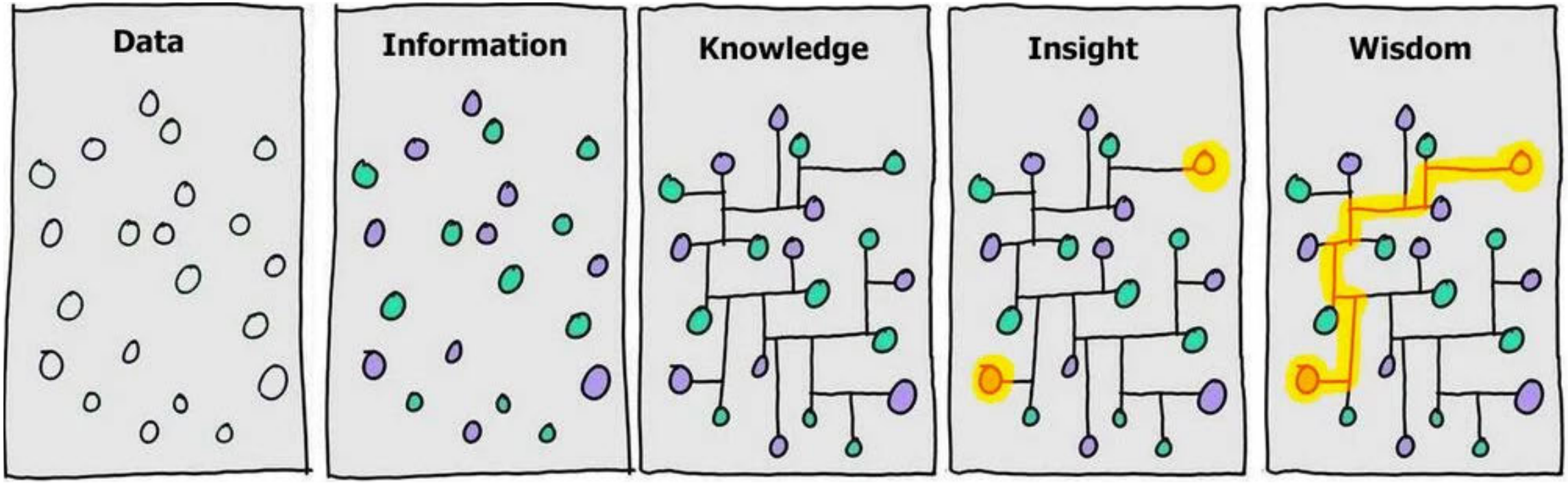
Data Science Core-Concepts

How to make sense of IoT Data (Science)



Waarom Data Science?

Veel van de huidige maatschappelijke en wetenschappelijke vraagstukken zijn dermate complex dat zij niet zonder de hulp van computertechnologie opgelost kunnen worden.

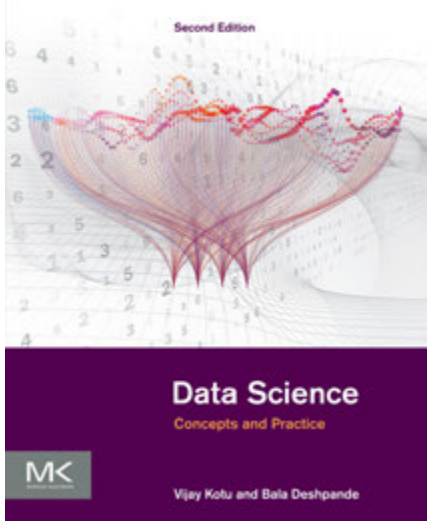
Bij deze vraagstukken is de rekenkracht van de computer nodig om tot een oplossing te komen.

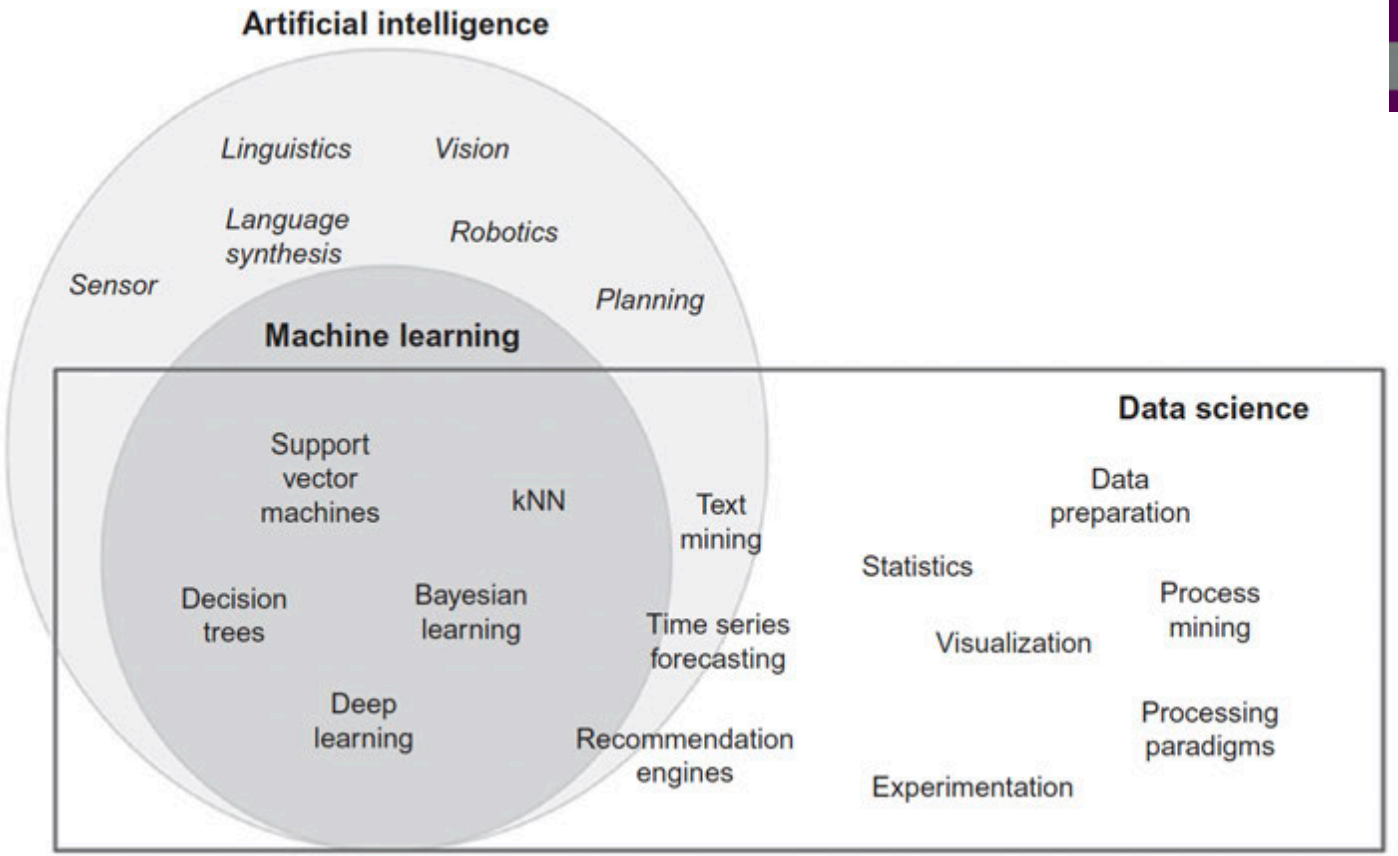
Fundamentals

DATA SCIENCE
(ANALYTICS)
VERSUS
DATA ENGINEERING
(PROBLEM SOLVING)

is a complex domain that requires a lot of skillful effort to perform adequately

Data Science:
Comprises many Techniques that extract Value from Data





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Thinking like a data scientist means more than being able to program a computer.

It requires thinking at multiple levels of abstraction called Computational Thinking

Viewpoint | Jeannette M. Wing

Computational Thinking

It represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use.

Computational thinking builds on the power and limits of computing processes, whether they are executed by a human or by a machine. Computational methods and models give us the courage to solve problems and design systems that no one of us would be capable of tackling alone. Computational thinking confronts the riddle of machine intelligence: What can humans do better than computers? and What can computers do better than humans? Most fundamentally it addresses the question: What is computable? Today, we know only parts of the answers to such questions.

Computational thinking is a fundamental skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability. Just as the printing press facilitated the spread of the three Rs, what is appropriately incestuous about this vision is that computing and computers facilitate the spread of computational thinking.

Computational thinking involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science. Computational thinking includes a range of mental tools that reflect the breadth of the field of computer science.

Having to solve a particular problem, we might ask: How difficult is it to solve? and What's the best way to solve it? Computer science rests on solid theoretical underpinnings to answer such questions precisely. Stating the difficulty of a problem accounts for the underlying power of the machine—the computing device that will run the solution. We must consider the machine's instruction set, its resource constraints, and its operating environment.

In solving a problem efficiently, we might further ask whether an approximate solution is good enough, whether we can use randomization to our advantage, and whether false positives or false negatives are allowed. Computational thinking is reformulating a seemingly difficult problem into one we know how to solve, perhaps by reduction, embedding, transformation, or simulation.

Computational thinking is thinking recursively. It is parallel processing. It is interpreting code as data and data as code. It is type checking as the generalization of dimensional analysis. It is recognizing both the virtues and the dangers of aliasing, or giving someone or something more than one name. It is recognizing both the cost and power of indirect addressing and procedure call. It is judging a program not just for correctness and efficiency but for aesthetics, and a system's design for simplicity and elegance.

Computational thinking is using abstraction and decomposition when attacking a large complex task or designing a large complex system. It is separation of concerns. It is choosing an appropriate representation for a problem or modeling the relevant aspects of a problem to make it tractable. It is using invariants to describe a system's behavior succinctly and declaratively. It is having the confidence we can safely use, modify, and influence a large complex system without understanding its every detail. It is

Computational thinking is a way of
solving problems,
designing systems, &
understanding human behavior
that draws on concepts
fundamental to data science.

Viewpoint | Jeannette M. Wing

Computational Thinking

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Computational Thinking

Computational thinking richt zich op de vaardigheden
die essentieel zijn om problemen op te lossen
waarbij veel informatie, variabelen en rekenkracht nodig zijn.

Het is daarbij belangrijk om te begrijpen hoe informatie tot stand komt
zodat je computersystemen kan benutten voor probleemoplossen,
voor het denken in stappen en
daarmee in voorwaardelijkheden voor volgorde van de benodigde gegevens.

Computertechnologie gebruiken bij het zoeken naar oplossingen *---Data Science---*
betekent inzicht krijgen in algoritmes (een reeks instructies om vanaf een beginpunt een bepaald doel te bereiken) en procedures (een verzameling activiteiten die in een bepaalde volgorde moet worden uitgevoerd).

DATA-DRIVEN IoT: WHAT IS DATA?

Data [gegevens]

Raw Facts
No Context
Numbers
Symbols

Data comes from the Latin word, "datum," meaning a "thing given."

Although the term "data" has been used since as early as the 1500s, modern usage started in the 1940s and 1950s as practical electronic computers began to input, process, and output data.

98734975471894614398734578
20875980542158009258202908
12349823094823048002343423

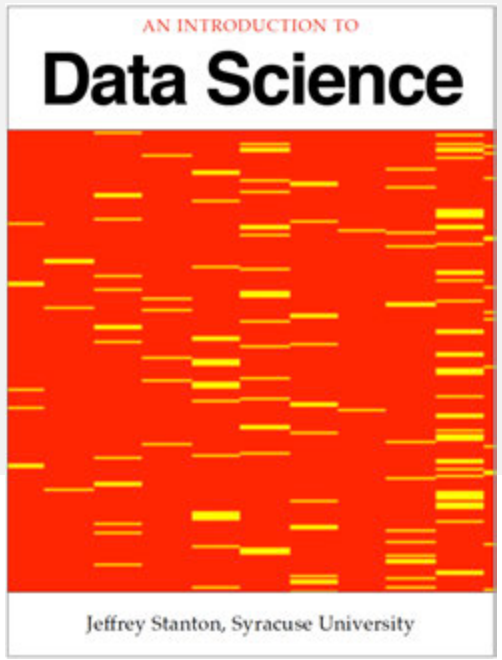
98734975471894614398734578
20875980542158009258202908
12349823094823048002343423

Wat is DATA?

HOGESCHOOL ROTTERDAM

Data [gegevens]

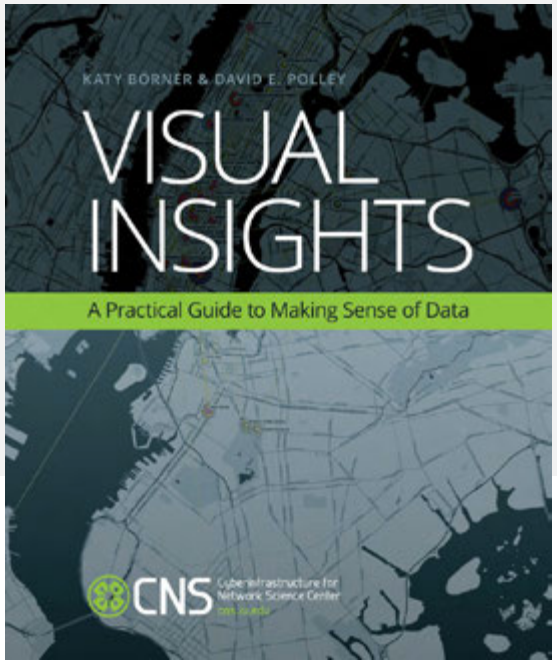
Raw Facts
No Context
Numbers
Symbols



Information [informatie]

Data with structure = processed data
Reduces Uncertainty about Data

- Summarised
- Organised
- Analysed



DATA STRUCTURING: Observations versus Variables

Data Table [DATA MATRIX]

A generalized version of the data table is shown. This table can represent any number of observations described over multiple variables.

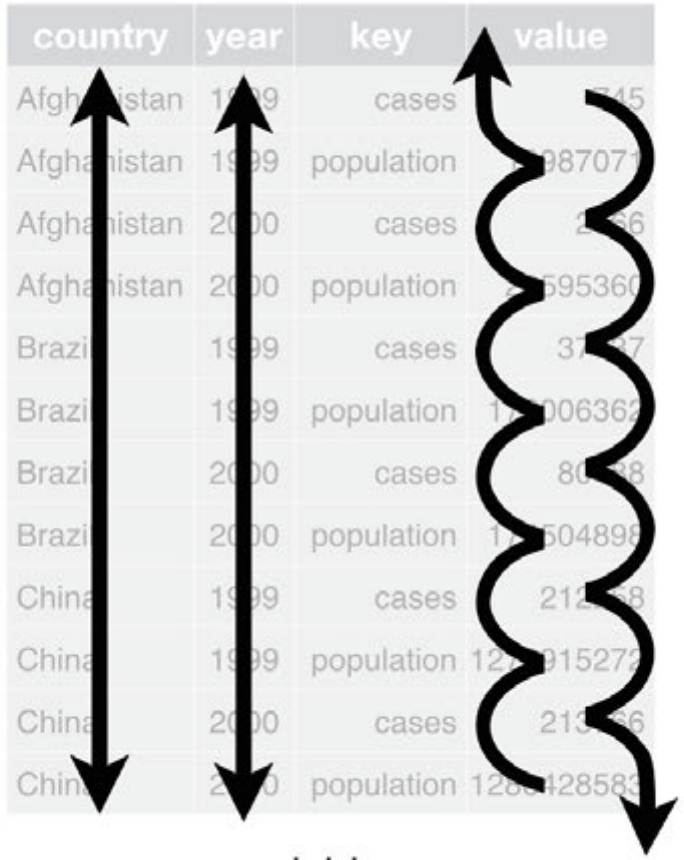
This table describes a series of observations (from o1 to on) where each observation is described using a series of variables (from x1 to xp). A value is provided for each variable of each observation.

