IS4
LESSON 6

Examples of IoT, IoT security
Artificial Intelligence of Things (AIoT),
Environments for IoT/AIoT




Outline

- IoT use case: The Pirelli **Connesso** IoT Architecture
- Security of IoT
- Artificial Intelligence Of Things (AIoT)
- Toolboxes:
  - Introduction to Matlab
  - Matlab for IoT and AIoT
    - The Arduino use case
  - Amazon AWS IoT, FreeRTOS
  - Azure ROT, and W10 IoT
- Industrial Board for AIoT

Three Types of IoT Data Sources

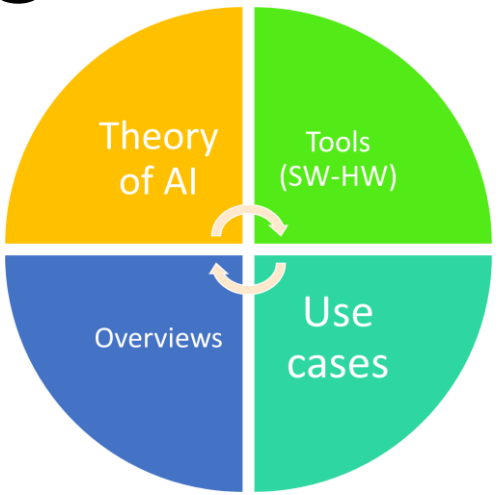
- **Passive data**
- **Active data**
- **Dynamic data**




Use cases

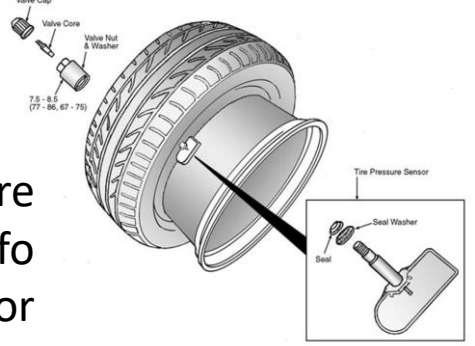
The Pirelli Connesso

From a sensor to the cloud computing



The Pirelli Connesso IoT

The tyre pressure + info sensor



PIRELLI CYBER CAR HOW DOES IT WORK

VEHICLE SETTINGS BASED UPON TYRE DATA

VEHICLE

CLOUD

END USER

NOTIFICATION MESSAGES

SENSOR INSIDE THE TYRE

TYRE DATA GATHERED

- PRESSURE
- TEMPERATURE
- TYRE ID
- VERTICAL LOAD
- TYRE WEAR
- AUTOLOCATION

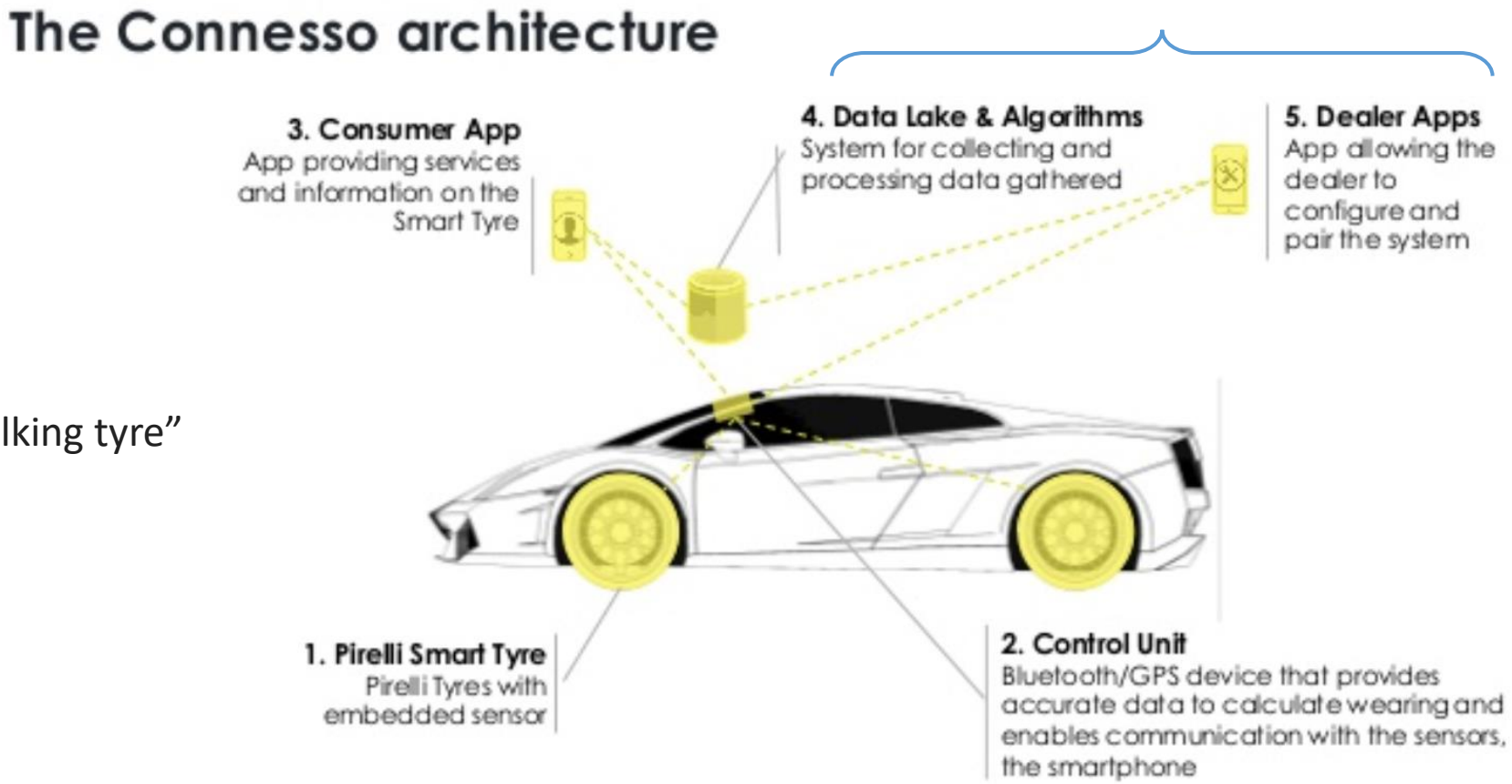
P ZERO

PIRELLI

Example of IoT application: Pirelli Zero Connesso

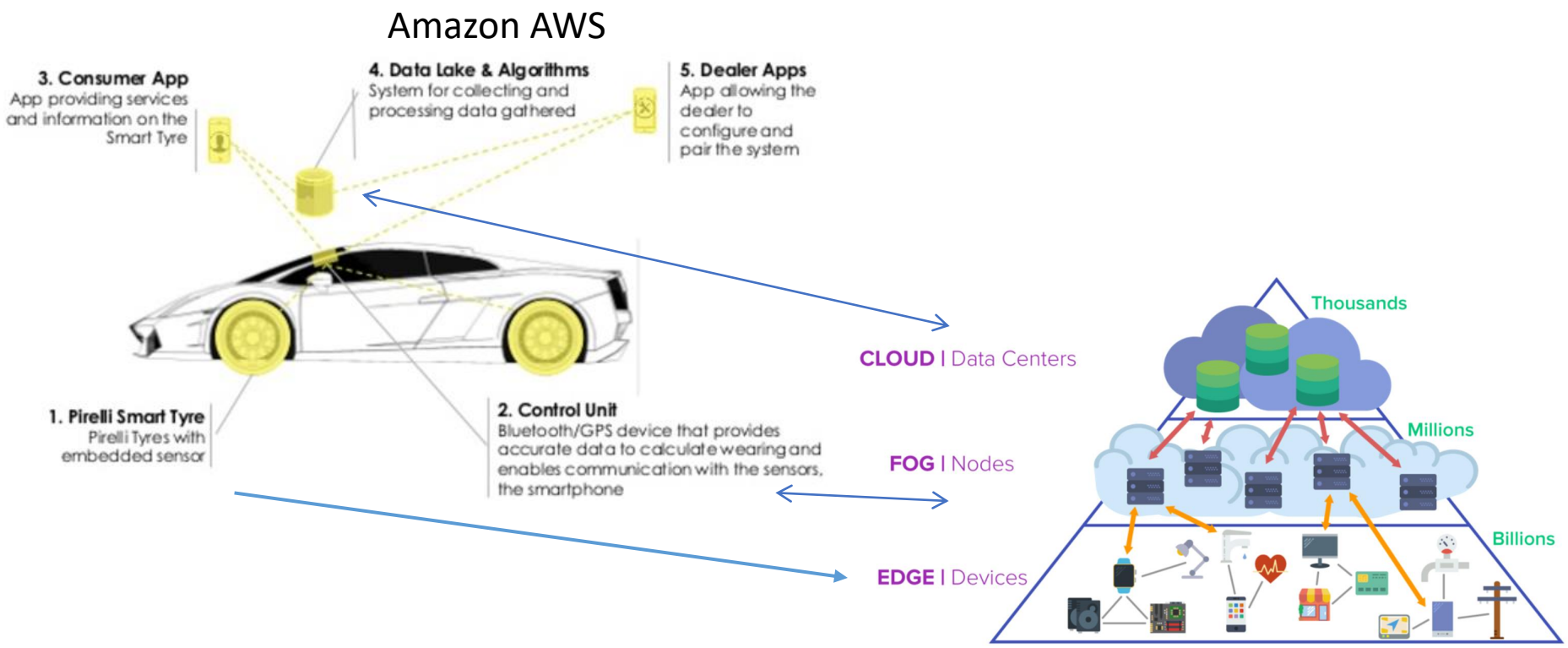
Tracking issue
Predictive maint.
R&D with users
…

Amazon AWS



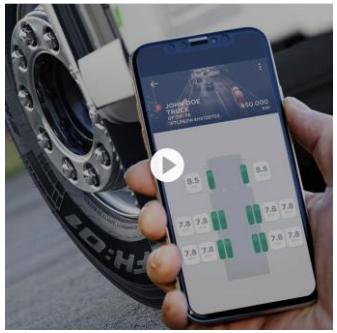
"talking tyre"