	Variables					
Observations		x_1	x_2	x_3	...	x_p
	o_1	x_{11}	x_{12}	x_{13}	...	x_{1p}
	o_2	x_{21}	x_{22}	x_{23}	...	x_{2p}
	o_3	x_{31}	x_{32}	x_{33}	...	x_{3p}
	...	...	...	...	...	...
	o_n	x_{n1}	x_{n2}	x_{n3}	...	x_{np}

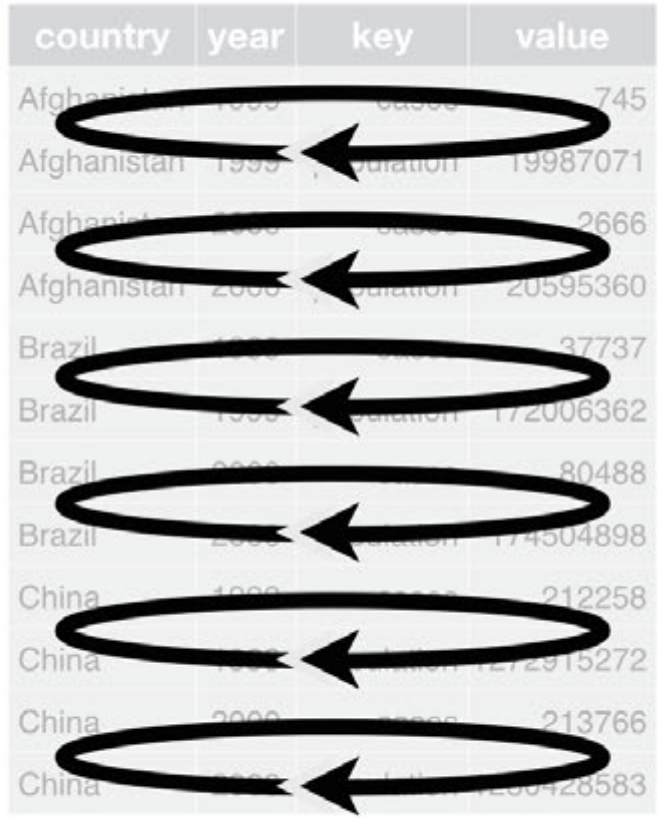
Patient ID	Treated	Age	Outcome	Random
1	Yes	Young	Positive	0.24
2	No	Young	Positive	0.85
3	Yes	Old	Negative	0.64
4	No	Old	Negative	0.70
5	No	Old	Negative	0.87
6	No	Old	Negative	0.72
7	No	Old	Negative	0.86
8	No	Young	Negative	0.16
9	No	Young	Positive	0.17

country	year	key	value
Afghanistan	1999	cases	745
Afghanistan	1999	population	19987071
Afghanistan	2000	cases	2666
Afghanistan	2000	population	20595360
Brazil	1999	cases	37737
Brazil	1999	population	172006362
Brazil	2000	cases	80488
Brazil	2000	population	174504898
China	1999	cases	212258
China	1999	population	1272915272
China	2000	cases	213766
China	2000	population	1280428583

table2



variables



observations

DATA STRUCTURING: Relationships & Patterns [Anscombe Quartet]

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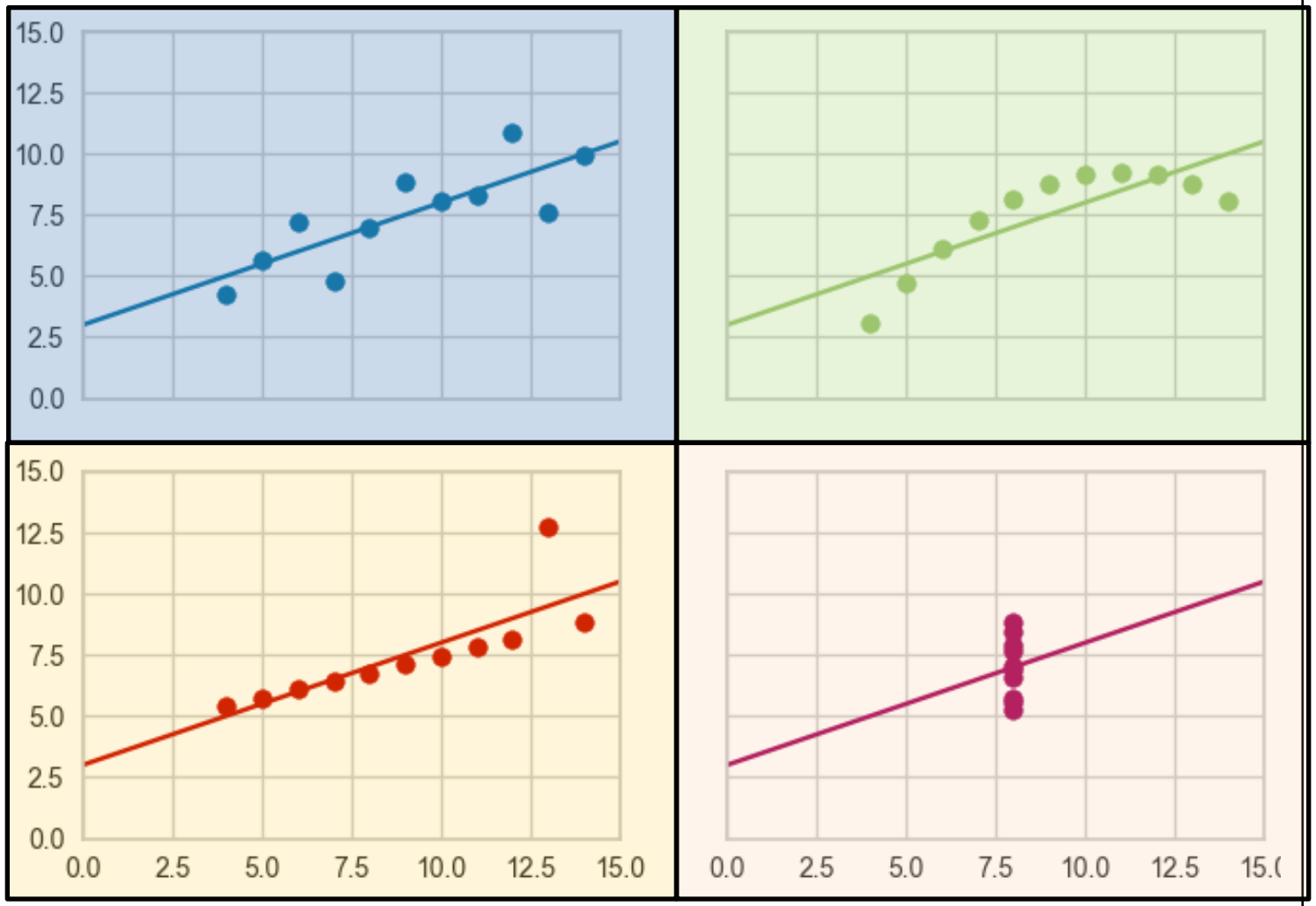
Anscombe's quartet

I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89



ORGANIZING DATA

- STRUCTURED DATA
  - lists
  - $n \times p$ tables, arrays
  - hierarchies (e.g., organization chart)
  - networks (e.g., travel routes, hypertext = links)
- Generic data-interchange formats: XML, JSON

- UNSTRUCTURED DATA
  - text
  - images
  - video
  - sound
- Often can be made structured by, e.g., parsing language, segmenting images, etc.

JSON

- Similar to XML but simpler

```
{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 25,
  "address": {
    "streetAddress": "21 2nd Street",
    "city": "New York",
    "state": "NY",
    "postalCode": "10021-3100"
  },
  "phoneNumbers": [
    {
      "type": "home",
      "number": "212 555-1234"
    },
    {
      "type": "office",
      "number": "646 555-4567"
    },
    {
      "type": "mobile",
      "number": "123 456-7890"
    }
  ],
  "children": [],
  "spouse": null
}
```

PARSING DATA INTO USEFUL INFORMATION

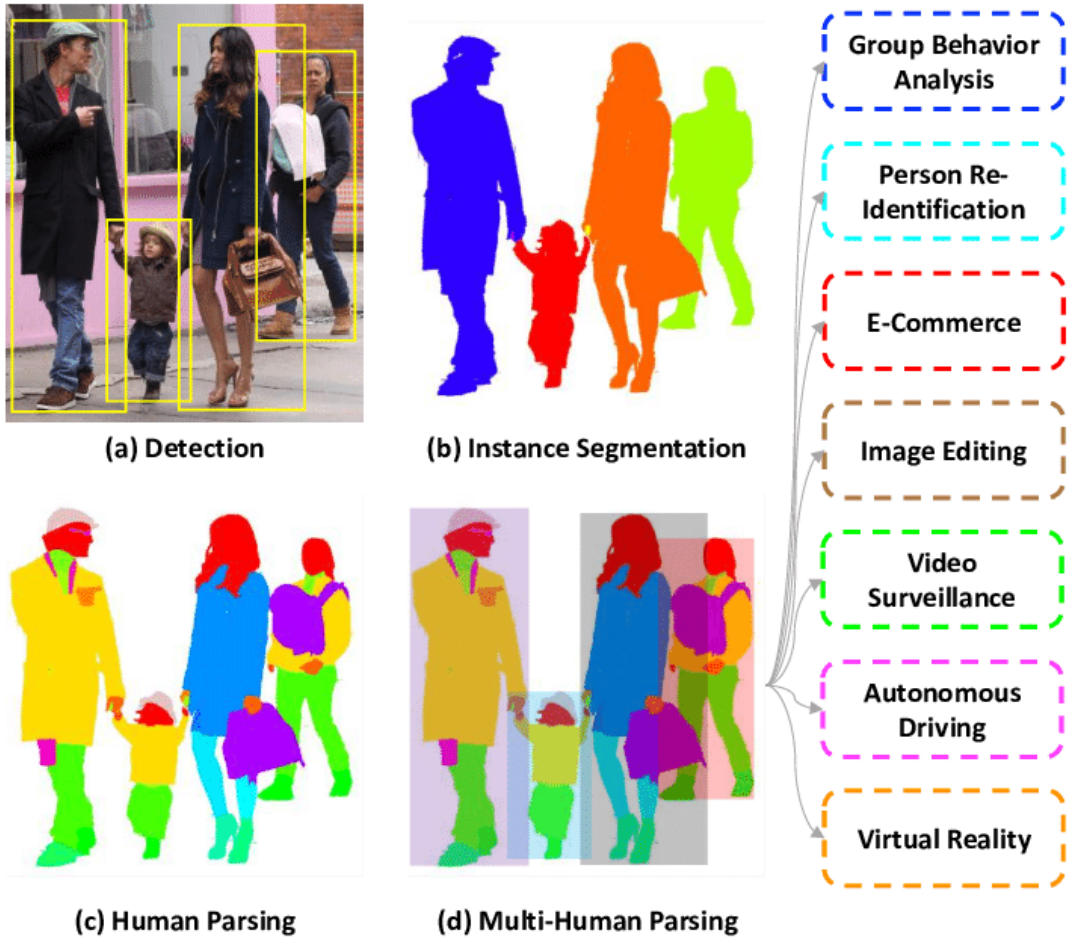
- Given a known grammar, unstructured text data can be parsed
- “It ain’t over till the fat lady sings”

  ((it, (ain't, over)), (till, ((the, (fat, lady)), sings)))

- Similarly, images can be segmented into parts

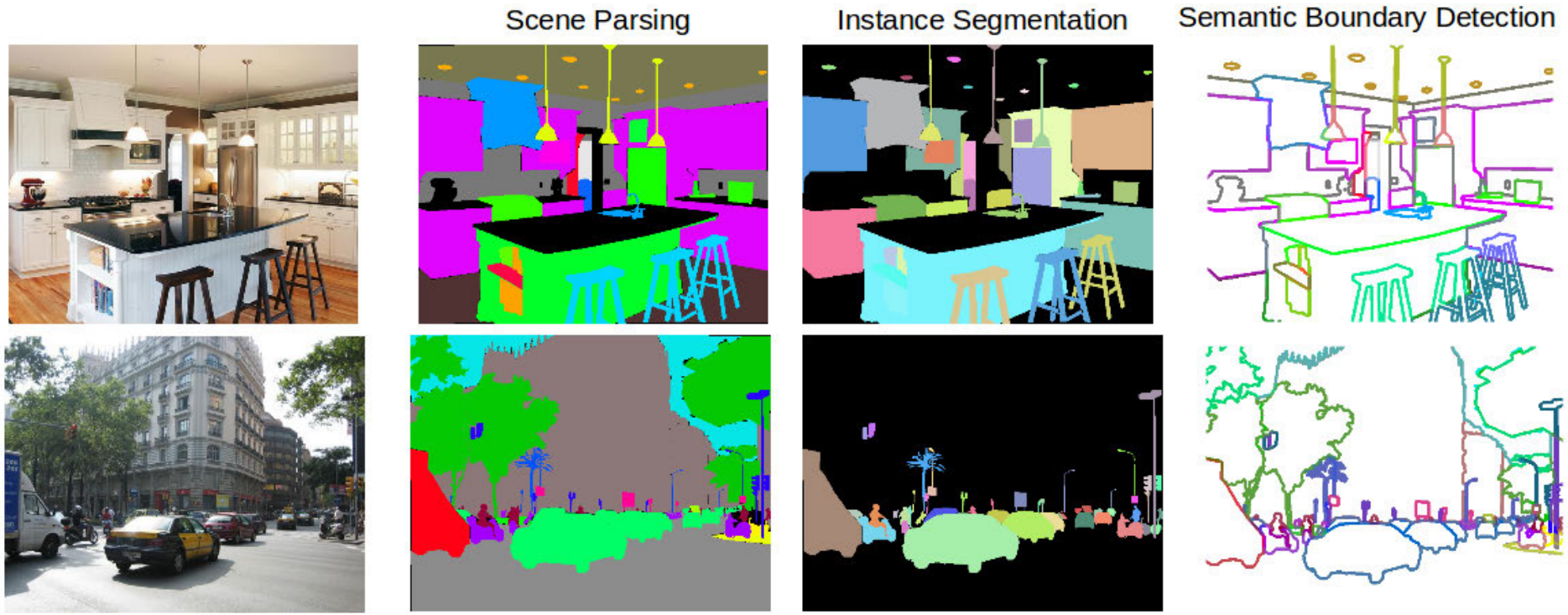
PARSING

- Similarly, images can be segmented into parts



PARSING

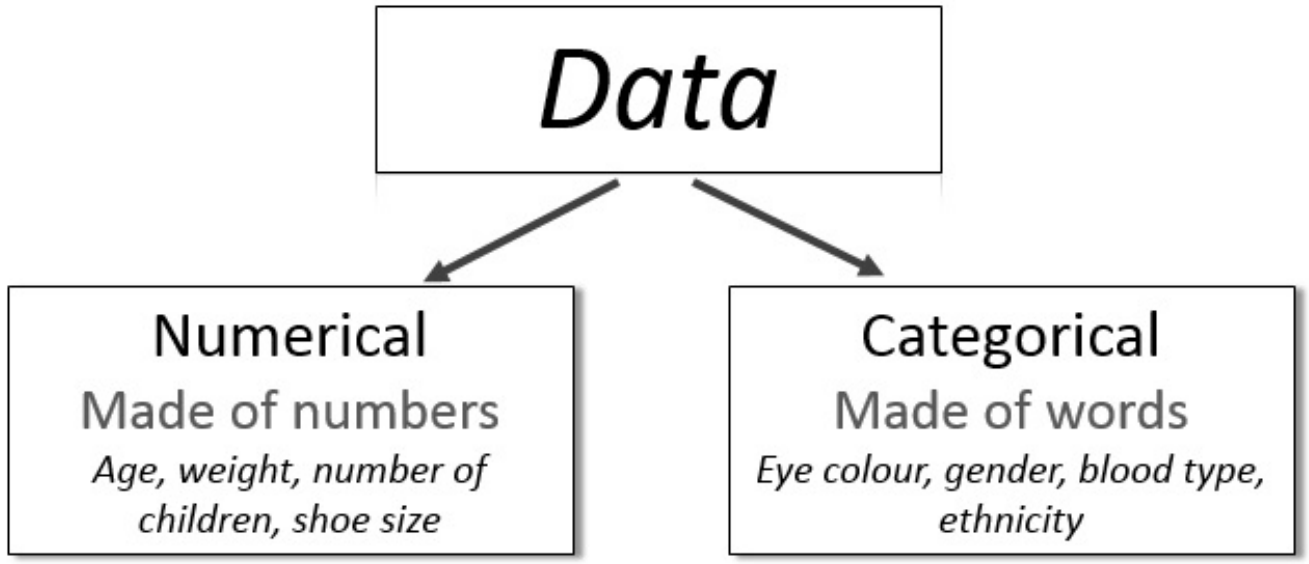
- Similarly, images can be segmented into parts



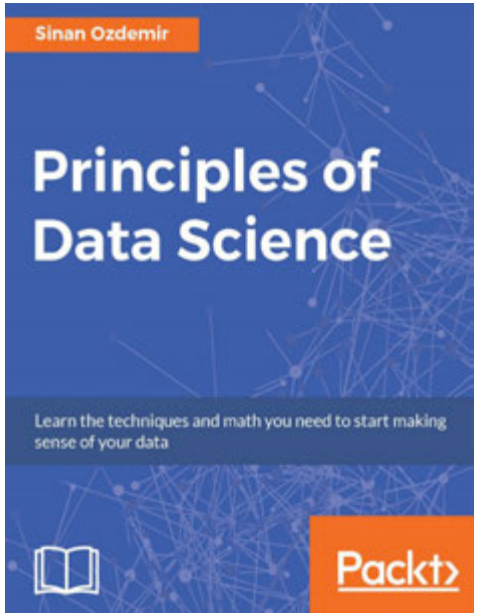
TYPES OF DATA: Quantitative versus Qualitative [numerical vs categorical]

Data Quantification

Quantitative [Numerical] data: This data can be described using numbers, and basic mathematical procedures, including addition, are possible on the set. It can be discrete (countable numbers) or continuous (infinitely large or small)
Qualitative [Categorical] data: This data are categories. It cannot be described using numbers and basic mathematics. Is generally thought of as being described using"natural" categories and language.



- Quantitative values
  - **Measure** things
  - *Revenue, Units, Marketshare, Duration, Customer Satisfaction, Visits, Price, etc.*
- Categorical values
  - Subdivide things into **groups**
  - *Region, product, category, employee, etc.*



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Data

Numerical
Made of numbers

Age, weight, number of children, shoe size

Continuous
Infinite options

Age, weight, blood pressure

Discrete
Finite options

Shoe size, number of children

Categorical
Made of words

Eye colour, gender, blood type, ethnicity

Ordinal
Data has a hierarchy

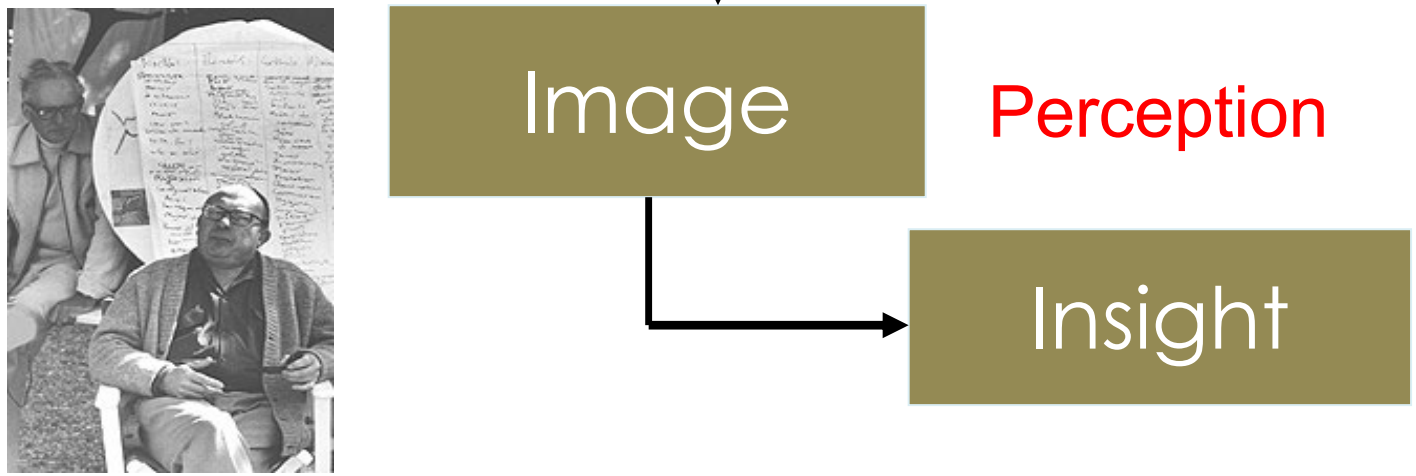
Pain severity, satisfaction rating, mood

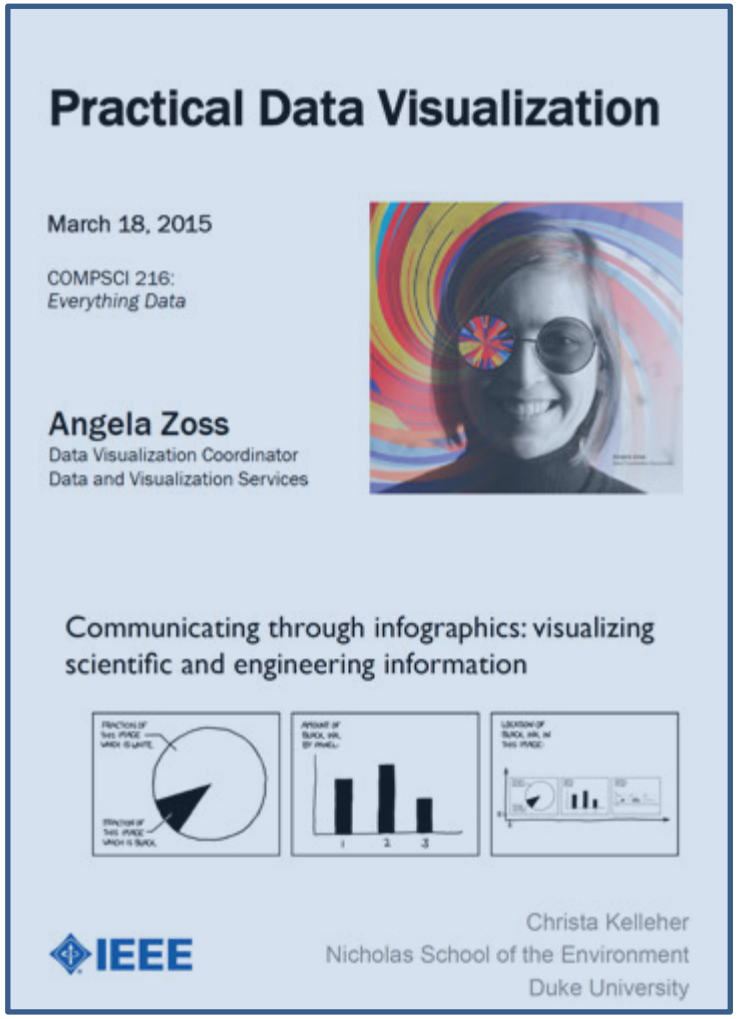
Nominal
Data has no hierarchy

Eye colour, dog breed, blood type

DATA STRUCTURING: data worden pas inzichtelijk als (beeld)figuur (graphical visualization) of GRAAF (graph)

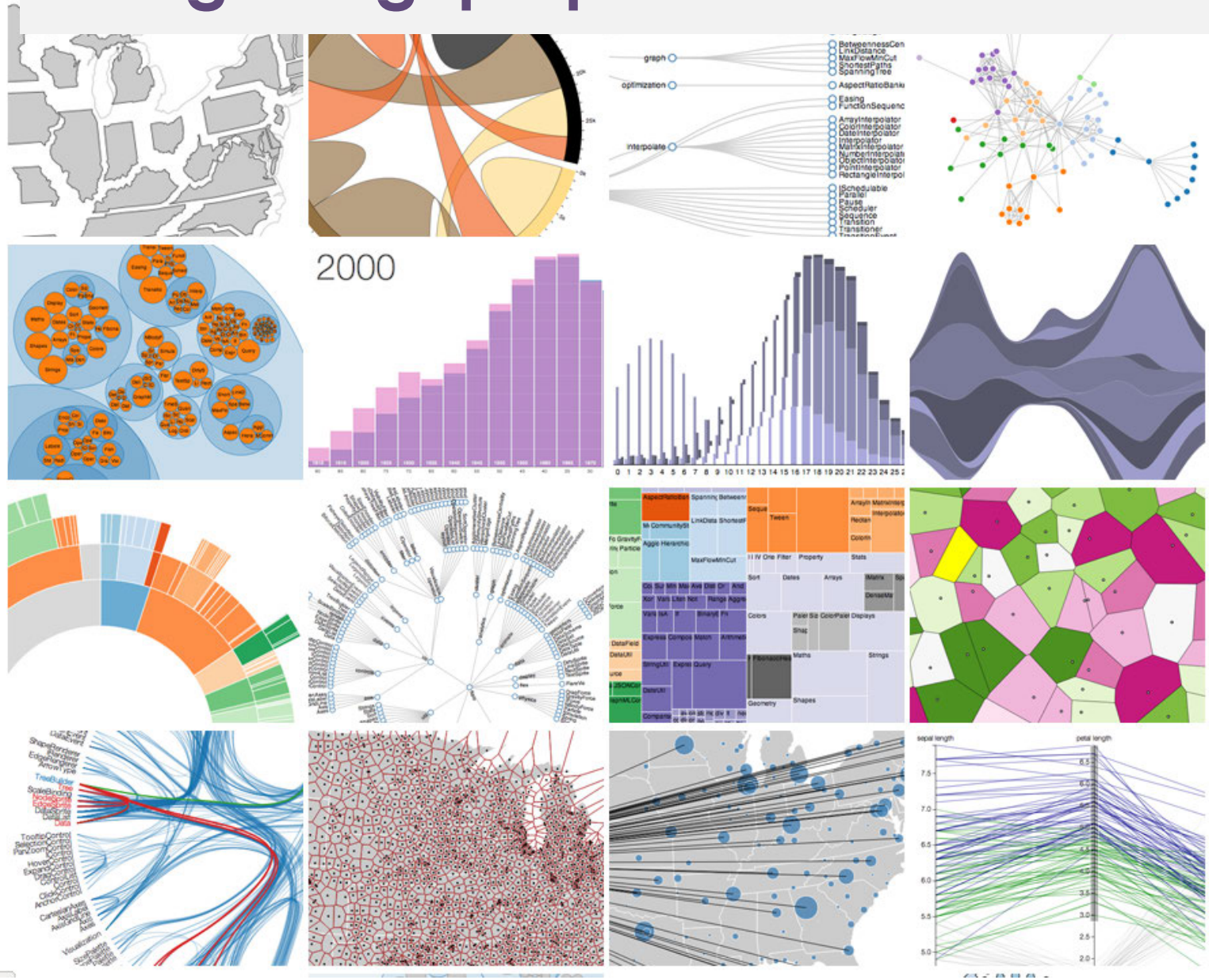
Jacques Bertin who wrote the classic works of **graphical visualization** "Semiology of Graphics" states that the "transformation from numbers to insight requires two stages"

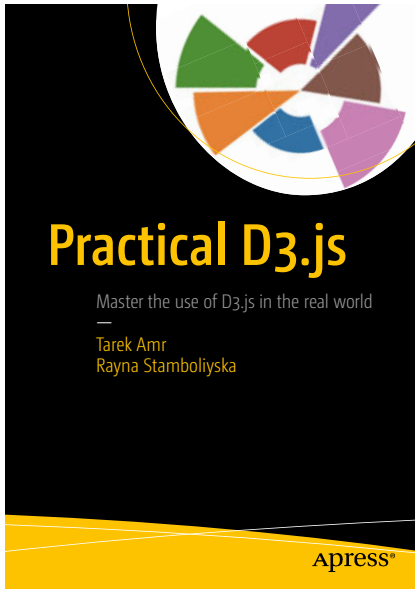


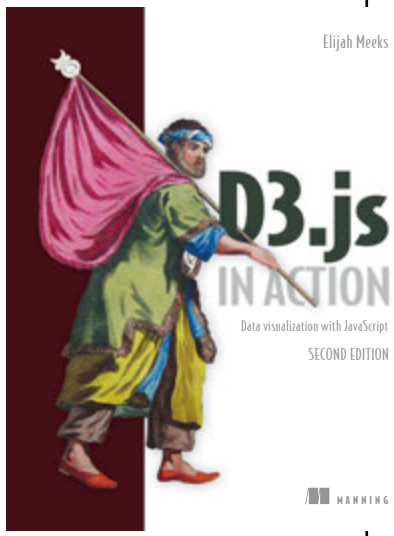


SEE ALSO: http://www.cs.wright.edu/~jgalli/hfe306/Data_Visualization_Quenin.ppt

Wat geeft grip op DATA?



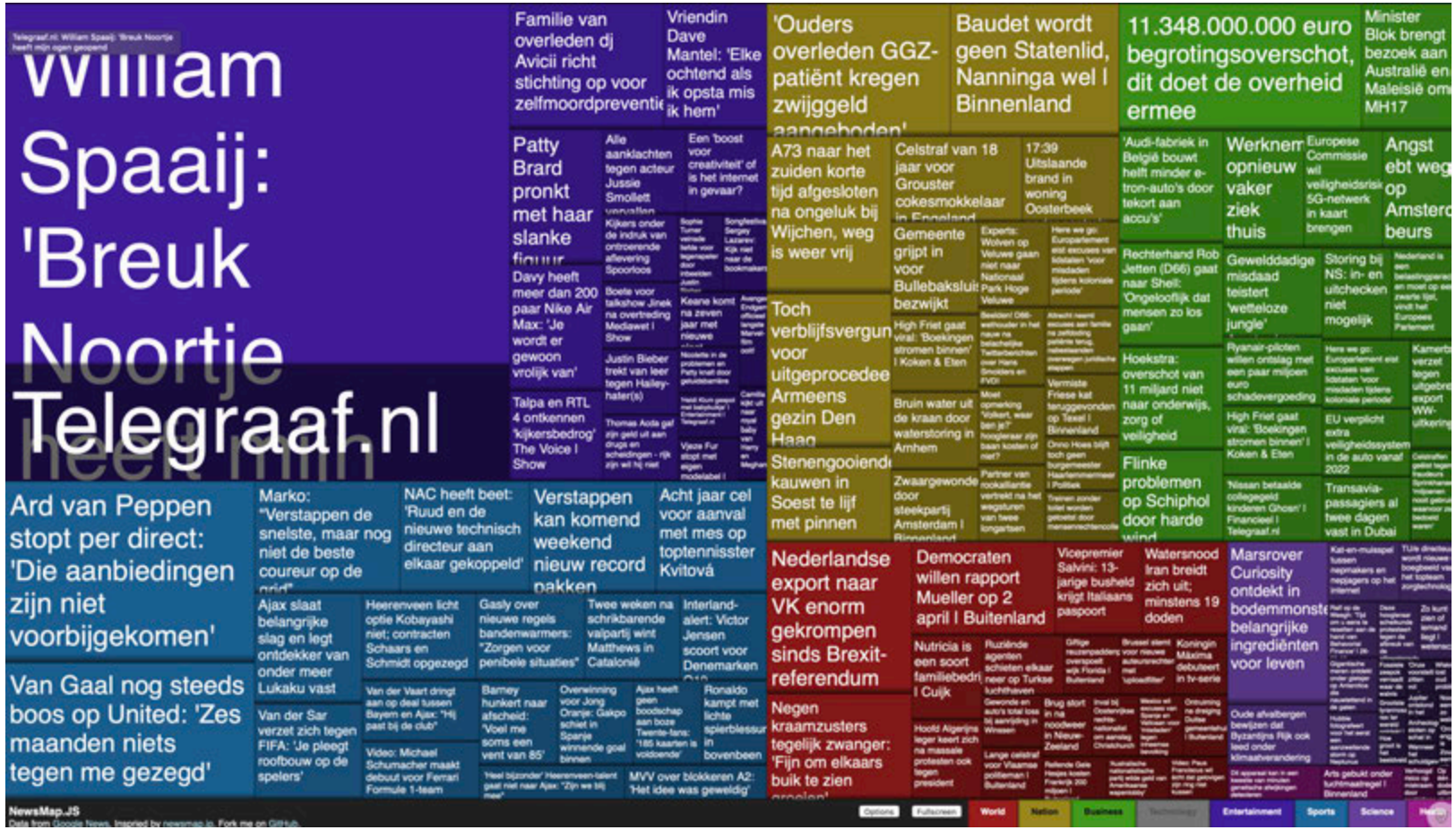




DATA STRUCTURING: TREE MAP [example]

https://github.com/IJMacD/newsmap-js

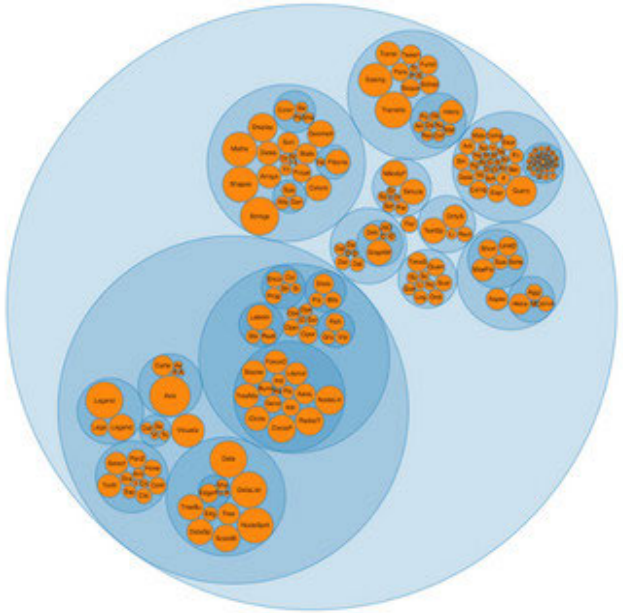
https://newsmap.ijmacd.com



DATA STRUCTURING: TREE MAP [example]