Pirelli Connesso: Edge←→Fog←→Cloud

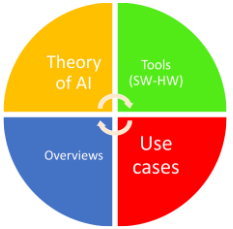


Pirelli connesso: example of business opportunities from the Intelligent Sensor Architecture

https://www.pirellicyberfleet.com/





THEORY

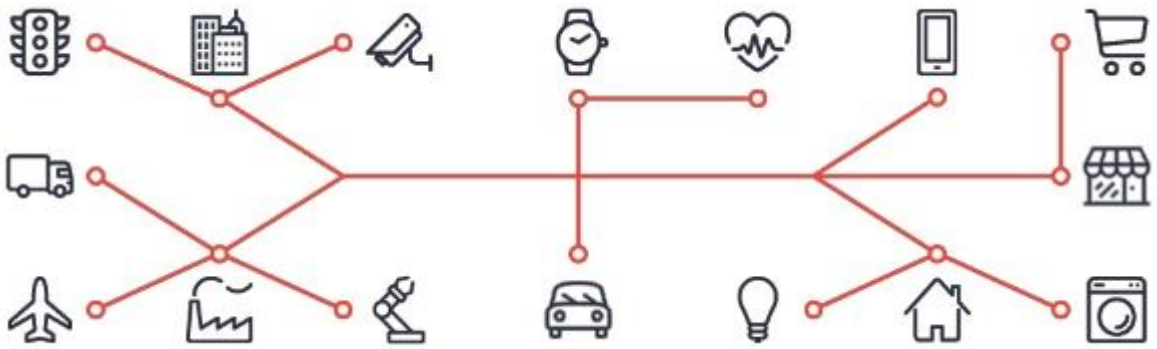
Security of IoT

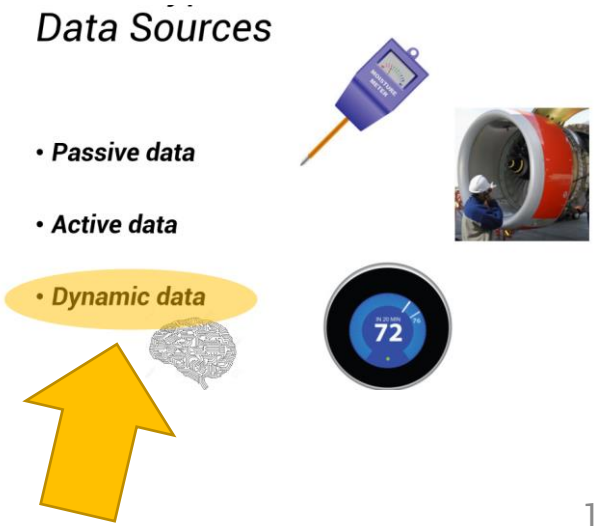
A new frontier for applications

Security of IoT

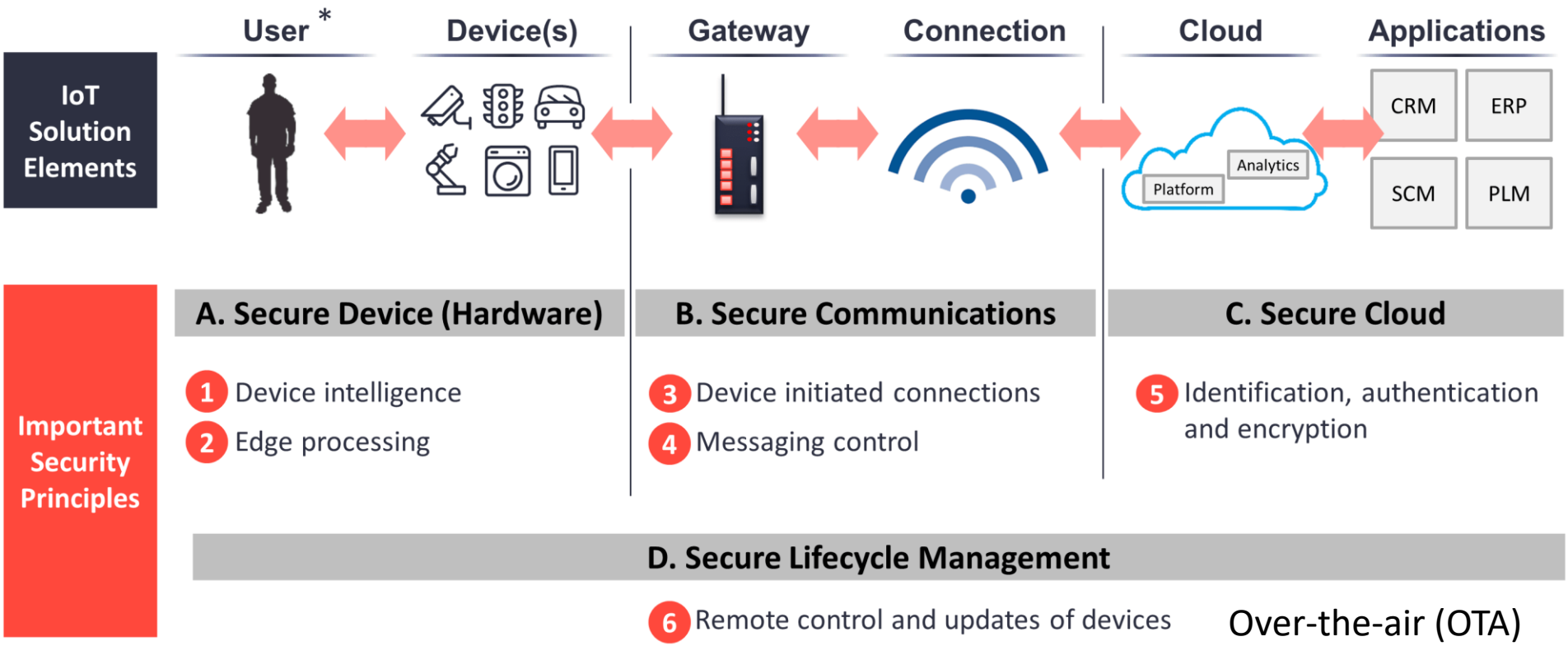
- The number and the devices and their relevance poses huge security problems
  - Just think to
    - Heart pacemakers
    - Traffic light systems
    - Car control-driving systems

Complex interactions→
More security issues

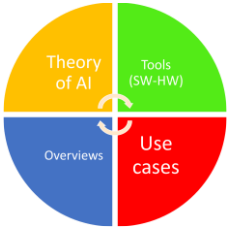




Six principles of IoT Cyber security in the stack



Note: PLM (Product Lifecycle Management) ERP (Enterprise Resource Planning) SCM (Supply Chain Management) CRM (Customer Relationship Management)



THEORY

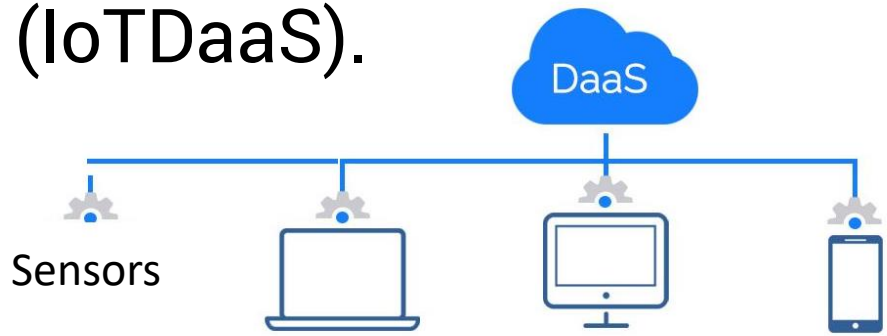
Artificial Intelligence Of Things (AIoT)

A new frontier for applications

Artificial Intelligence Of Things (AIoT)

- AI + IoT → new branch of this emerging technology
- AI can be used to transform IoT data into useful information for improved decision making processes, thus creating a foundation for newer technology such as IoT Data as a Service (IoTDaaS).

DaaS: its data product can be provided to the user on demand, regardless of geographic or organizational separation between provider and consumer.



Artificial Intelligence Of Things (AIoT)

What is enabling the AI?

- **HW**
  With AIoT, AI is embedded into infrastructure components all interconnected with IoT networks, such as
  - protocols
  - chipsets
  - edge computing, accelerators.
- **SW**
  APIs are used to extend interoperability between components at the 1) device level, 2) software level and 3) platform level
  - See the matlab IoT description at the end of this lesson.

AIoT improvements (1)

While developing your AI+IoT application you should keep in mind in your design to create a system that can be

- more **robust**
  - Self calibration, self diagnosis
  - Better noise reduction due to adaptive capabilities
- more **secure**
  - Information are provided with accuracy and assessing quality of the data
    - Temperature = 152 degree (sensor error, or engine is melting?)
- more **scalable**
  - Supporting different protocols and data format can talk and work with many different applications/devices/services

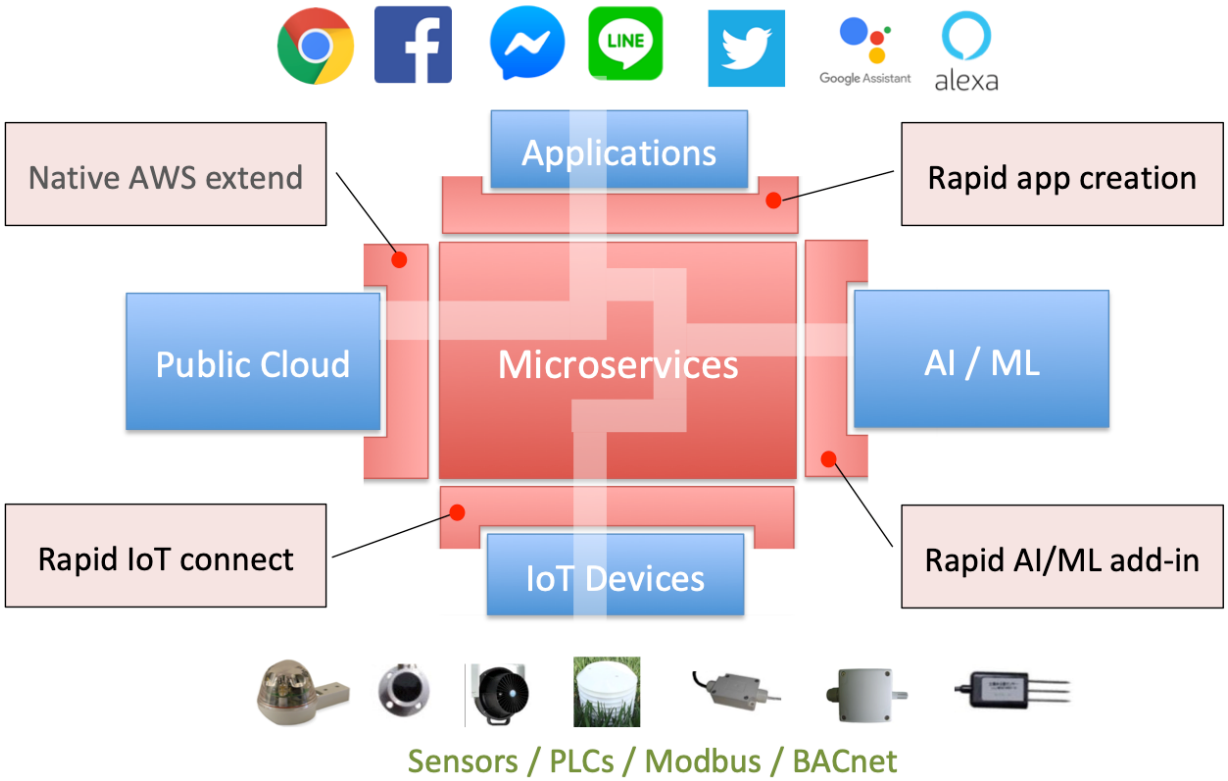
In brief → more **valuable**

- Same components, but the SW is making the device more attractive

AIoT improvements (2)

- In terms of data analytics, AIoT technology create data "learning machines".
- Typical applications
  - enterprise
  - industrial
- Actions
  - harness IoT data (such as at the edge of networks)
  - to automate tasks in a connected workplace.
- Real time data is a key value of all AIoT use cases and solutions.