A

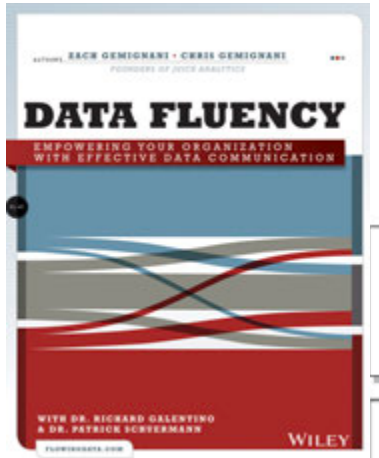
B

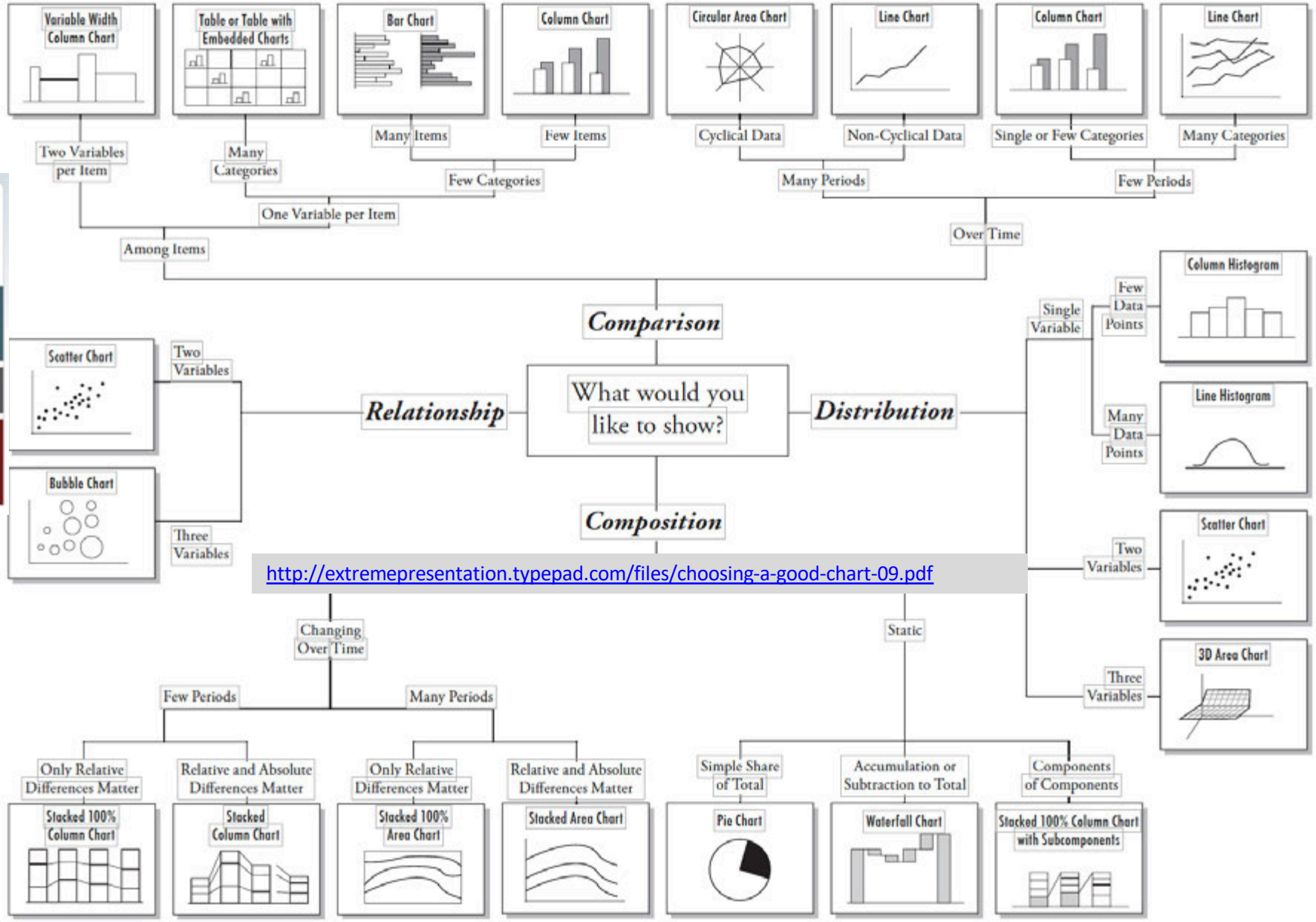


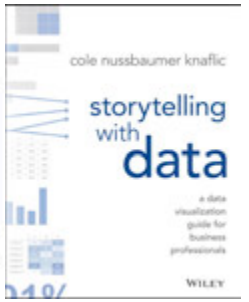
C

D

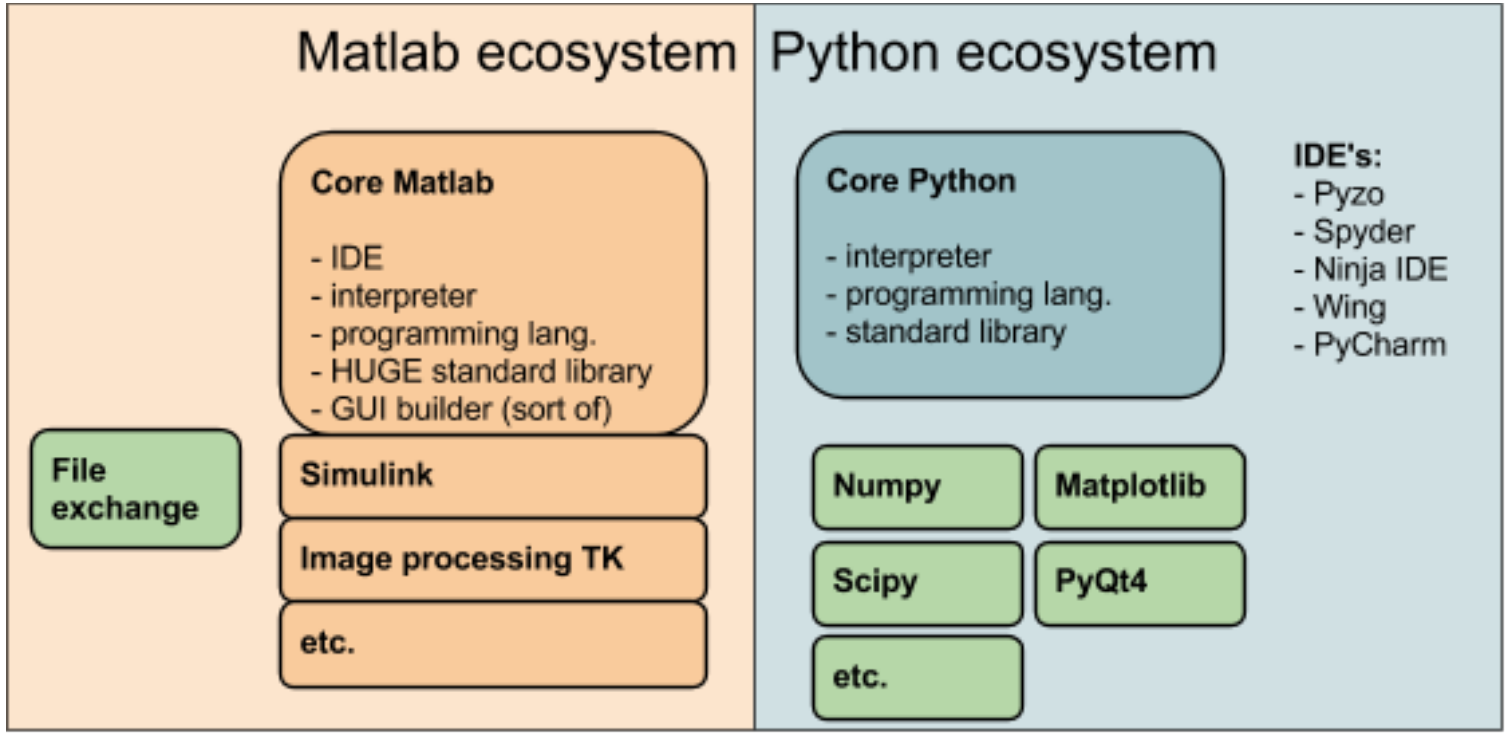
http://labs.juiceanalytics.com/chartchooser/index.html



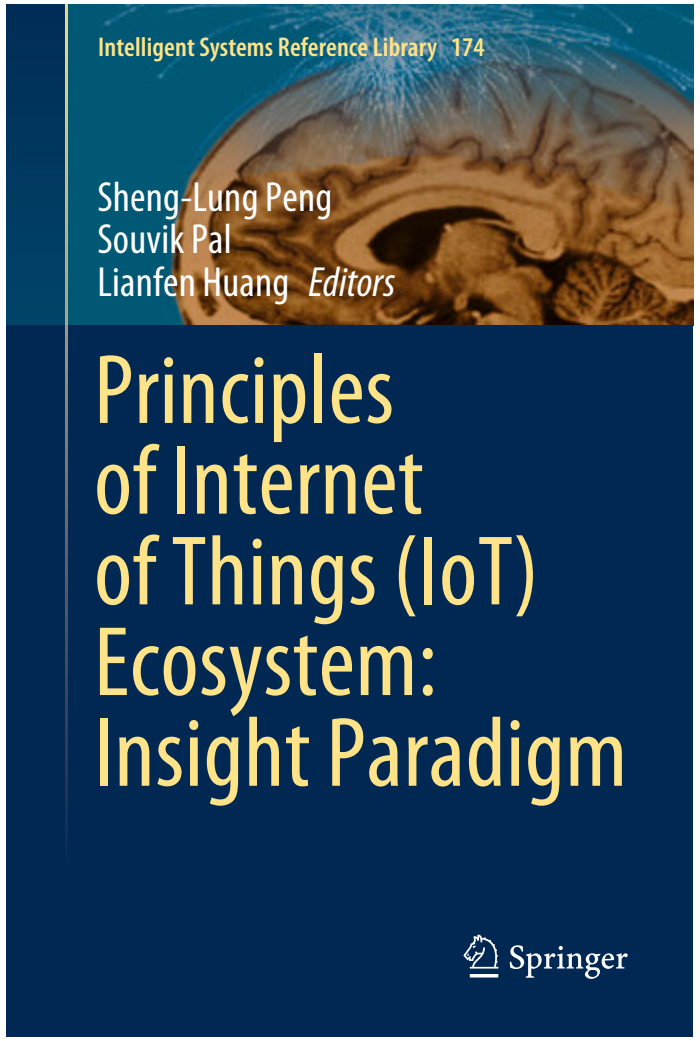


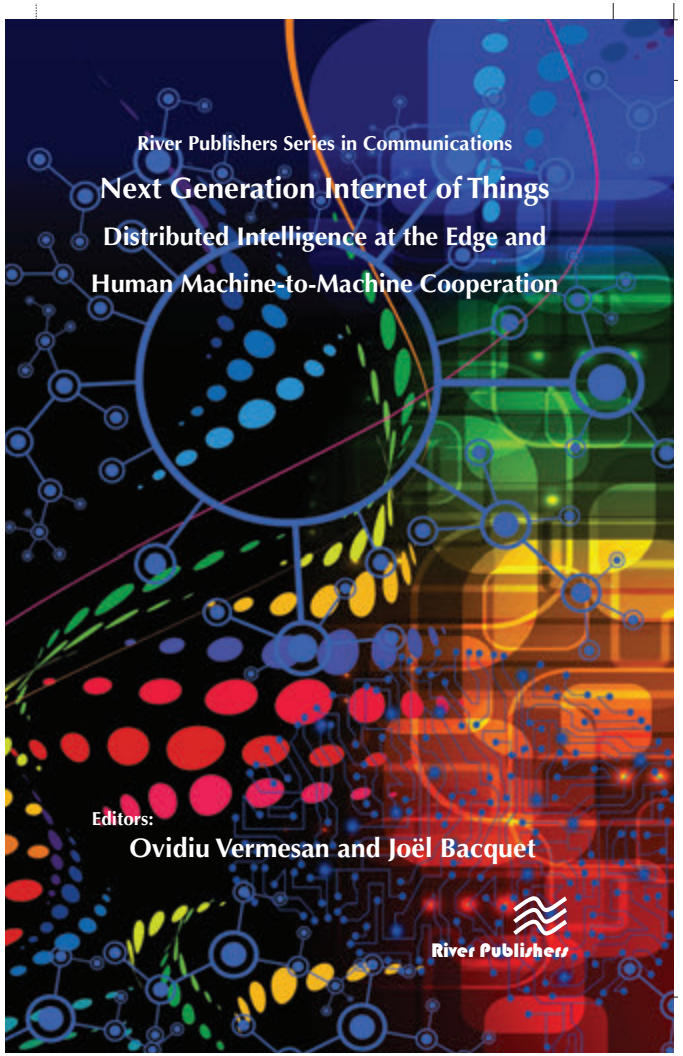


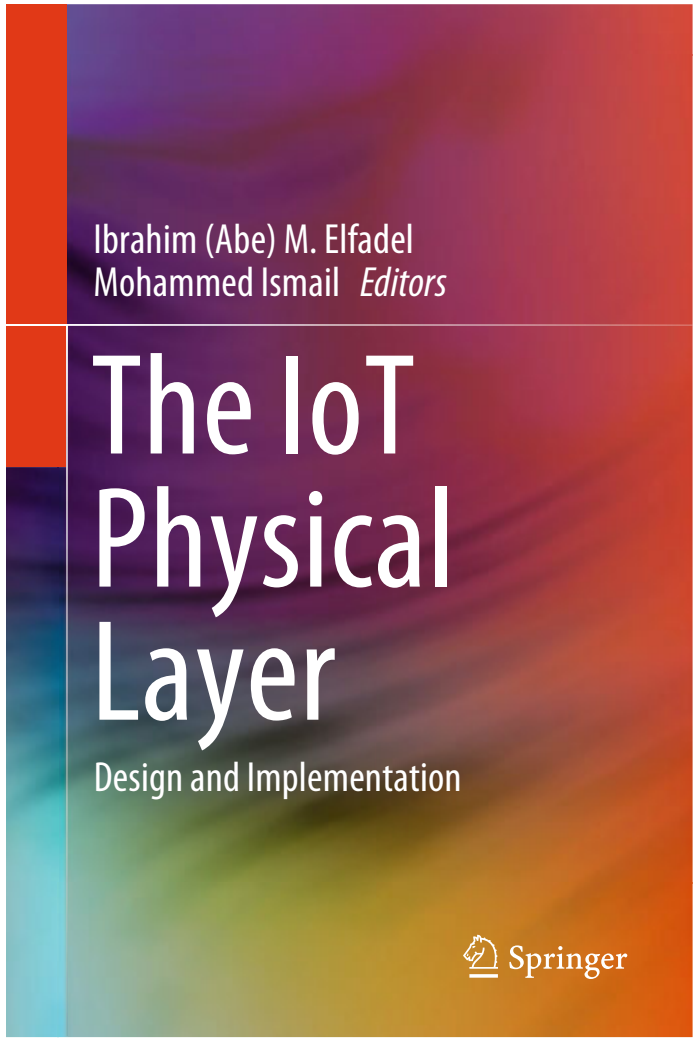
Tools to Organize/Structure Data to allow for Data-analysis



https://pyzo.org/python_vs_matlab.html


Intelligent Systems Reference Library 174
Sheng-Lung Peng
Souvik Pal
Lianfen Huang Editors
Principles of Internet of Things (IoT) Ecosystem: Insight Paradigm
Springer