AIoT: expected features for platforms and Software as a Service (SaaS)

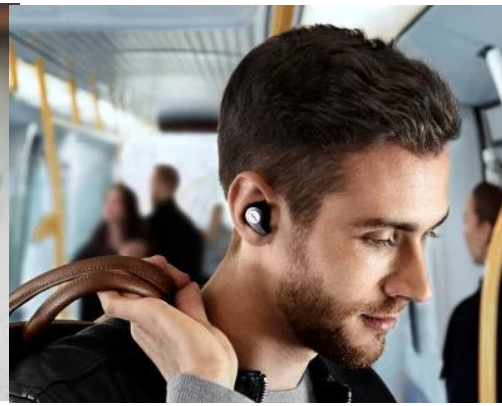


- Manage IoT devices from cloud
- Access cloud data storage as easy as passing messages
- **Serverless microservices** to plugin custom software
- Sharing resources among users for team collaboration
- Interact with external services through APIs

https://www.aiothings.com/

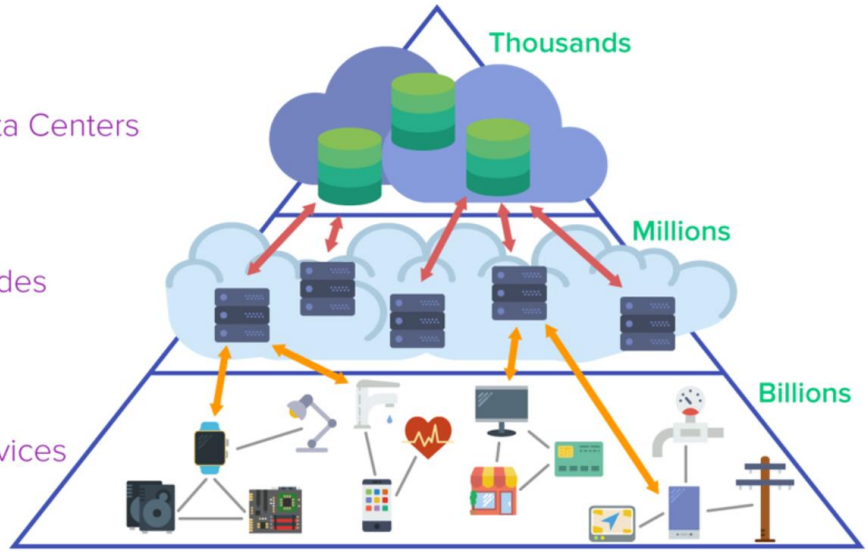
Example of AIoT: Smart speakers

- AI enabled smart speaker can process the trigger word using a Natural Language Processing (NLP) model locally rather than sending all the voice capture to the cloud for processing.
- Type: Dynamic Data Source
- Hybrid approaches
  - Local processing → activation,
  - Remote processing → NLP



Example of AIoT: Smart speakers (2)

- The Fog layer is almost not present.
  - Without connections the capability of the devices is strongly limited

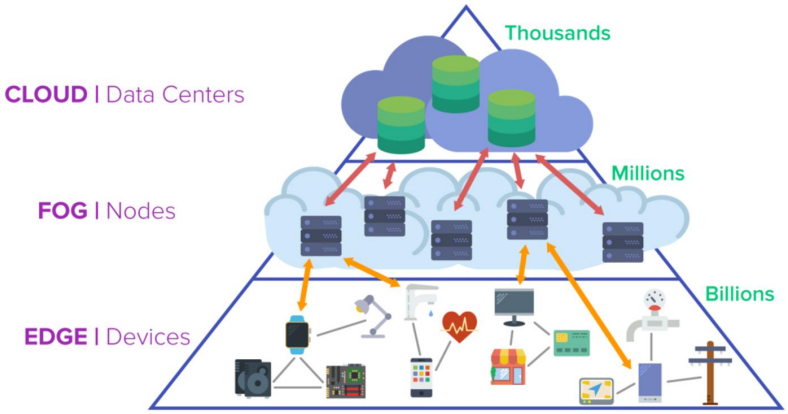


Example of AIoT: Intelligent & connected lighting

Edge Devices

zigbee

(Bridge)



Edge Device

Trad. IoT

AIoT

Edge Device

Bluetooth (no bridge)

Source of commands (NLP via cloud) and directly to the bridge

4 Examples of AIoT for Smart Retail/Ads Boards

1. A camera system equipped with computer vision capabilities can use facial recognition to identify customers when they walk through the door.
2. The system gathers intel about customers, including their gender, product preferences, traffic flow and more, analyzes the data to accurately predict consumer behavior and then uses that information to make decisions about store operations from marketing to product placement and other decisions

3.

The light bulb remains dark until the moment a passerby walks beneath it. Then the bulb, thanks to motion sensors, lights up. It appears to people looking at the board as though the person walking under just had a fantastic idea — the light bulb moment

4.

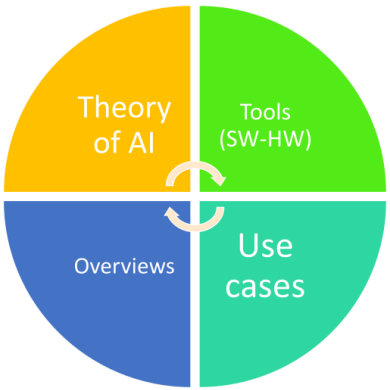
British Airways
Piccadilly Circus
#LookUp campaign




Toolboxes

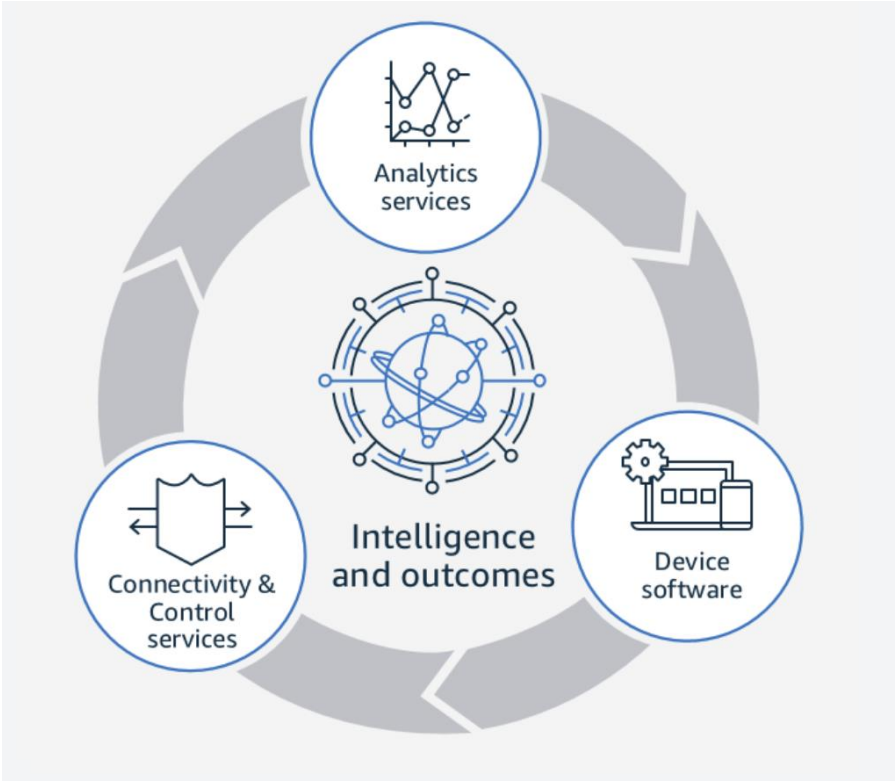
Amazon AWS for IOT

A platform at your disposal

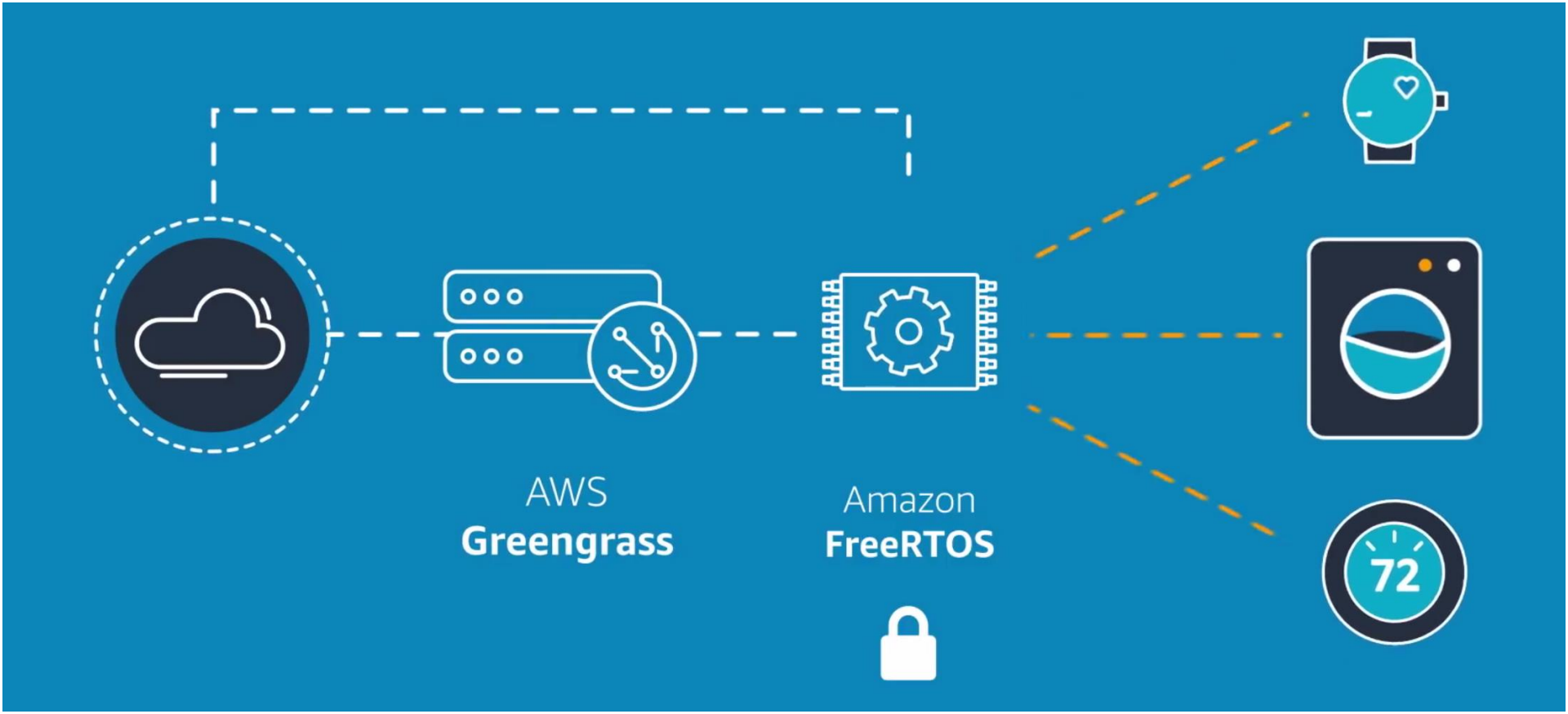


Amazon AWS IoT

- IoT services for industrial, consumer, and commercial solutions
- Broad and deep
  - From the edge to the cloud, device software (FreeRTOS) provides local data collection and analysis (AWS IoT Greengrass)
  - Data management + Rich analytics

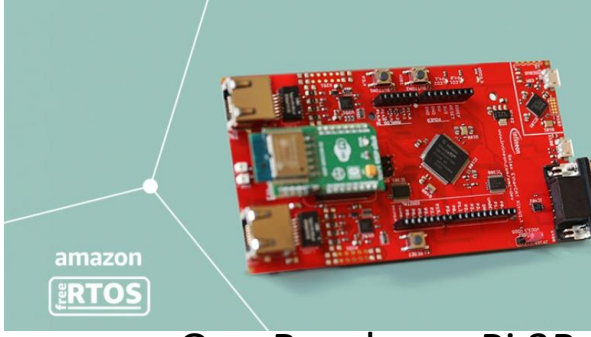


The basic idea



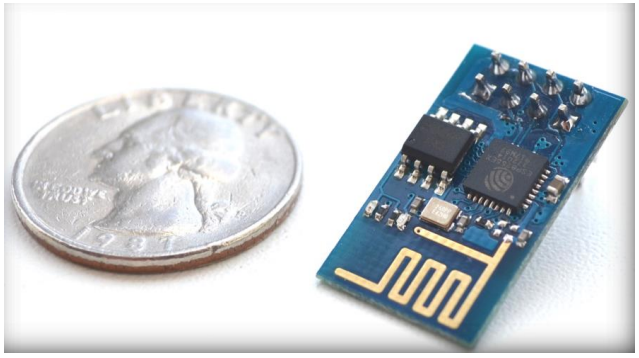
AWS: FreeRTOS

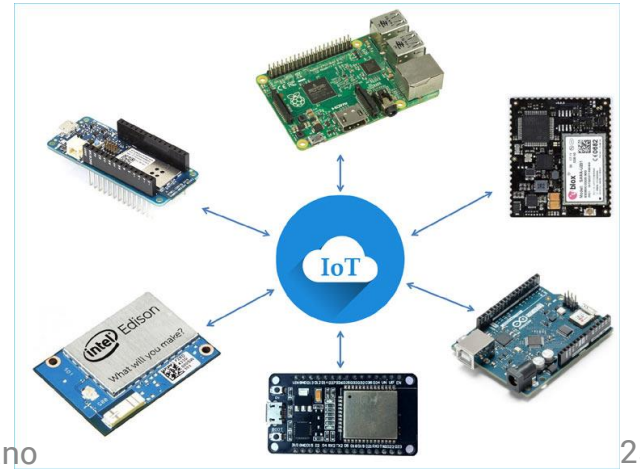
Real-time operating system for microcontrollers



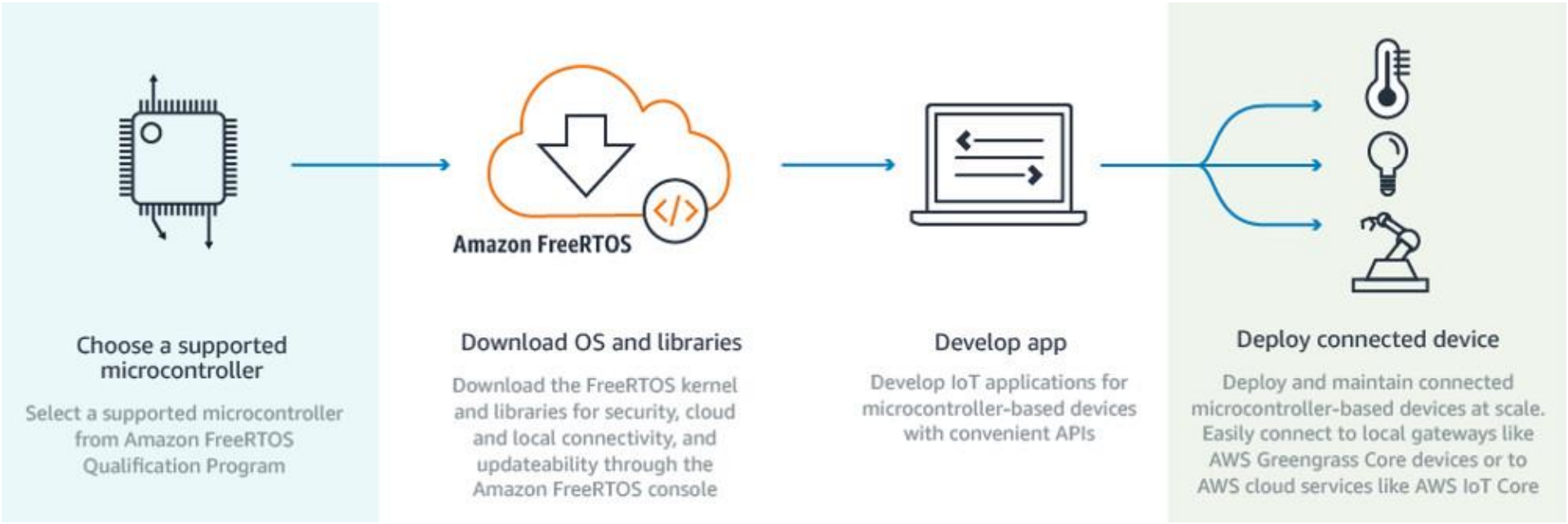
Or a Raspberry Pi 3B.

- FreeRTOS is an open source, real-time operating system for microcontrollers that makes small, low-power edge devices easy to program, deploy, secure, connect, and manage.
- A microcontroller contains a simple, resource-constrained processor that can be found in many devices, including appliances, sensors, fitness trackers, industrial automation, and automobiles.