River Publishers Series in Communications
Next Generation Internet of Things
Distributed Intelligence at the Edge and
Human Machine-to-Machine Cooperation
Editors:
Ovidiu Vermesan and Joël Bacquet
River Publishers


Ibrahim (Abe) M. Elfadel
Mohammed Ismail Editors
The IoT Physical Layer
Design and Implementation
Springer

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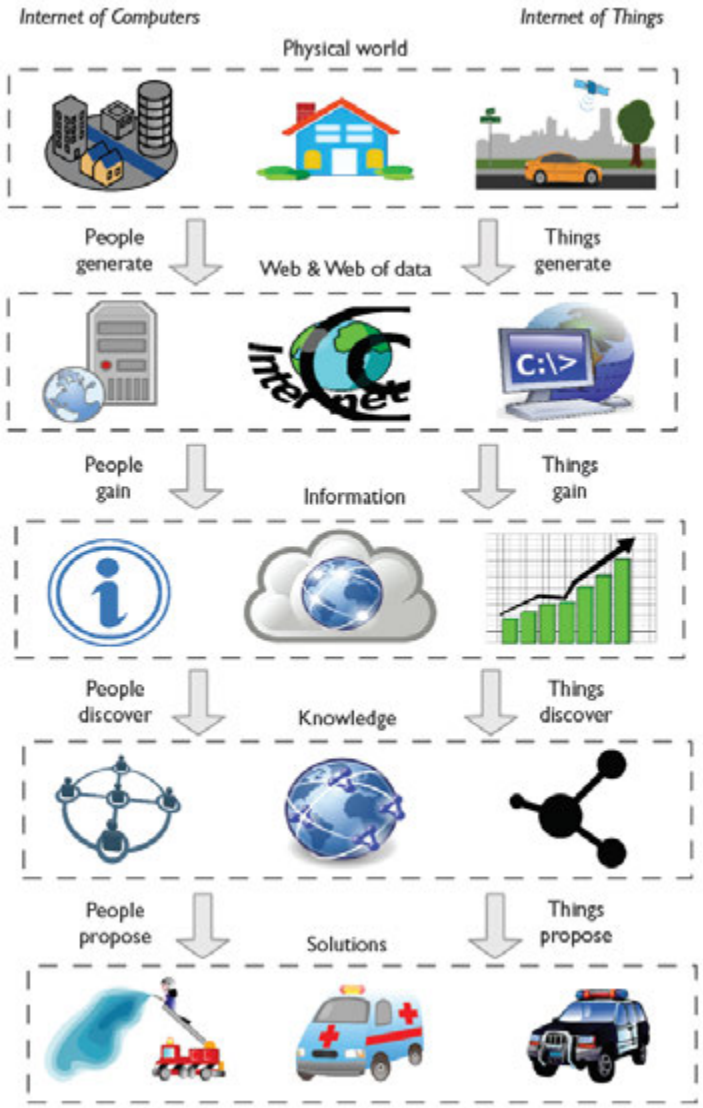
IoT Core-Concepts

World Wide Web (WWW) vs IoT

WWW:
In the Internet of Computers (WWW), the main data producers and consumers are human beings.

IoT:
The main actors become things, where things are the majority of data producers and consumers.

Qin, Y., Sheng, Q. Z., & Curry, E. (2015). Matching over linked data streams in the internet of things. *IEEE Internet Computing*, *19*(3), 21-27.



IoT Core Concepts

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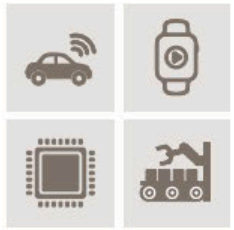
Devices

- Sensors
- Actuators
- Machines



Connectivity

- Network
- Protocol
- Security

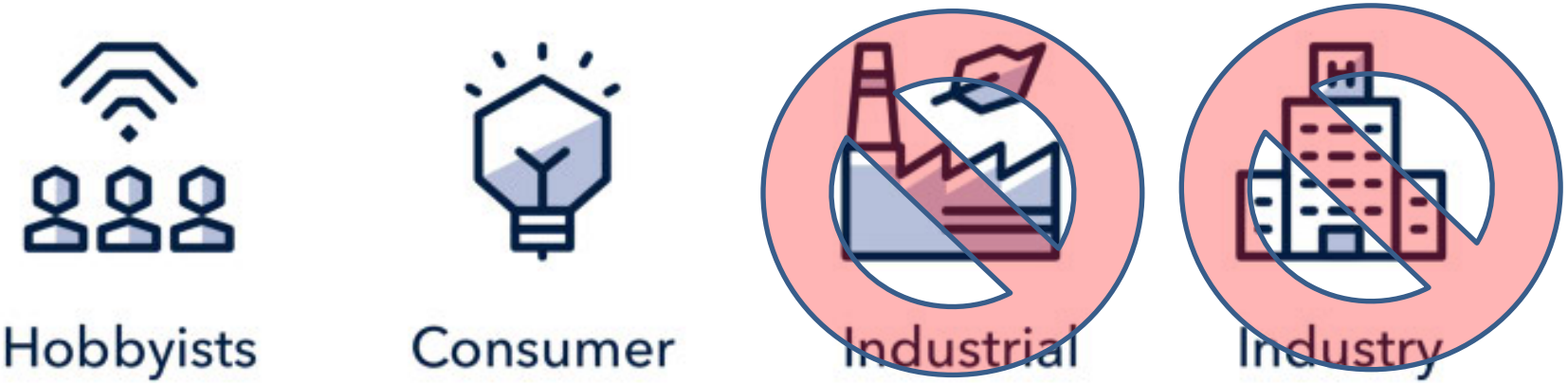
Business Model

- Outcome driven
- Product as a service
- Leverage existing investment

Platform

- Storage
- Analytics
- Visualization
- Integration

IoT Platform + User-Types



The Internet of Things is a state where the things on the face of the earth connect to the internet and start talking to each other. Things here can be electronic, electrical, mechanical, or electro-mechanical objects.

The number of connected things is projected to grow at an annual compound rate of 23.1% between 2014 to 2020, reaching 50.1 billion things in 2020. [1]

IoT Platforms == MiddleWare

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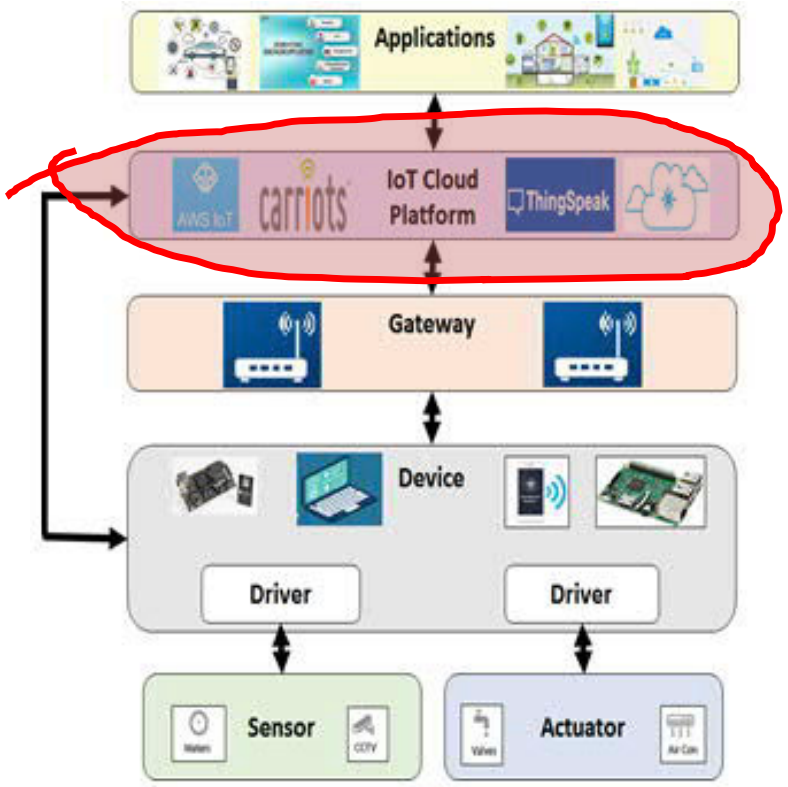

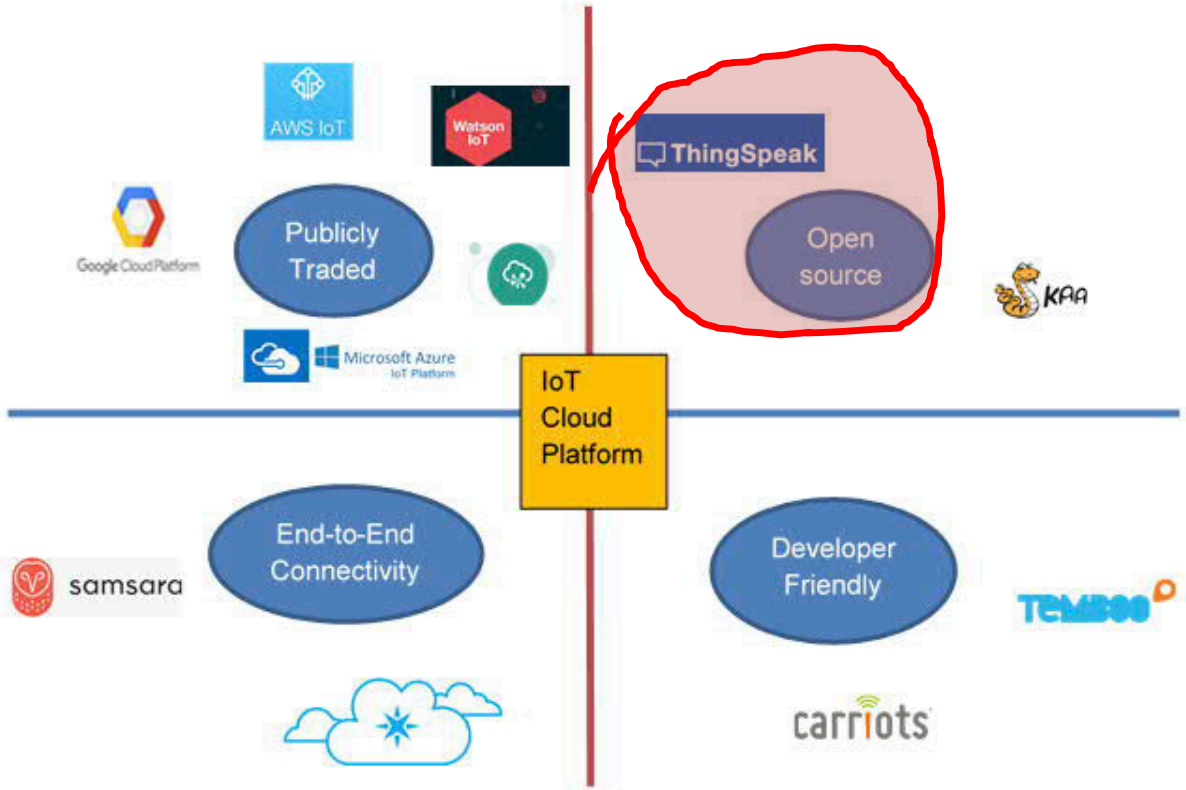

http://www.thetips4you.com/iot-best-open-source-applications-open-source-industrial-iot-platform

Technologies enabling IoT

WIRELESS TECHNOLOGIES

802.11, 802.15.4, Zigbee, Bluetooth, BLE, CDMA, GSM, LTE

NETWORK TECHNOLOGIES

Ethernet, CAN, rs485/rs422/rs232, 1-wire, i2c, SPI, ModBus/MudBusRTU, IPMI, iSCSI

WEB SERVICE TECHNOLOGIES

SOAP, REST, WSDL, XML, JSON, UDDI, WebSockets

TCP/IP PROTOCOLS

Sockets, IPv4, IPv6, TCP, UDP, ICMP, QOS, SNMP, IMAP, POP3, IPMI, etc.

MOBILE TECHNOLOGIES

Android SDK, Qt, iOS SDK, Objective C, Java, Swift

PROTOCOL TECHNOLOGIES

HTTP, JMS, AMQP, D-Bus

AUTHORIZATION & AUTHENTICATION TECHNOLOGIES

Oauth2, PAM, LDAP

PLATFORMS AND CPU ARCHITECTURES

ARM, X86, PowerPC, AVR, PIC

PROGRAM / SCRIPTING LANGUAGES

Java, C/C++, C#, JavaScript, Ruby, Groovy, Python, Tcl/Tk, ASM, Bash

https://doi.org/10.15779/Z38WW0V

https://doi.org/10.1016/j.eswa.2019.05.014

IoT-device communication protocols

Protocol Name	Transport Protocol	Messaging Model	Security	Best-Use Cases	Architecture
AMPQ	TCP	Publish/Subscribe	High-Optional	Enterprise integration	P2P
CoAP	UDP	Request/Response	Medium-Optional	Utility field	Tree
DDS	UDP	Publish/Subscribe and Request/Response	High-Optional	Military	Bus
MQTT	TCP	Publish/Subscribe and Request/Response	Medium-Optional	IoT messaging	Tree
UPnP	—	Publish/Subscribe and Request/Response	None	Consumer	P2P
XMPP	TCP	Publish/Subscribe and Request/Response	High-Compulsory	Remote management	Client server
ZeroMQ	UDP	Publish/Subscribe and Request/Response	High-Optional	CERN	P2P