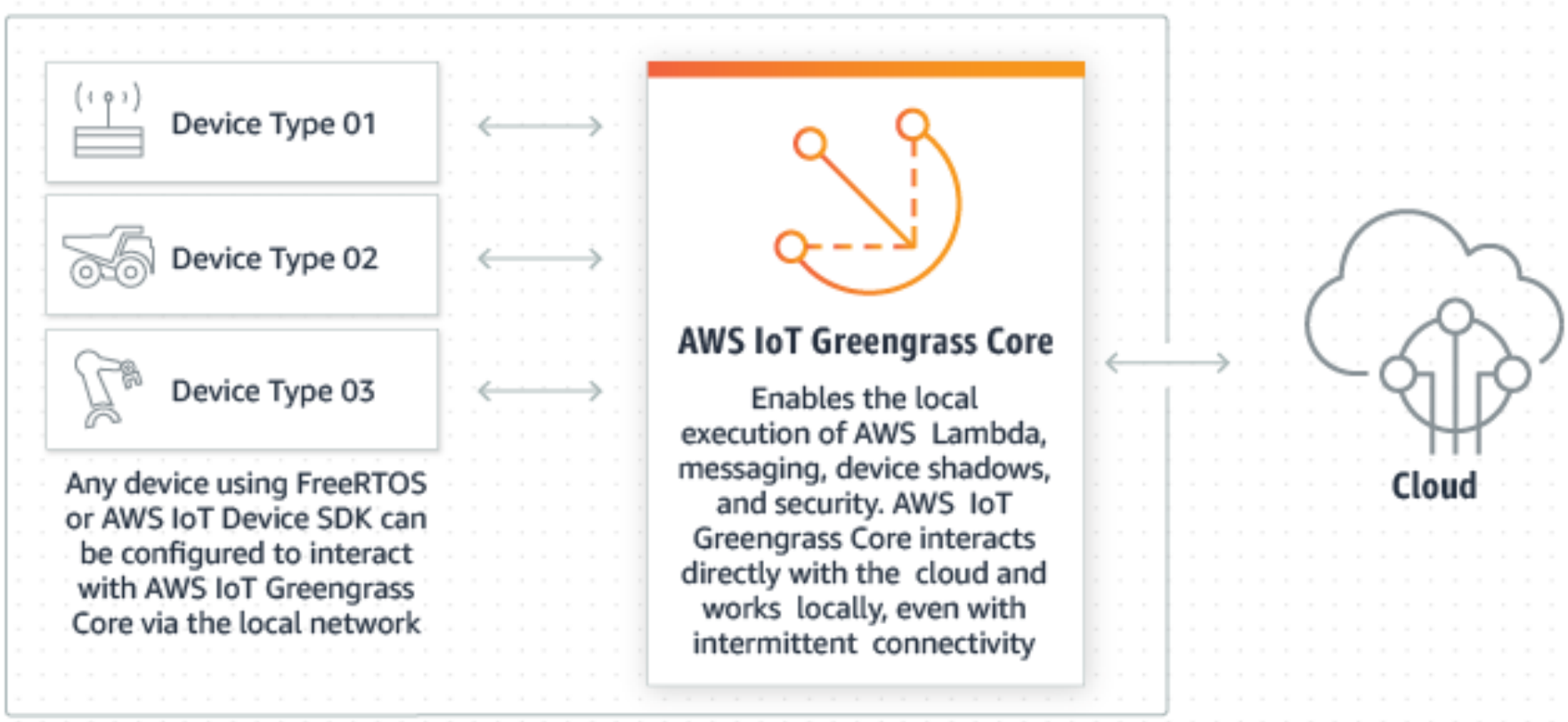




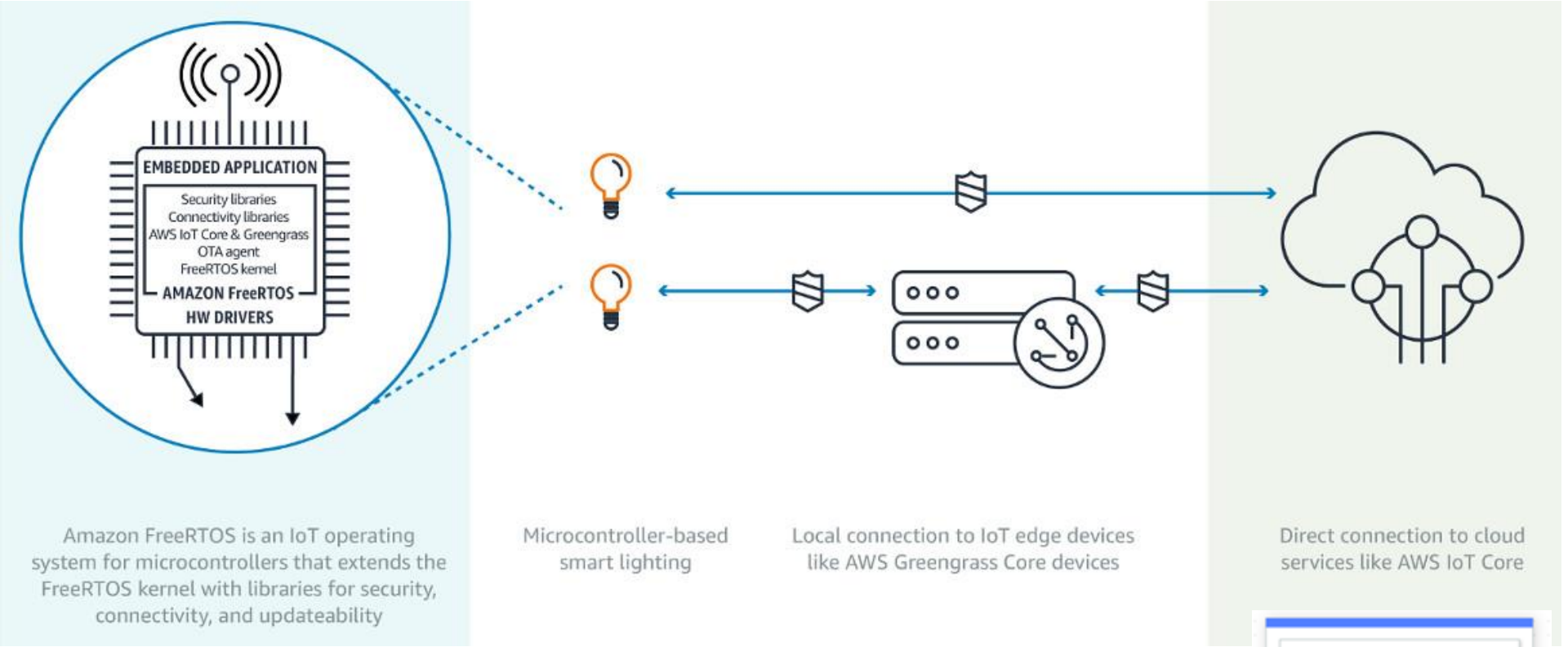
Design steps



AWS IoT Greengrass



From a «lamp» to 3rd party app



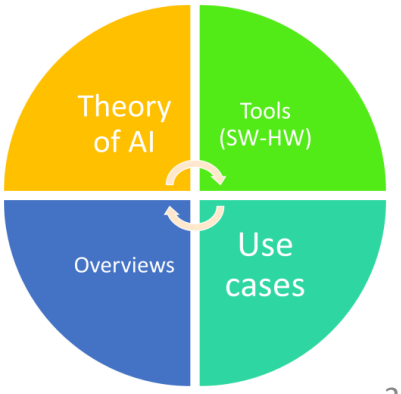
As we will see in the next lessons
AWS is providing also an AI platform




Toolboxes

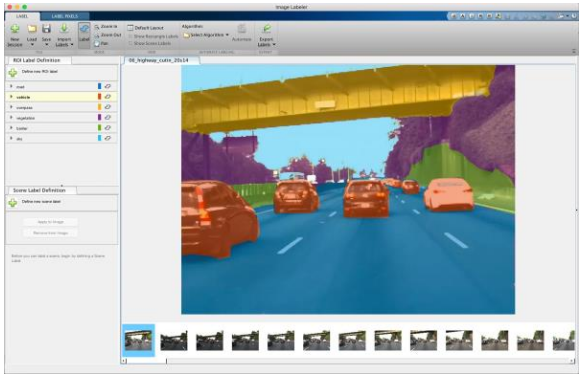
Matlab

Let's start with the first tool!



Matlab version: R2022a

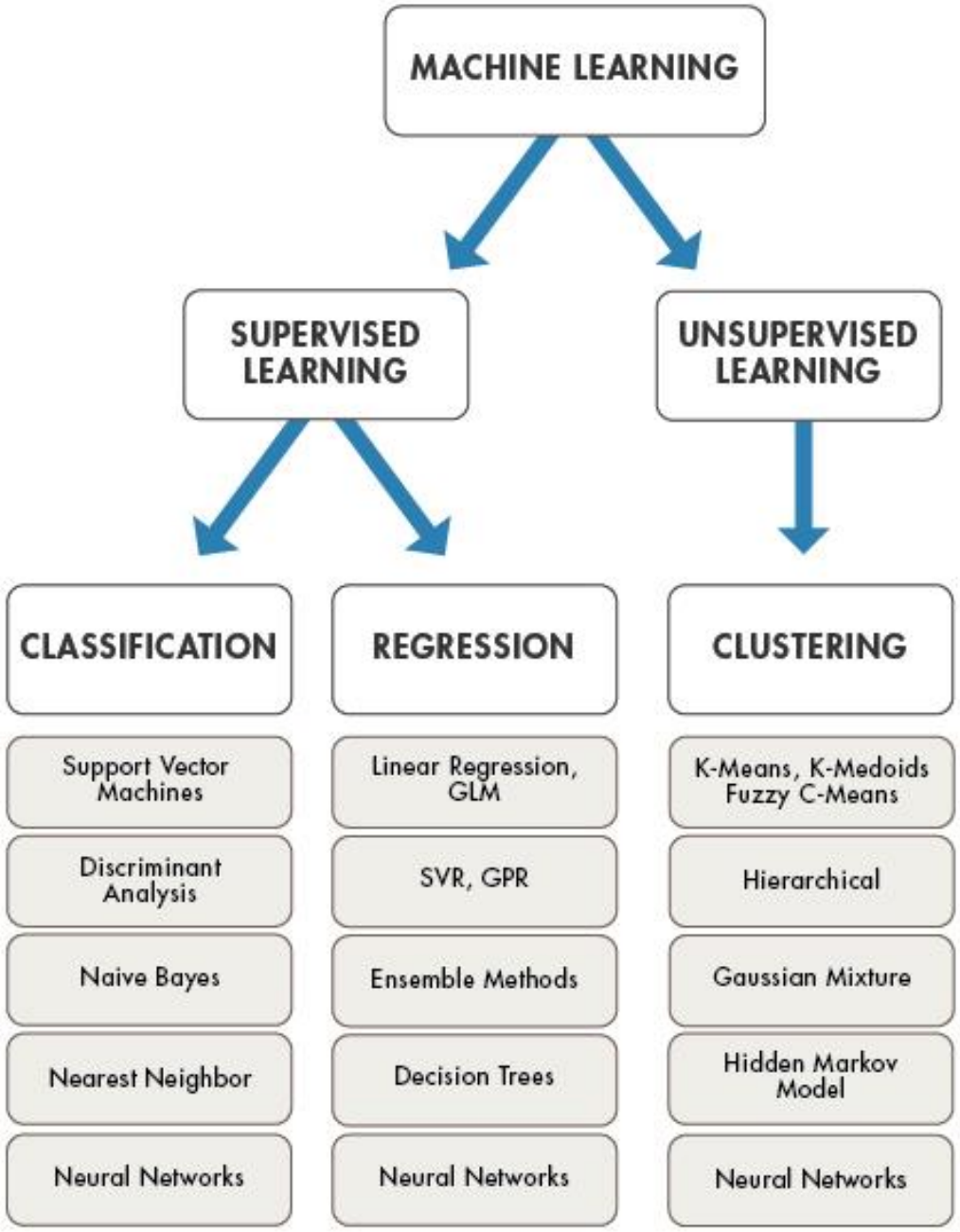
- Improved data preparation and labelling
- Deep learning interoperability
  - That's very importnat to get and use pretrained NN
- Better learning methods
- Manager App
  - Manage multiple deep learning experiments,
    keep track of training parameters,
    analyze and compare results and code
- Better debug and visualization
- New reinforcement learning methods



Matlab: main points

- Interpreter : >>x=[1:5];
- Object oriented
  →very easy to manage neural NNs
- E full environment
  - Compiler, Debugger, toolbox
  - Matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages
- All needed toolboxes in the same environment
  - Deep learning
  - Vision
  - Data and database management
  - Statically and data process toolbox

Main machine learning methods in the course



and many others!

Matlab: first things to do

- Take the general tutorial
- Loading and saving data
- General plotting tutorial
- Your goal is to arrive to simple coding
  - Working with matrices (**Mat**rix **Lab**oratory)

```
>>
[train_feature_data] = [first_part , sec_part];
```

  - Create functions to extract feature from data and images like

```
>>
for ….    % all images
[f1, f2] = myfunct( ‘image.bmp’) % extract measures
end
```



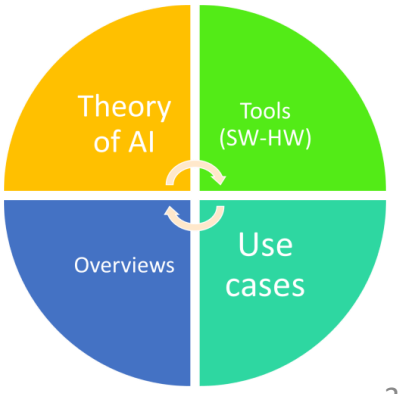

Toolboxes

Matlab & IOT

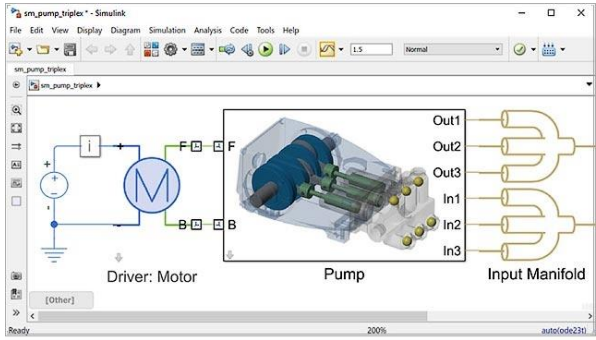
MathWorks®

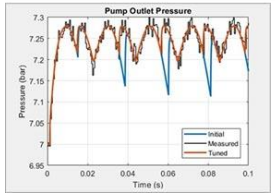
Focusing on embedded boards

Arduino



Matlab+ Simulink → IoT

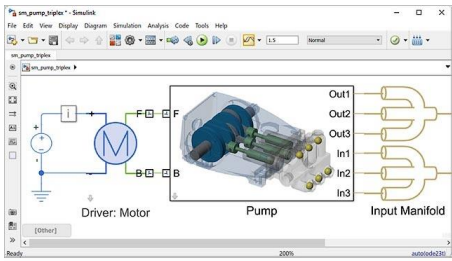


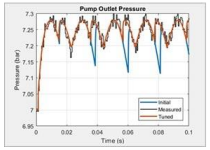


- Help to design, prototype, and deploy IoT applications such as predictive maintenance, operations optimization, supervisory control,…

- Access and preprocess **streaming and archived data** using **built-in interfaces** to cloud storage, relational and nonrelational databases, and protocols (REST, MQTT, OPC UA)

Matlab+ Simulink → IoT

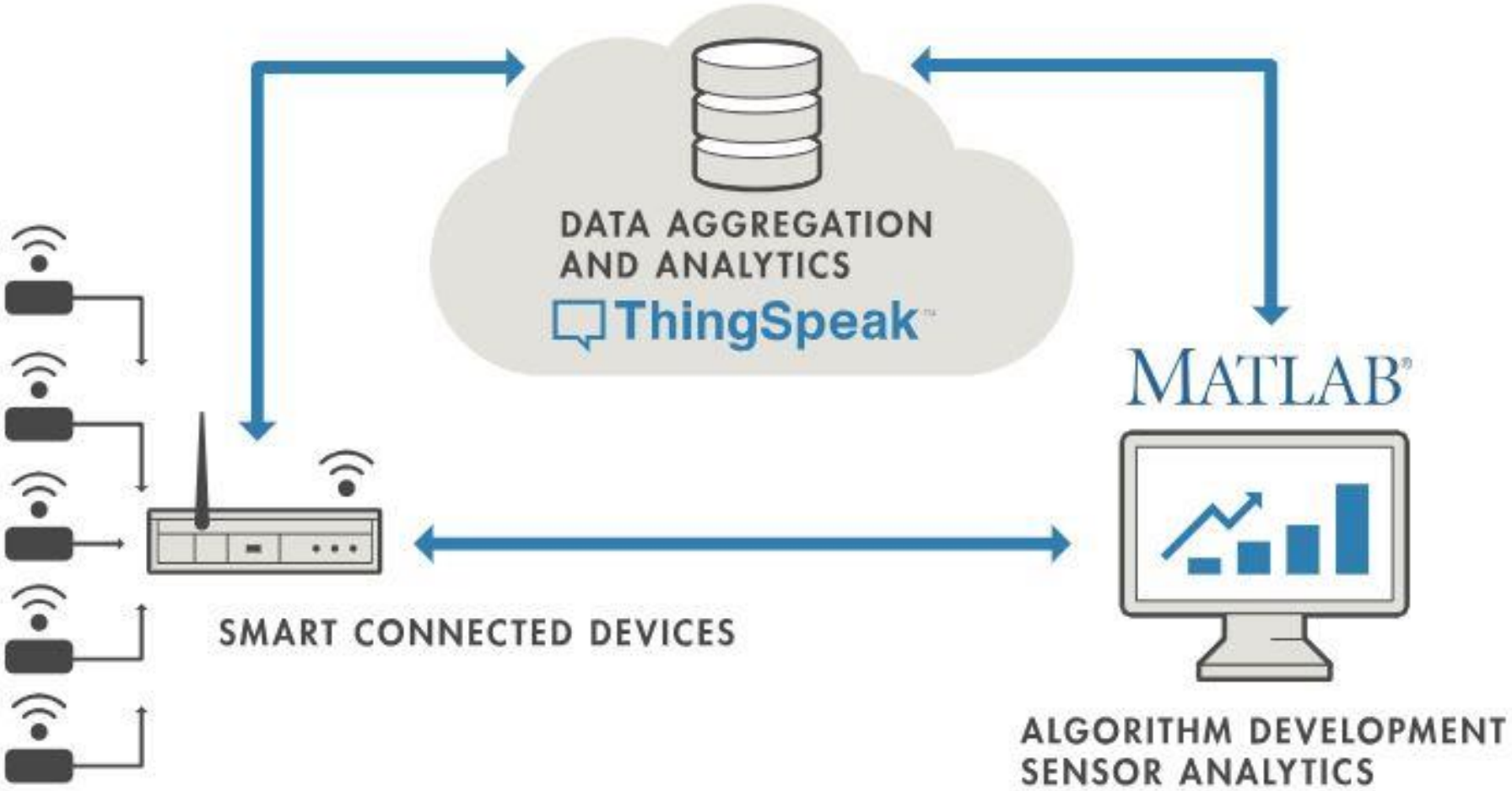




- Design **custom IoT analytics and algorithms** quickly from thousands of proven, prebuilt functions for topics such as data cleaning, machine and deep learning, computer vision, controls, and optimization

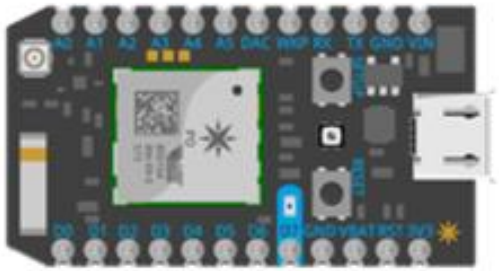
- Deploy MATLAB analytics and Simulink models to your choice of **asset**, **edge**, or **cloud** by automatically generating C/C++, HDL, PLC, GPU, .NET, or Java® based software components

Matlab ThingSpeak



Off-line/On-line functions

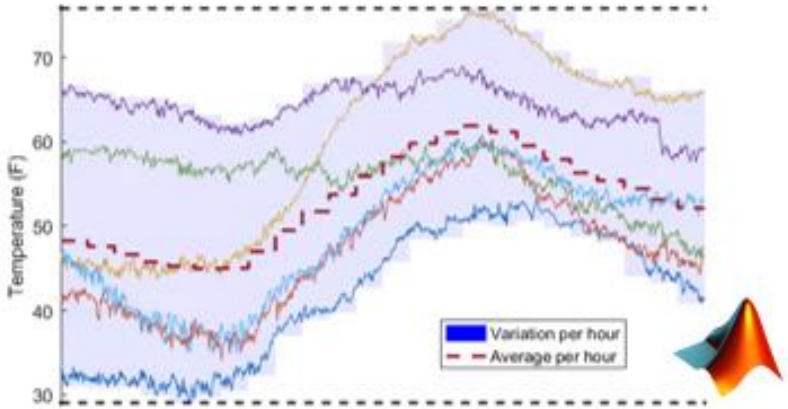
1 While offline, collect sensor data



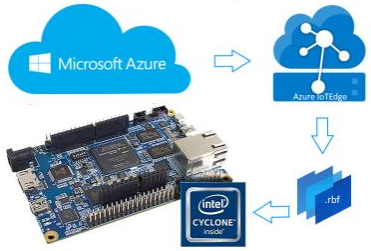
2 Periodically connect to network and send collected data to ThingSpeak.com all at once using `bulk_update`