IoT communication Protocols

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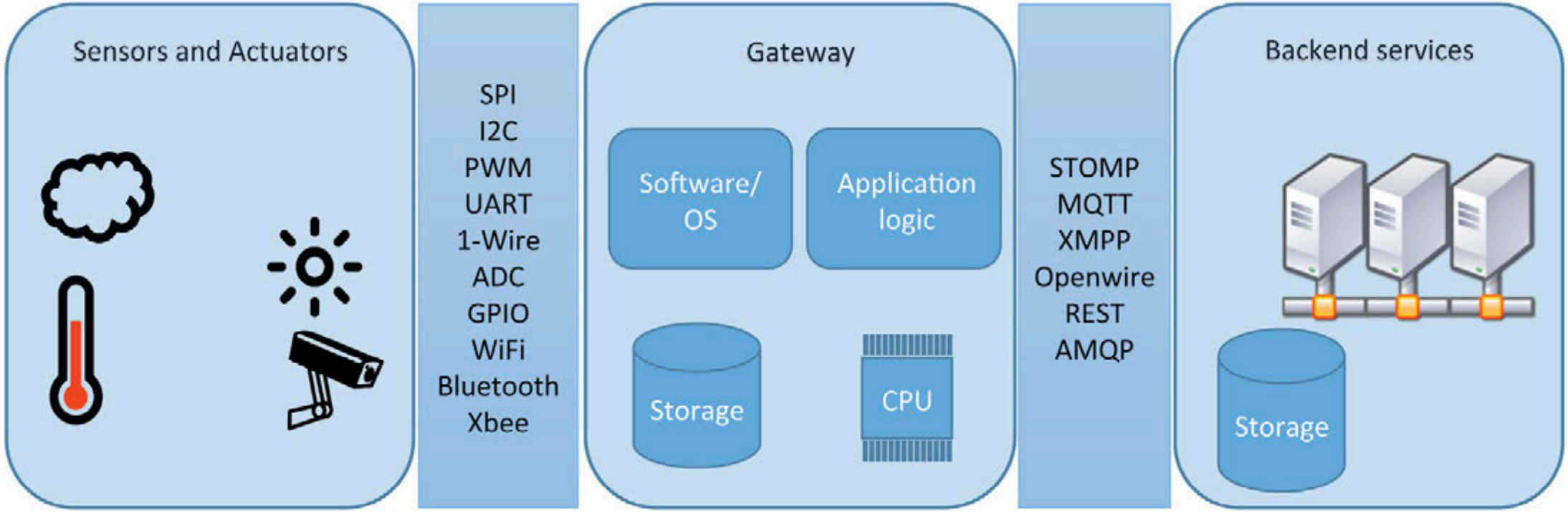
Publisher ***Broker***



SENSOR TO GATEWAY COMMUNICATION

IoT Communication

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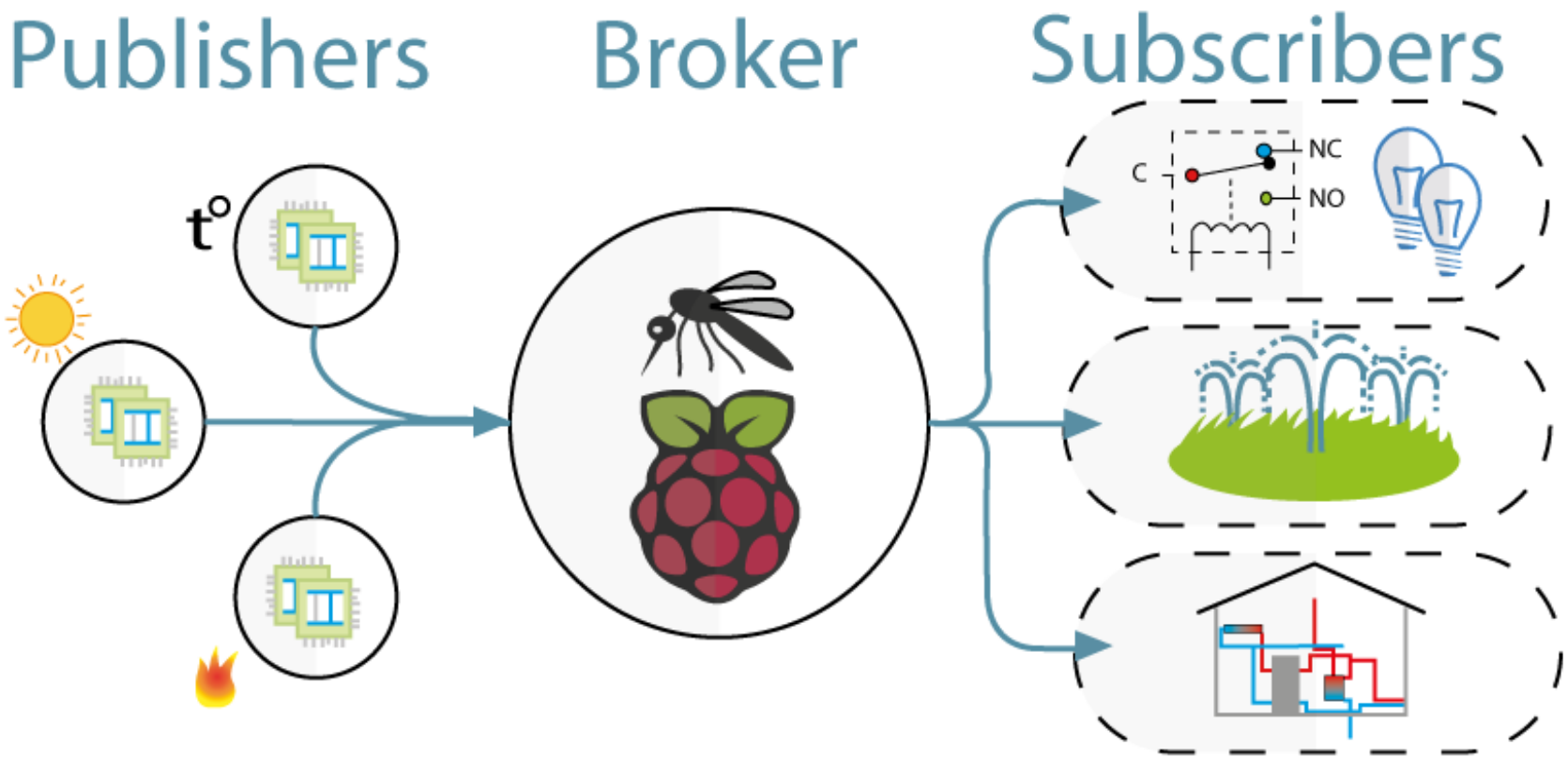
The Broker. The broker acts as a gateway; it receives messages from a publisher (a client) and delivers the messages to a subscriber (another client). Brokers are sometimes referred to as *servers*.

The Subscriber. The subscriber declares its topics of interest to the broker, and the broker sends messages published to those topics.

The Publisher. The publisher sends messages to the broker using a name- space or a topic name, and the broker forwards the messages to the respective subscribers.



https://raspberry-valley.azurewebsites.net/Mosquitto/

Setting Up Your IoT Device

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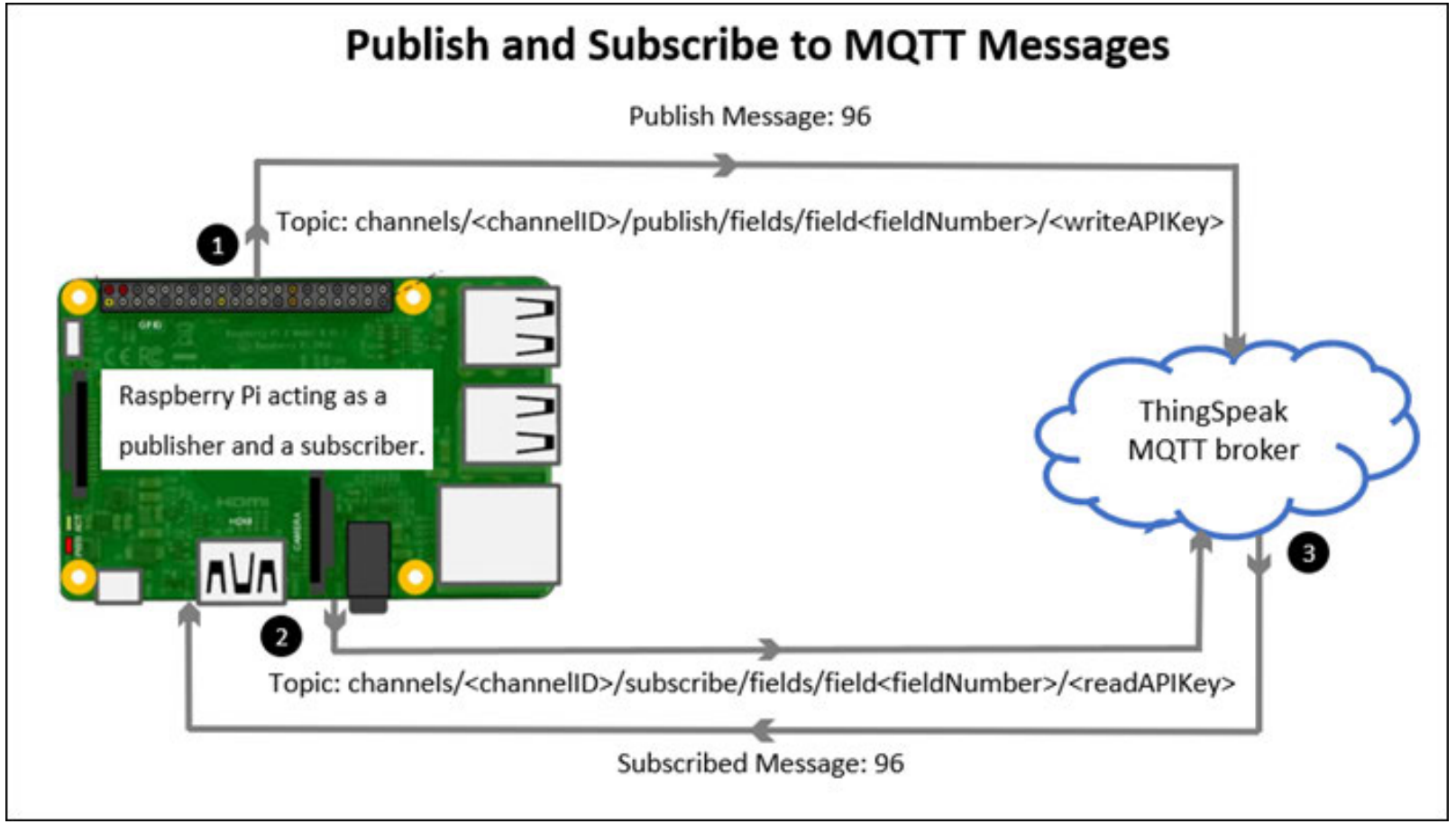
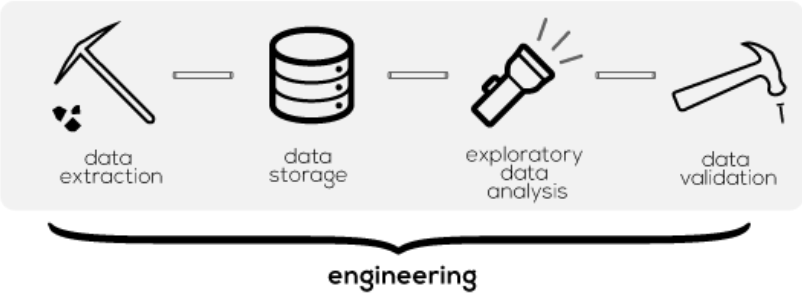
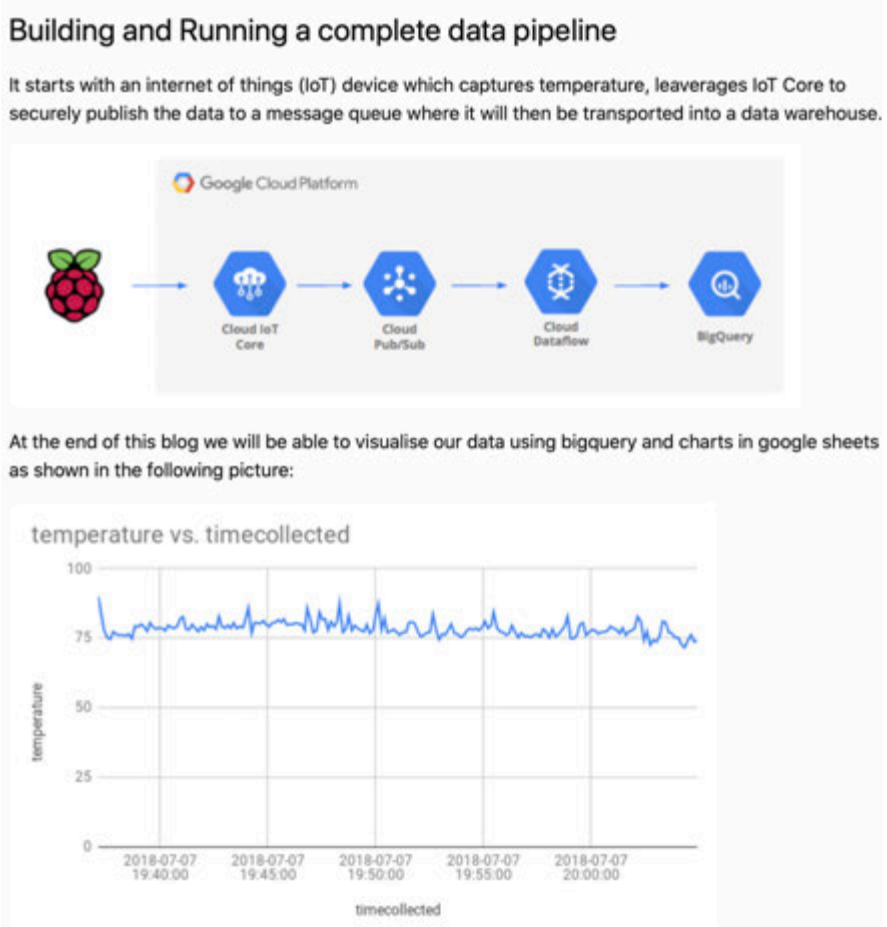
{IoT device == micro-controller== Rasperry Pi}



Engineering a IoT Data Pipeline



https://alexpetralia.com/posts/2016/6/22/the-data-pipeline-part-2



https://uplua.github.io/jekyll/update/2019/06/23/Fourth-Week_report.html

Engineering a IoT Data Pipeline

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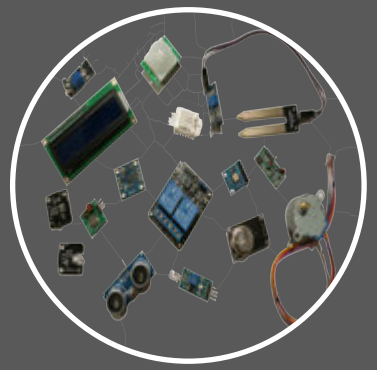
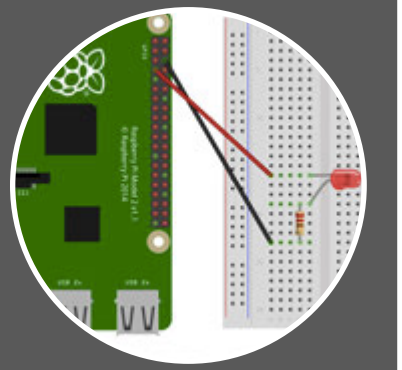


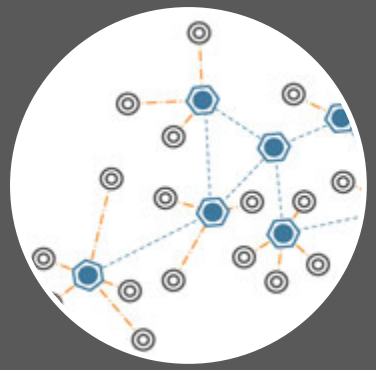
Sensors &

Actuators



Micro-Processors/ Controllers

(Development Boards)