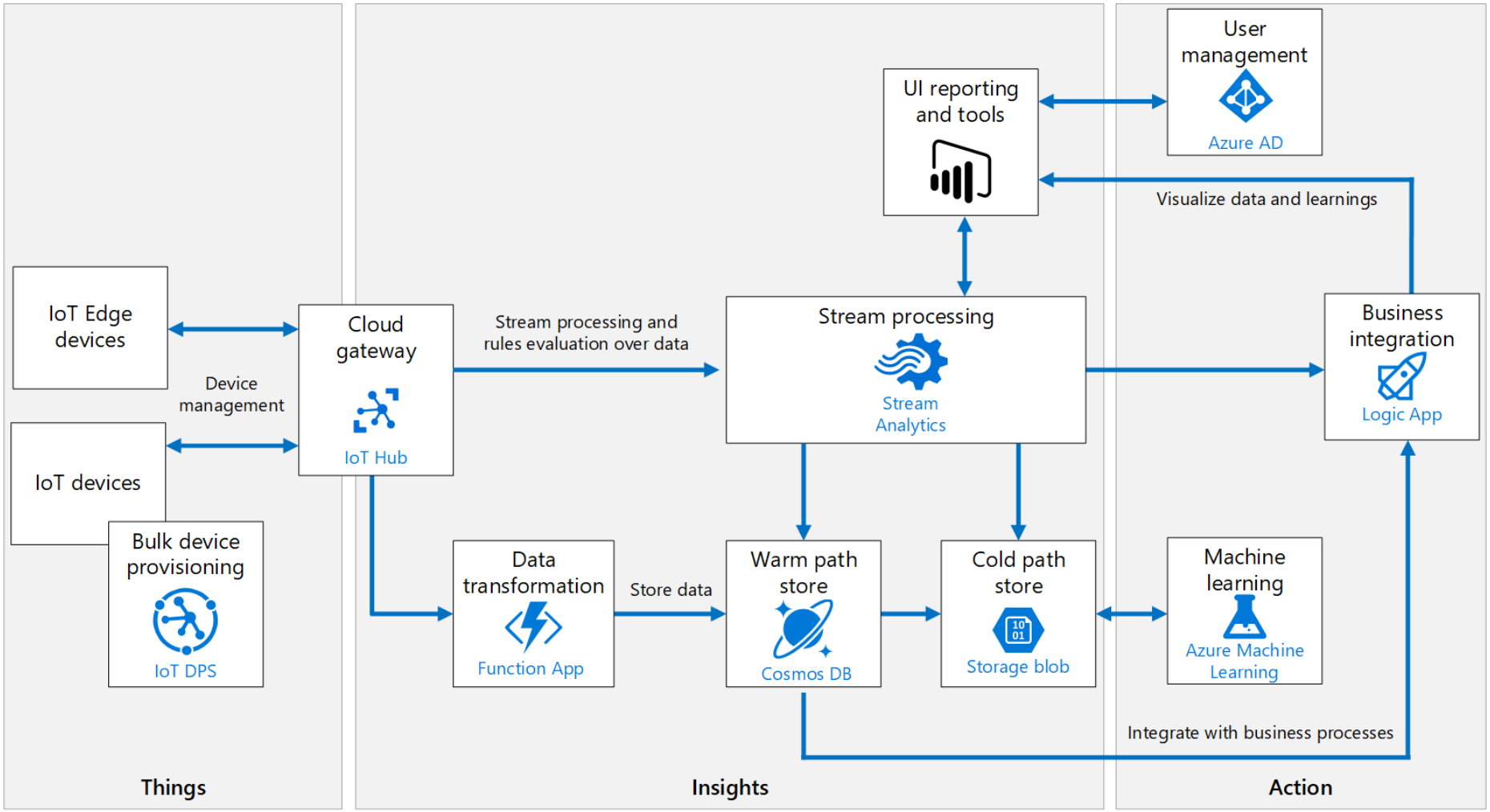
ThingSpeak™

3 Analyze data using `thingSpeakRead` in MATLAB

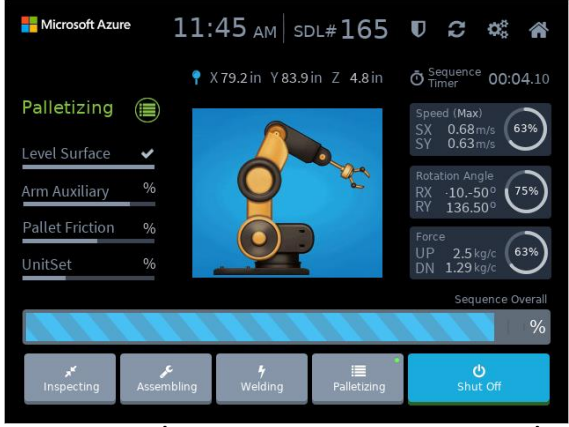


Microsoft Azure IoT





Azure RTOS



by Azure RTOS GUIX Studio

- Embedded development suite including a small but powerful operating system that provides reliable, ultra-fast performance for resource-constrained devices.
- Easy-to-use
- Portable: Azure RTOS supports the most popular 32-bit microcontrollers and embedded development tools (reuse of previous projects and knowledge).
- Market-proven: more than 6.2 billion devices worldwide.
- Safe: Ipsec (IP level), TLS and DTLS (socket level)
- The **Azure** IoT firmware can be updated by **over-the-air** using automatic device management

Windows 10 IoT Core

- A more traditional approach
- Built for small-footprint smart devices, while still offering the manageability and security offered by Windows
- Equipped with Windows 10 IoT Core Services
  - Windows Server IoT is for edge-computing workloads, for connecting, storing and analyzing data from large databases of connected applications, networks and web services.
- SQL Server IoT 2019: Data storage and analytics on Windows for IoT
- Over-the-Air (OTA) device updates
- Can use the Azure platform




Toolboxes

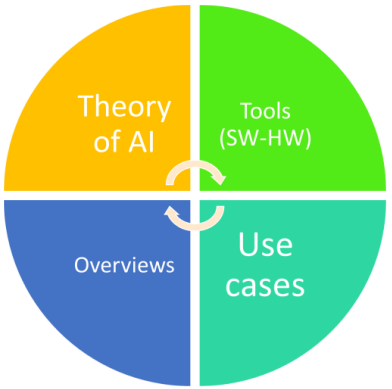
Boards for IOT

MathWorks®

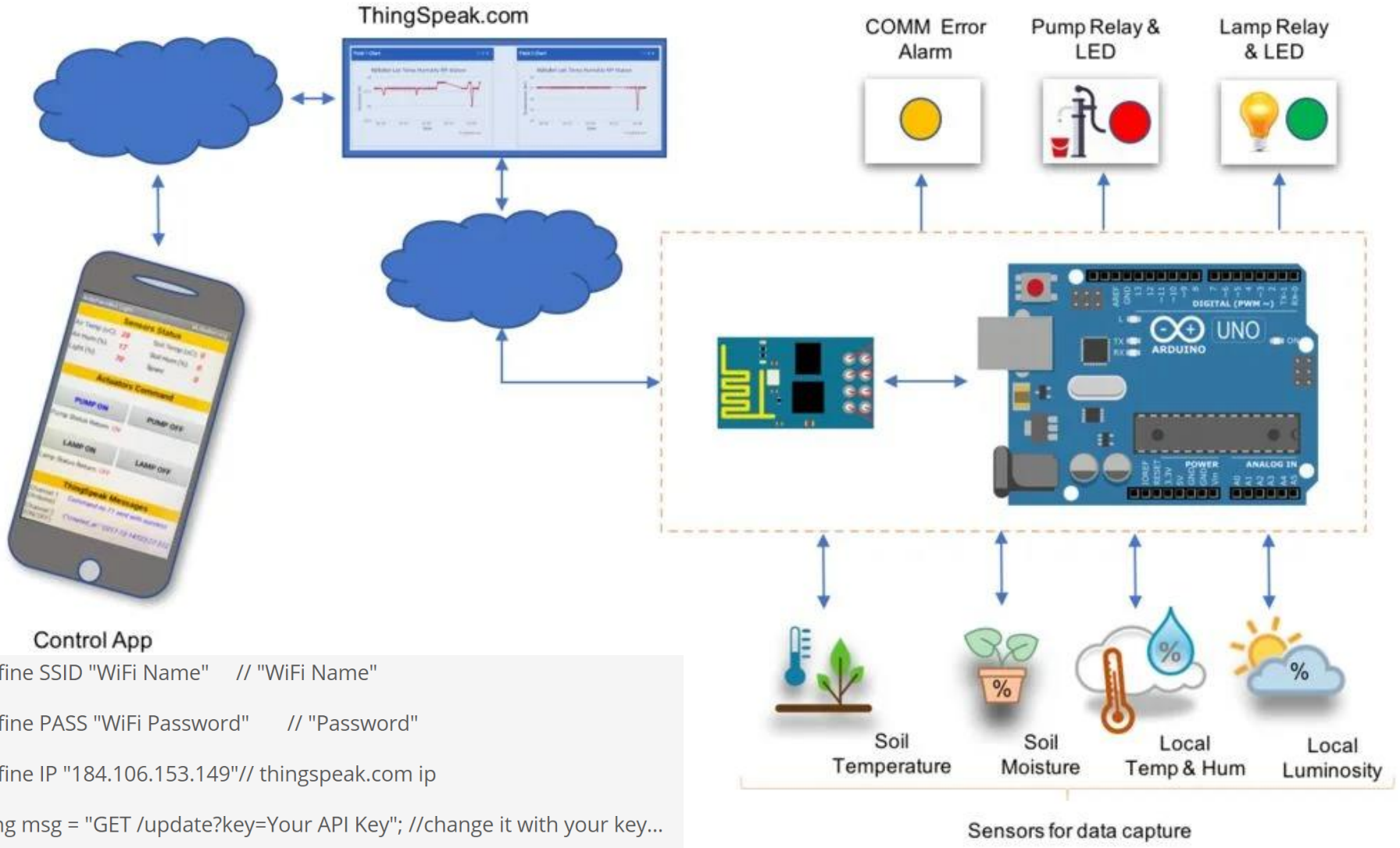
Focusing on embedded boards

Arduino

Industrial boards and accelerators



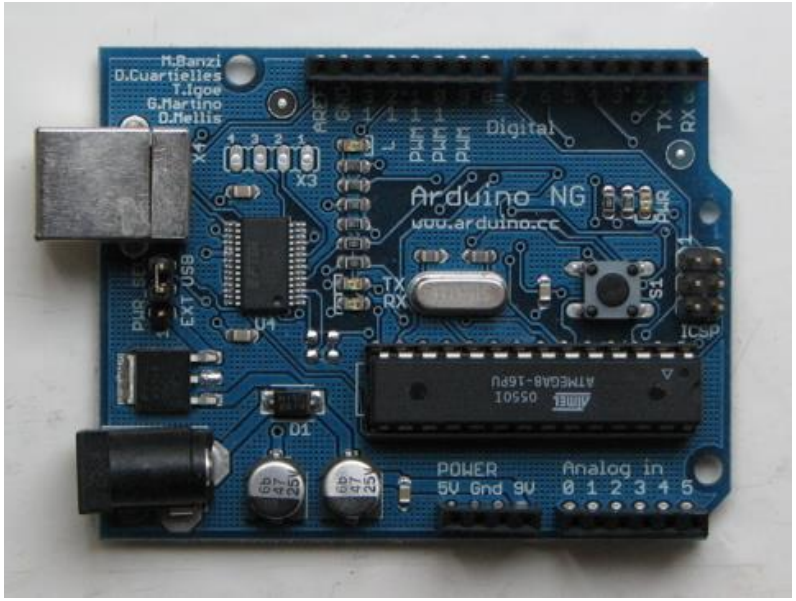
Basic Example:
Arduino 1 + ESP8266-01 (Wi-Fi SoC)

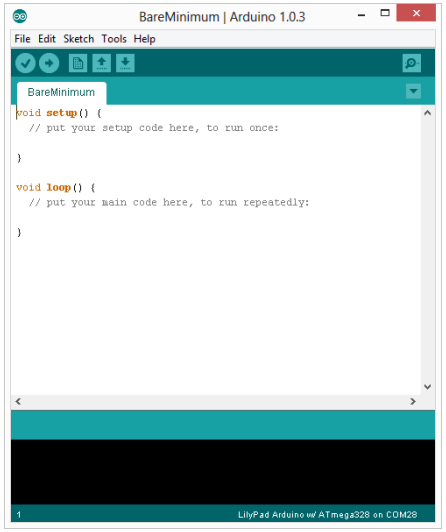



```
#define SSID "WiFi Name"     // "WiFi Name"

#define PASS "WiFi Password"       // "Password"

#define IP "184.106.153.149"// thingspeak.com ip

String msg = "GET /update?key=Your API Key"; //change it with your key...
```

What is Arduino?

- Physical computing platform
- Open source
- “Hardware Abstracted” Wiring Language
  - Coding is accessible & transferrable
    → (C++, Processing, java)
- USB programmable
- Atmega328 microcontroller
- Large community
  - >1million boards sold
- Inexpensive (20€)



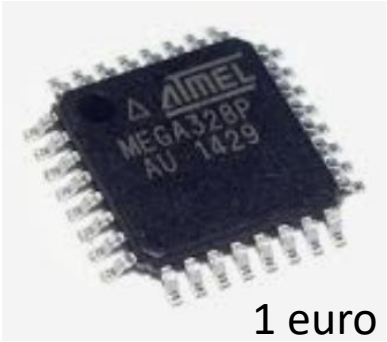


Arduino Zero

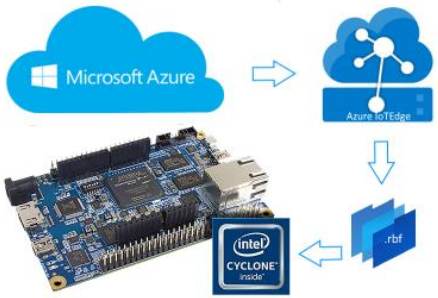
- **Arduino Zero** is a simple and powerful 32-bit extension of the platform established by the UNO providing a platform for innovative projects in smart IoT devices, wearable technology, high-tech automation, …
- 40 euros
- ATSAMD21G18, 32-Bit ARM Cortex M0+
- Flash Memory 256 KB
- Atmel's Embedded Debugger (EDBG)
- AI capability: only a small classical NN

Some IoT devices

- From a very small microcontroller ATmega328P (Arduino UNO) 8bit 32 KB flash
  - Matlab yes; AWS IoT no
- Atmel ATSAMW25 SoC designed for IoT projects and devices (**MKR1000** Arduino)
- ARM larger processor 32bit, 64bit
  - Matlab yes; AWS IoT yes
- FPGA + Huge microcontroller + Vision cameras



1 euro



Boards and AIoT

Raspberry Pi Pico

2x Cortex-M0+ CPU

-

-

133 MHz - 264 KB

☆☆☆☆☆

€ 5

Just some I/O, an RP2040 MCU and 2 MB of flash. Can it be used for deep learning? Barely. However, TensorFlow TinyML has some examples here.

Raspberry Pi 4 B

4x Cortex-A72 CPU

VideoCore VI GPU

32 GFLOPS

1.5 GHz - 1/2/4/8 GB

★★☆☆☆

€ 40/€ 40/€ 60/€ 85

The successor to the Raspberry Pi 3 with a slightly faster processor, USB 3.0 and GigaEhternet.

Intel Neural Stick 2

Intel Movidius Myriad X

16 SHAVE cores

1 TOPS

☆☆☆☆☆

★★☆☆☆

€ 87

Special Intel neural network USB 3 dongle for PC and single boards like Raspberry Pi. Accelerates tensor arithmetic enormously. Fully supported by OpenCV.

https://qengineering.eu/deep-learning-with-raspberry-pi-and-alternatives.html

Boards and AIoT (2)

Jetson Nano 2 GByte

4x Cortex-A57 CPU
128x CUDA
1.88 TOPS
1.43 GHz - 2 GB
★★☆☆☆
★★★☆☆
€ 50

Stripped Nano version to compete with the Raspberry. One USB 3 port, a single camera and 2 GByte of RAM. A good start for your first deep learning steps, as long as your model fits the 2 GB RAM. More NVIDIA boards.

Google SOM

4x Cortex-A53 + 1x Cortex M4 CPU
GC7000 Lite 3D GPU
4.0 TOPS NPU
1.5 + 1.0 GHz - 1 GB
★★☆☆☆
★★★☆☆
€ 105

Single tiny (40x48 mm) pluggable module with full I/O and the Edge TPU accelerator.

https://qengineering.eu/deep-learning-with-raspberry-pi-and-alternatives.html

Boards and AIoT

TOPS= **T**era **O**perations **P**er **S**econd.

We will use/retrain them in the course

Model	Framework	Raspberry Pi (TF-Lite)	Raspberry Pi (ncnn)	Raspberry Pi Intel Neural Stick 2	Raspberry Pi Google Coral USB	JeVois	Jetson Nano	Google Coral
EfficientNet-B0 (224x224)	TensorFlow	14.6 FPS (Pi 3) 25.8 FPS (Pi 4)	-	95 FPS (Pi 3) 180 FPS (Pi 4)	105 FPS (Pi 3) 200 FPS (Pi 4)	-	216 FPS	200 FPS
ResNet-50 (244x244)	TensorFlow	2.4 FPS (Pi 3) 4.3 FPS (Pi 4)	1.7 FPS (Pi 3) 3 FPS (Pi 4)	16 FPS (Pi 3) 60 FPS (Pi 4)	10 FPS (Pi 3) 18.8 FPS (Pi 4)	-	36 FPS	18.8 FPS
MobileNet-v2 (300x300)	TensorFlow	8.5 FPS (Pi 3) 15.3 FPS (Pi 4)	8 FPS (Pi 3) 8.9 FPS (Pi 4)	30 FPS (Pi 3)	46 FPS (Pi 3)	30 FPS	64 FPS	130 FPS
SSD Mobilenet-V2 (300-300)	TensorFlow	7.3 FPS (Pi 3) 13 FPS (Pi 4)	3.7 FPS (Pi 3) 5.8 FPS (Pi 4)	11 FPS (Pi 3) 41 FPS (Pi 4)	17 FPS (Pi 3) 55 FPS (Pi 4)	-	39 FPS	48 FPS
Binary model (300x300)	XNOR	6.8 FPS (Pi 3) 12.5 FPS (Pi 4)	-	-	-	-	-	-
Inception V4 (299x299)	PyTorch	-	-	-	3 FPS (Pi 3)	-	11 FPS	9 FPS
Tiny YOLO V3 (416x416)	Darknet	0.5 FPS (Pi 3) 1 FPS (Pi 4)	1.1 FPS (Pi 3) 1.9 FPS (Pi 4)	-	-	2.2 FPS	25 FPS	-
OpenPose (256x256)	Caffe	4.3 FPS (Pi 3) 10.3 FPS (Pi 4)	-	5 FPS (Pi 3)	-	-	14 FPS	-

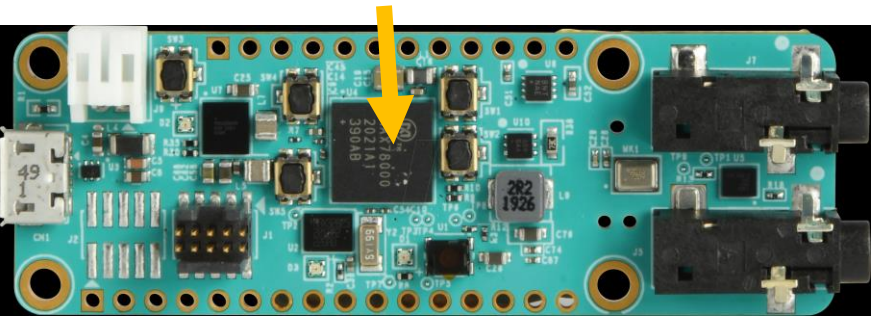
https://qengineering.eu/deep-learning-with-raspberry-pi-and-alternatives.html

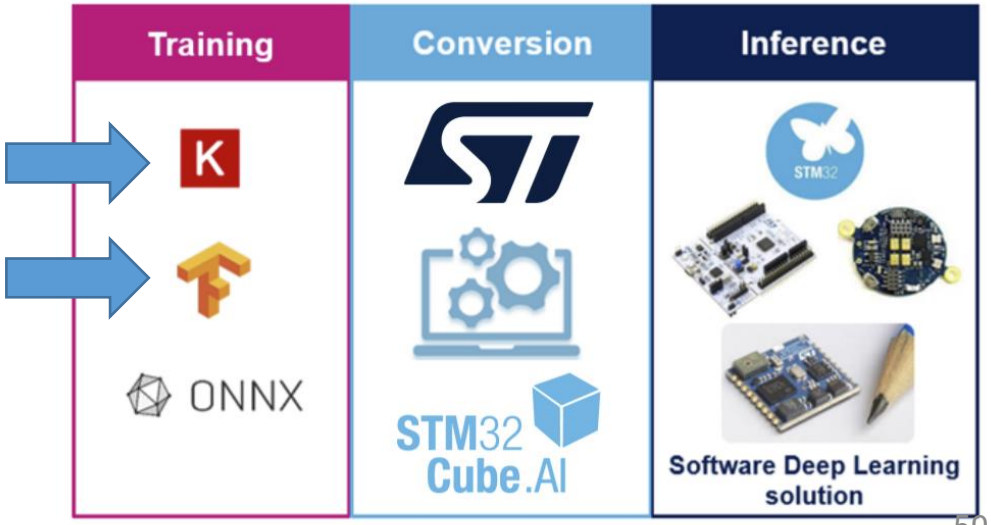
Industrial boards for AIoT

Many other companies are now producing industrial boards with Deep Learning model accelerators such as ST with STM32CubeMX

- Automatic conversion of pre-trained Neural Network
- Integration of generated optimized library into the user's project
- Azure compliant

Example: MAX78000





AIoT in Logistics and general apps

- Intelligence on the sensor
- Intelligent asset tracking with machine learning
  - You can build decision tree for the sensor without writing a single line of code

- LSM6DSOX 6-axis inertial module with machine learning core and explain how you can build intelligent asset tracking logic into this sensor with simple steps that will have you developing quickly and getting to market ahead of time.

Main points

- Usecase: The Pirelli **Connesso** IoT Architecture
- Security of IoT
- Artificial Intelligence Of Things (AIoT)
- Toolboxes:
  - Introduction to Matlab
  - Matlab for IoT and AIoT
    - The Arduino use case
  - Amazon AWS IoT, FreeRTOS
  - Azure ROT, and W10 IoT
- Industrial Board for AIoT