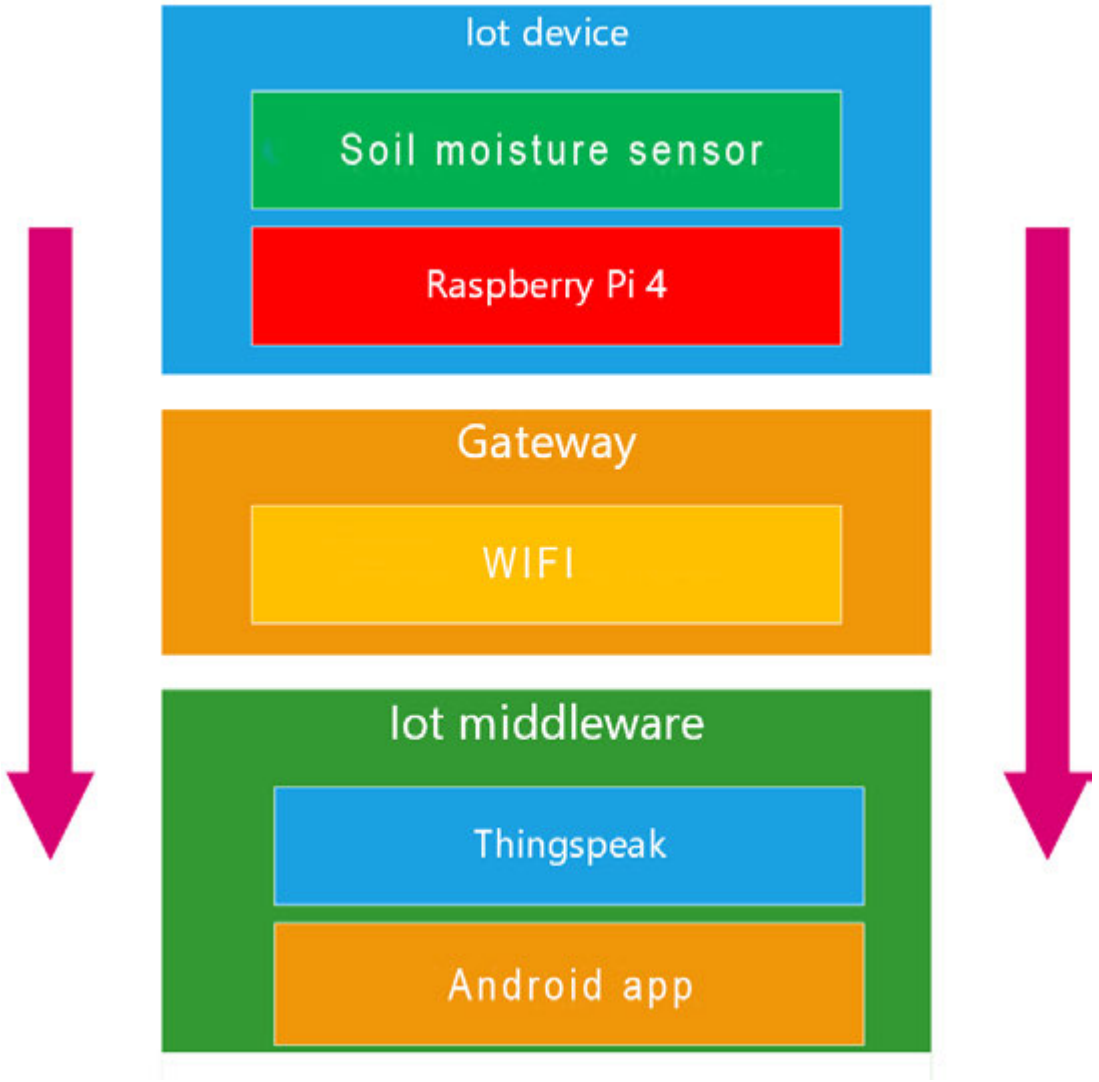
Network / Protocols

Platforms,

Cloud &

Data Analytics

Engineering a IoT Data Pipeline



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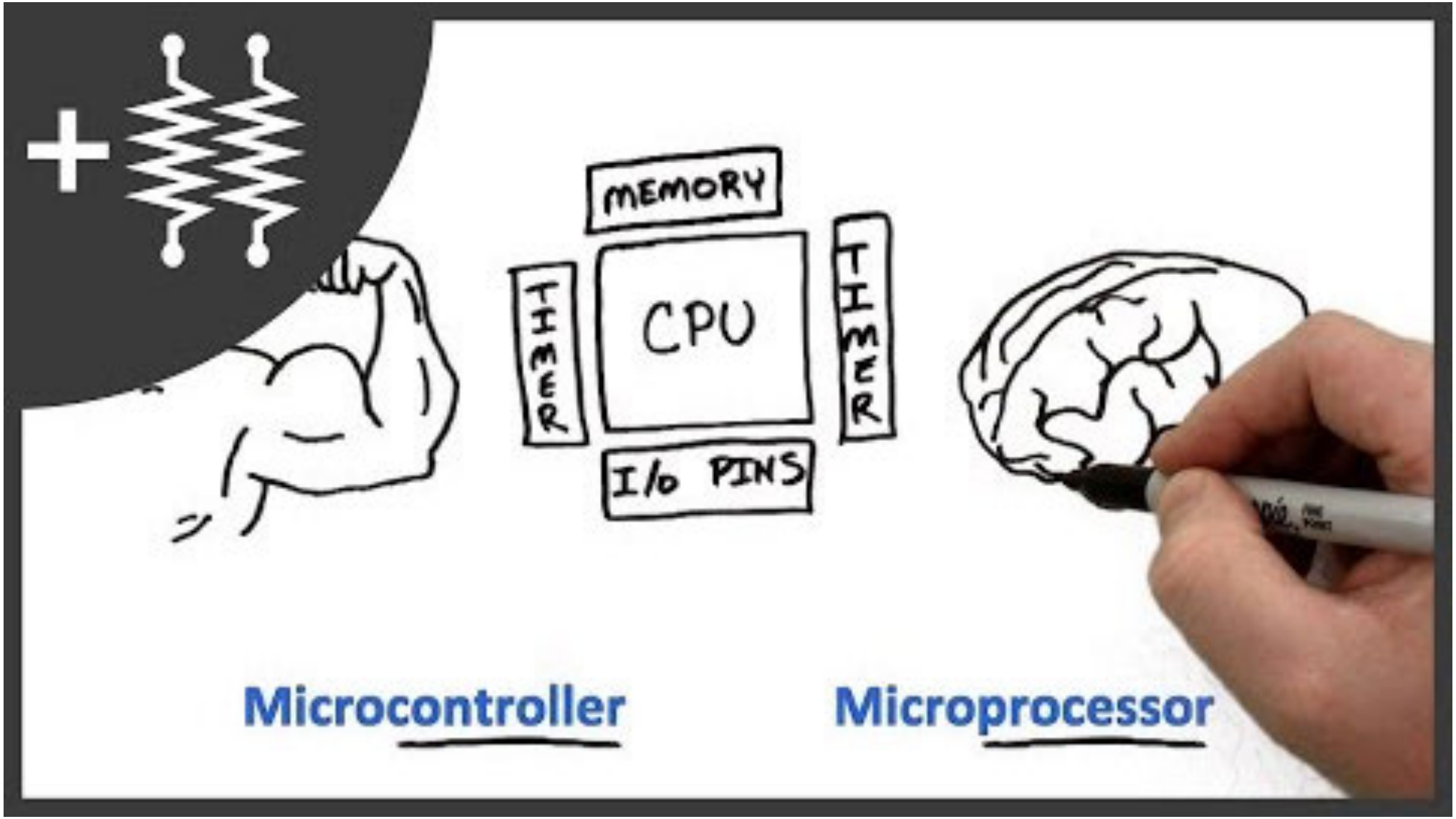
Micro-controller/processor Core-Concepts



https://www.youtube.com/watch?v=7vhvnaWUZjE

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Microprocessor	Microcontroller
Only CPU; other peripherals are interfaced via the CPU bus	CPU + (Flash) Memory + RAM + ROM + I/O + Timers + UARTS + ADC + DAC and so on on a single chip
General purpose	Single purpose
High processing power	Low processing power
Power hungry	Can work on a battery

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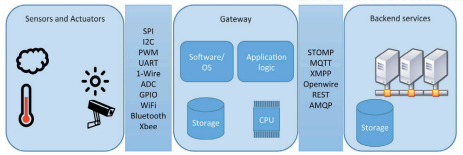
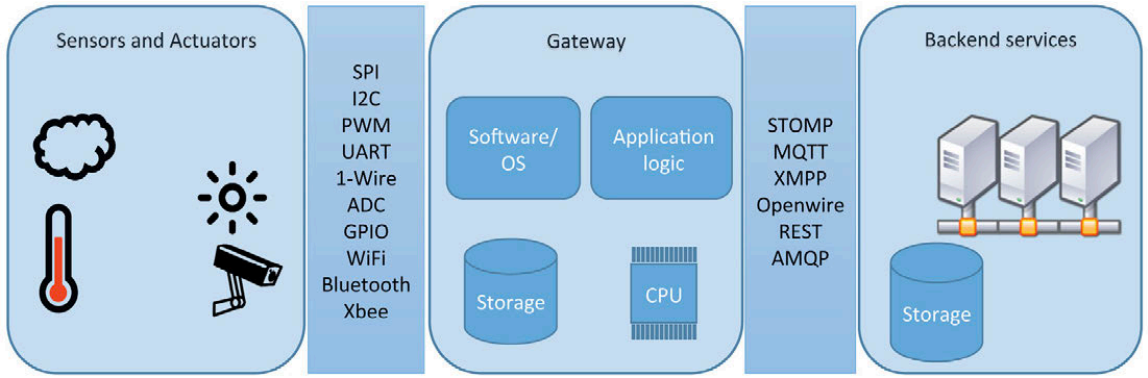
Sensor / Actuator Core-Concepts

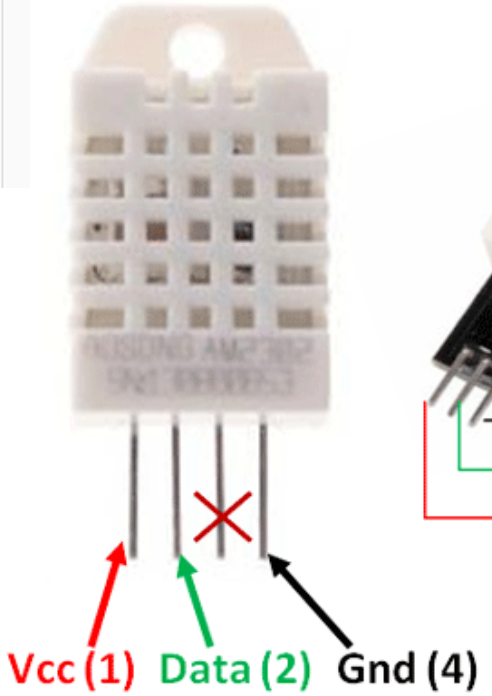
(connecting) SENSORS

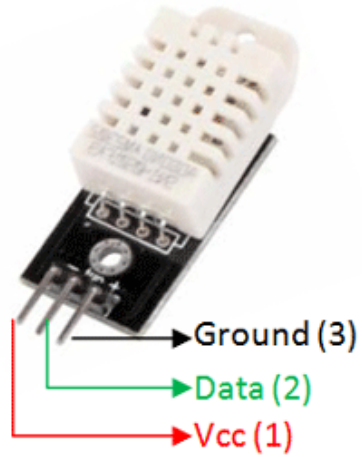
Sensor	Interface	Processor/Hardware	Power
Wind vane	Analog	Switched resistors	—
Anemometer	GPIO interrupt	Reed switch	—
Rain gauge	GPIO interrupt	Reed switch	—
UV intensity	Analog	ML8511	1,000 µW
Humidity and temperature	2-wire serial	SHT15	80 µW
Barometric pressure	I^2C	BMP180	30 µW
Luminosity	I^2C	TSL2561	720 µW
Lightning sensor	SPI + GPIO interrupt	AS3935	100 µW
Geiger counter	RS-235	LND712	147,000 µW
Weather board	I^2C	Si7020	540 µW
Weather board	I^2C	BMP180	30 µW
Weather board	I^2C	Si1132	1,419 µW



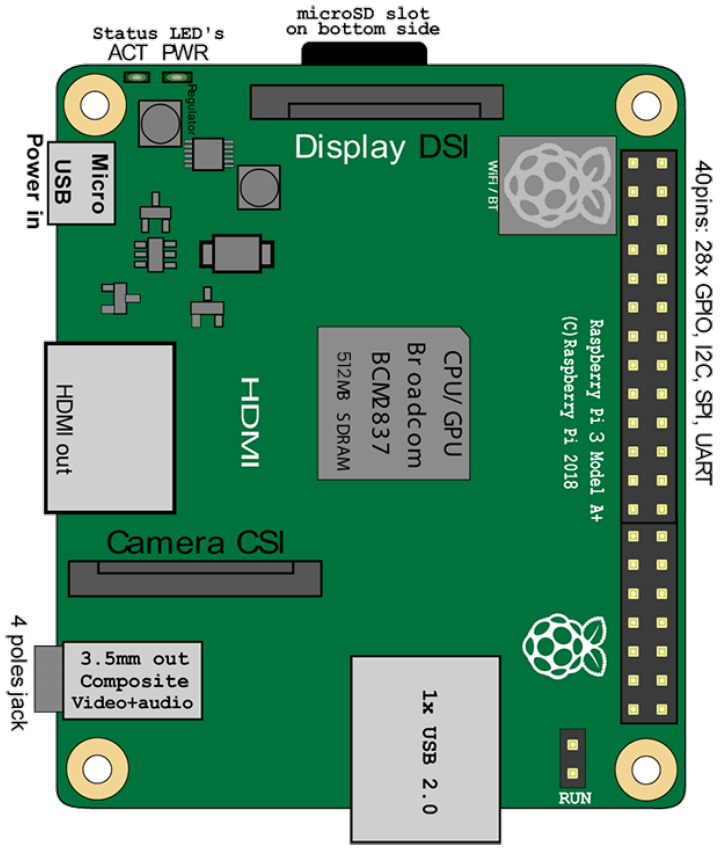
Sensor name	Datasheet link
Temperature and humidity sensor (DHT11)	https://akizukidenshi.com/download/ds/aosong/DHT11.pdf

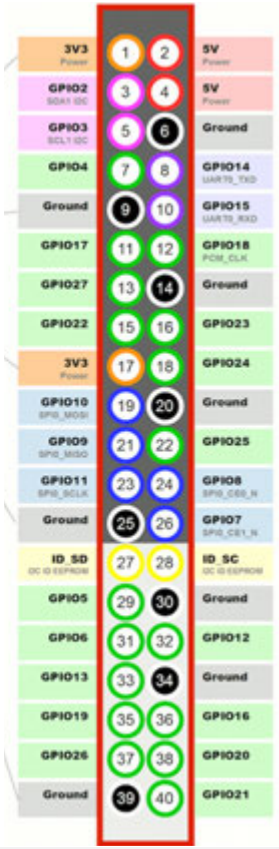






Raspberry Py 3A+





GPIO schematics of the Raspberry Pi 3 A Plus hardware.

Shown als are general positioning of all the vital circuitry on the board.
The Raspberry Pi 3 A+ is a cut down version of the Pi 3B. As you can tell by its diagram, it features a single USB 2.0 Port. It's only means of network connectivity is the inbuilt Wi-Fi.

CPU: 1.4 GHz quad core ARM Cortex-A53
GPU: 250MHz Broadcom VideoCore IV
RAM: 512mb (Shared with GPU)
Storage: Micro SD
USB 2.0 Ports: 1
USB 3.0 Ports: 0
Networking: 802.11b/g/n/ac dual band 2.4/5 GHz wireless, Bluetooth 4.2 LS BLE
Video Input: 15-pin MIPI camera interface (CSI) connector
Video Ouputs: HDMI 1.3, MIPI display interface, DSI
Audio Inputs: Audio over I2S
Audio Outputs: 3.5mm phone jack, Digital Audio via HDMI
Low-Level peripherals: 17 x GPIO, +3.3v, +5v, ground, Plus the following that can be used as GPIO: UART, I2C Bus, SPI bus with two chip select, I2S audio
Power Source: 5v via MicroUSB or GPIO header
Size: 65.00mm x 56.50mm x 17mm
Weight: 23 g (0.81 oz)

Raspberry Pi Sensor to ThingsBoard using Constrained Application Protocol

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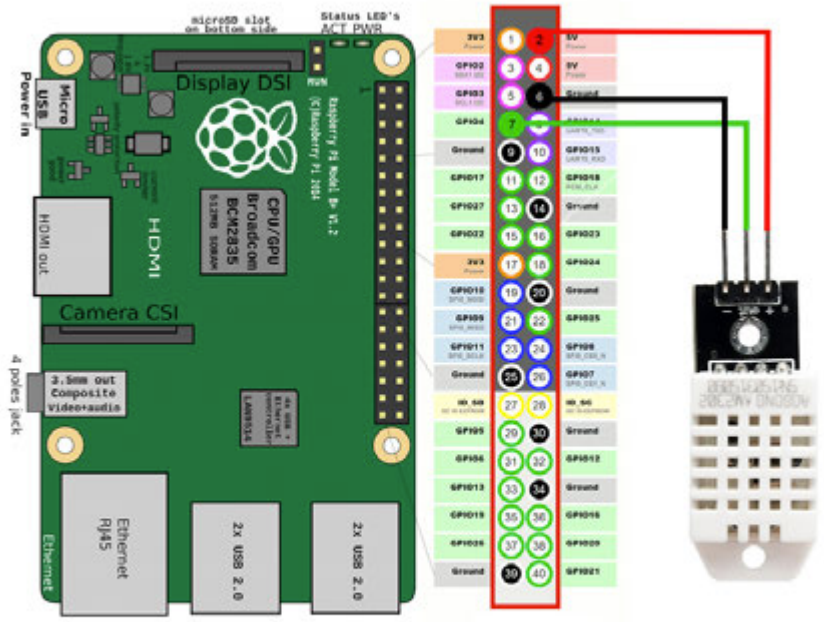
Installation

Connecting the sensor



To connect the DHT22 sensor to the RPi:

1. Connect the `-` output on the sensor the pin 6 on the RPi.
2. Connect the `+` input on the sensor to pin 2 on the RPi.
3. Connect the `output` pin on the sensor to pin 7 on the RPi.

https://github.com/Silver292/rpi-coap

Introduction

This script is designed to be run on Raspberry Pi 3 hardware running the Raspbian 9.6 operating system.
It is also assumed that a DHT22 temperature and humidity sensor is connected to the Raspberry Pi (RPi) using GPIO 4 pin.
The process of connecting the sensor is described here.

The script creates a Constrained Application Protocol (CoAP) client on the RPi and repeatedly polls the attached DHT22 sensor for temperature and humidity data.

This data is then formatted to JavaScript Object Notation (JSON) and is sent to a CoAP endpoint provided by the ThingsBoard Cloud Platform.

This data is then displayed on the ThingsBoard dashboard that shows the current temperature and humidity as well as historical readings in a graph form.

ACTUATORS

An actuator is a component of a machine that is responsible for moving or controlling a mechanism or system. An actuator requires a control signal and a source of energy.

The control signal is relatively low energy and may be electric voltage or current, pneumatic or hydraulic pressure, or even human power.

ACTUATORS

Actuators

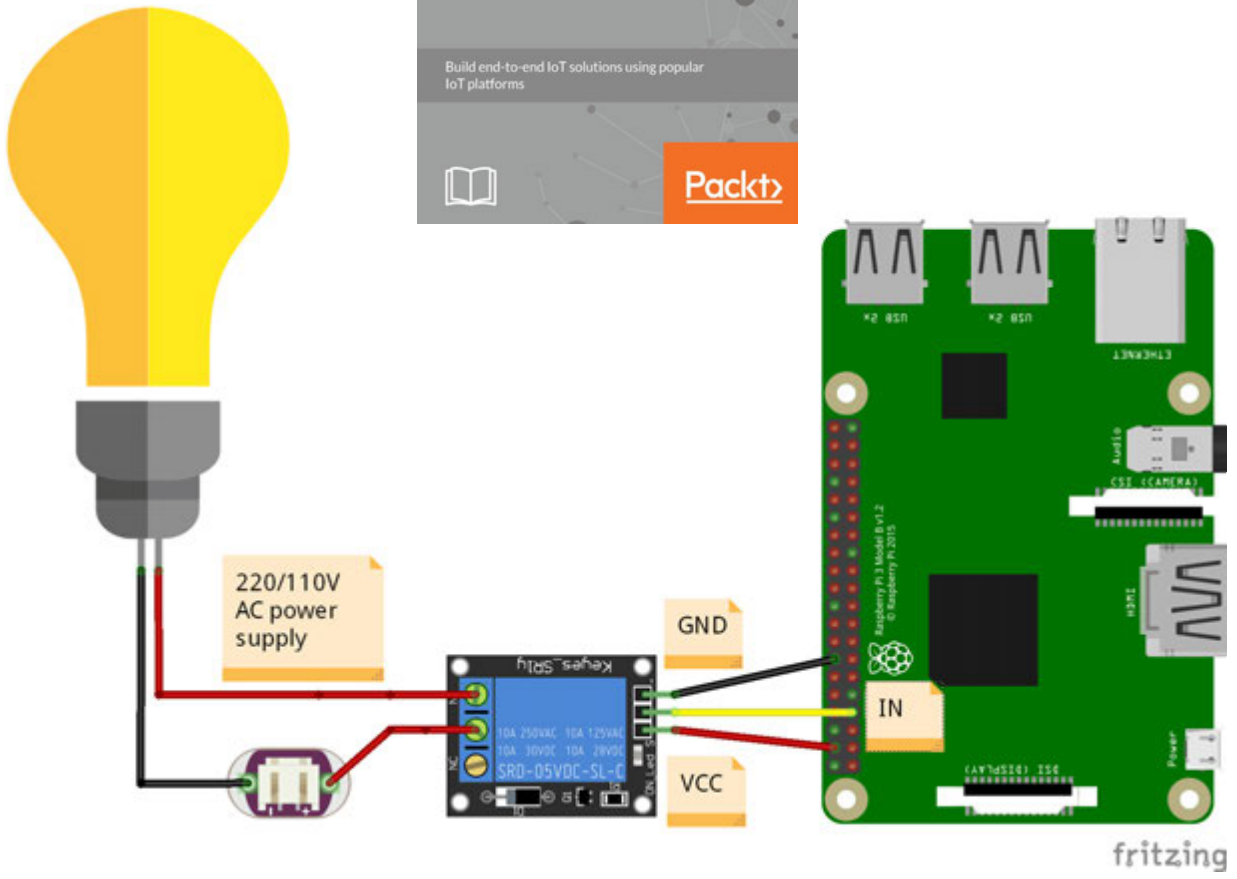
While sensors sense the environment around them, an actuator is responsible for controlling a system by actuating (open/close or on/off). For example, a switch that can be used to turn a light on or off can be controlled via an actuator.

An actuator generally takes a signal which indicates the nature of an operation. For example, if we need to turn a switch on or off, we use a relay.

A relay is an electromagnetic switch that takes in the AC mains power supply at one end and a digital signal at other. The general state of the relay is open and that means there is no power supply flowing through from the mains to our load. Once there is a digital high or a digital low signal (depending on the type of relay), the relay moves to a closed state where the load and mains are short and the power flows through.

To get a better understanding of how a relay works and how to use it, take a look at *How to use a relay, the easy way*: https://www.youtube.com/watch?v=T1fNQjelojs.

A relay is one of several core actuator components, which are then reused in other actuators such as a solenoid valve.



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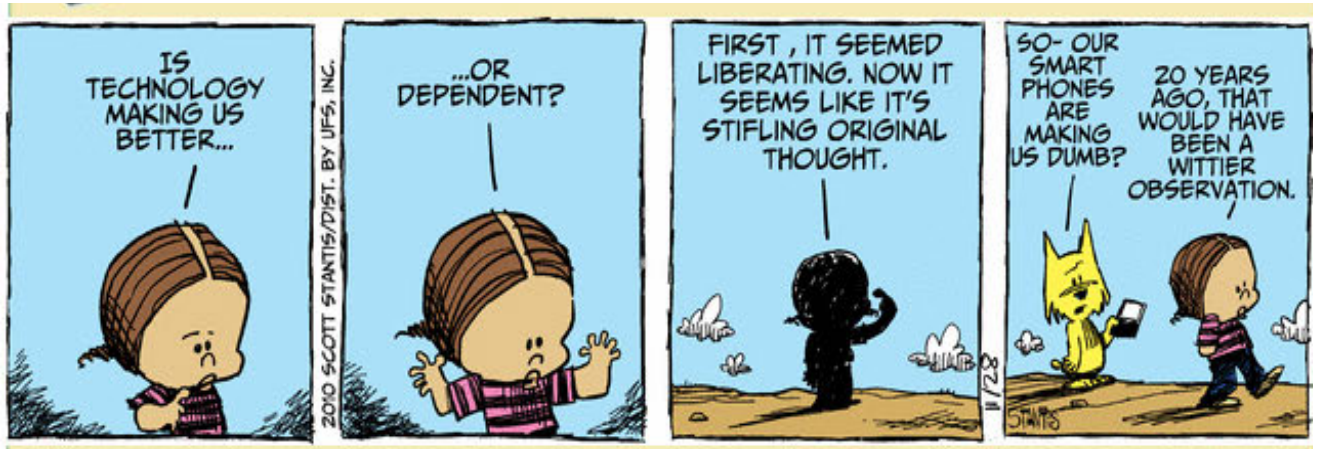

This lesson was developed by:
Rob van der Willigen
CMD, Hogeschool Rotterdam
NOV 2021

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Grading

Data Science for IoT

A hands-on introductory course exploring the Internet of Things form a Data Science point of view.

OPDRACHT OMSCHRIJVING

Learning Objective

1. Prepare a (Rapid) prototype for an Internet of Things (IoT) data-pipeline scenario
2. Become familiar with Data Science concepts surrounding IoT applications by building them
3. Learn to design and develop simple lightweight IoTprototypes
4. Learn to report on IoT prototypes & data-pipelines

Choosing IoT data-pipeline scenario

The objective is to choose a topic you care deeply about. A subject or theme that's genuinely interesting to you is of essence to succeed and learn the most. Keepin mind that it should be reasonably well scoped

→→something small, discrete and easy to implement ←←.
Identify a small solvable problem that illustrate your key idea.
Keep it constrained but conceptually interesting.
The lectures outline the scope of Data Science for IoT and relevant literature.

Deliverables:

The course requires the following to be delivered:

- A working prototype that includes software (code), hardware and electronics elements. Code (commented) for the application
- Documentation of the project (contributed to a personal GitHub Repository).
- An online demo (video or IoT Platform implementation) of the completed IoT data-pipeline/project.

Data Science for IoT

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OPDRACHT OPLEVERING

Submitting your work:

You'll submit your work to the HR LMS as follows:

Documentation should be accessible a personal GitHub Repository summited in the format of a text file (.txt) containing the URL to your Repository to the lms.hr.nl **INLEVER_MAP_OP2 (vakcode: CMIDAT01K | 2020-2021)**

You should document your IoT data-pipeline comprehensively, including:

- ❑ Add/upload code and any supporting documentation and files to your GitHub Repository. Describe the concept and goals (include video or diagrams if needed.)
- ❑ Describe relevant prior projects, approaches or methods you researched that inspired the project. Be thorough and show what informed the project.
- ❑ Process Outline you underwent to reach the outcome (experiments, hacks, tests, refinements, iterations, failures). Describe the realized outcome and how it works.
- ❑ Include supporting images, a video of the working prototype, circuit diagrams, etc. Outline next steps and future directions.

Data Science for IoT

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Grading

BEOORDELING

Take note:

Main goal is to come up with a compelling IoT data-pipeline scenario.

Provide evidence for a working prototype as proof-of-concept.

A strong grade will result by create interesting, well-crafted and well documented IoT prototype + data-pipeline. As such, each data driven IoT prototype will be graded as follows:

20%	**Approach and Topic** Merit, creativity, and context for the outcome/proposal
40%	**Proof-of-Concept Documentation** Well illustrated with appropriate use of code, video, diagrams, repeatability, etc.
30%	**Technical Implementation** Quality of data + Executability of Electronics & Code
10%	**Process** Description and Narration of the Process (ideation, iteration, etc.) and personal/critical reflection on the realized learning objectives.

Anote on documentation:

Each Repository has to be accompanied with a written description.
This is a starting point for your exploration.
Everyone is encouraged to use Jupiter Notebooks.

Data Science for IoT

A hands-on introductory course exploring the Internet of Things form a Data Science point of view.

CIJFER

Grading Rubric (Part1)

Merit - Approach and Topic:

How interesting is the IoT concept? Does it represent a data pipeline approach, or an original perspective, based on Data Science principles? Does it deviate from known or standard approaches? Does it use materials or code in aninnovative way?

0: incomplete: does not satisfy brief and no originality or creativity demonstrated (e.g. direct replication of prior approach without extension)

1: passing: satisfies minimum requirements of the brief and/or a minor increment over existing work (extension/adaptation of a precedent)

2: good: shows engagement, exploration and insight; uses precedents and/or materials in relatively original ways.

3: excellent: shows deep insight, and significant understanding of the problem; goes beyond the brief and demonstrates significant originality in the ideas and their application; uses precedents and/or materials in unexpected ways; surprising and delightful outcome.

Proof-of-Concept - Documentation:

Is the problem space or scenario clearly explained? How clearly are the key principles and goals of the work articulated? How informed is the work? Does it show connections to Data Science, IoT ideas & research, sensor electronics, IoT frameworks or other elements of the domain?

0: incomplete: No mention of problem space, scenario and/or does not include precedents

1: passing: satisfies requirements, provides core-functionality, is basic in operation; requires improvement

2: good: provides a thoughtful and considered introduction to the work with limited references and limited analysis of past work

3: excellent: provides a thoughtful and considered introduction to the work and supports the context with relevant references and critical analysis of past work.

Data Science for IoT

A hands-on introductory course exploring the Internet of Things form a Data Science point of view.

Grading Rubric (Part2)

Technical implementation - Data & Code + Sensory/Actuator Electronics:

How well implemented is the electronics, data & code? Is it well commented, well formatted, well-structured and functioning? Does it show sophisticated approaches? How well composed is it? Does it show technical skill and mastery of programming?

0: incomplete: does not work – electronics, data or code are not included or not error-free

1: passing: satisfies requirements - provides core functionality only, is basic in operation and requires improvement.

2: good: functional; provides reasonably well-structured approach; well commented; and shows technical competence.

3: excellent: provides a considered well organized, well commented and structured data implementation; and/or has implemented complex functionality beyond the brief and/or demonstrated technical skill

Process – Description & Narration:

How well authored, curated, illustrated is the documentation? Is it sufficiently detailed to repeat the outcome? Does it include a critical reflection? Does it communicate the project and its goals succinctly and effectively?

0: incomplete: documentation is missing or doesn't provide any illustration reasonably poor quality, verbose, unclear or shows other communication issues.

1: passing: satisfies minimum requirements - provides the minimum core functionality, is basic in operation and could be improved.

2: good: functional; provides reasonably well-structured approach; well commented; and shows technical competence.

3: excellent: provides a considered well organized, well commented and structured data implementation; and/or has implemented complex functionality beyond the brief and/or demonstrated technical skill

DEADLINE OPLEVERING

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Om voor beoordeling in aanmerking te komen lever je een ascii text file (.txt) aan met de link (URL) van jouw Git-Hub account met de IoT-repository.

De repository bevat een beschrijving van het IoT-Project waarin bewijzen
---zoals video-materiaal / code / design concept / data organisatie---
zijn opgenomen van op basis van de door jouw bedachte/geteste IoT data-pipeline/Prototype
zoals beschreven op https://github.com/robvdw/CMIDAT01K-DATA-SCIENCE-for-IOT

Deze text-file moet je uploaden via de LMS **INLEVER_MAP_OP2**
van de CURSUS CMIDAT01k Data Science for IoT (2020-2021).
Deadline is: 27 APRIL (vanaf 28 april kun je niet meer inleveren).

Beoordeling vindt plaats conform het beoordelingsmodel:
https://github.com/robvdw/CMIDAT01K-DATA-SCIENCE-for-IOT/blob/master/Docs/BEOORDELINGS_MODEL_DS_for_IoT_V24_npv_2020.pdf

Deze mededeling wordt als E-mail bericht wordt verstuurd (20 APRIL)
in week 10 OP3 collegejaar 2020-2021

Nota Bene! Stuur een Reply op deze E-Mail
als je voor beoordeling van de cursus: CMIDAT01k Data Science for IoT (2020-2021) **in aanmerking wilt komen.**