IoT Engineering 12: Raspberry Pi as an IoT Edge Device

Slides: tmb.gr/iot-12

Overview

These slides introduce *Edge Computing on the Pi*.

A definition and use cases for edge computing.

How to read sensors and use the Pi camera.

Prerequisites

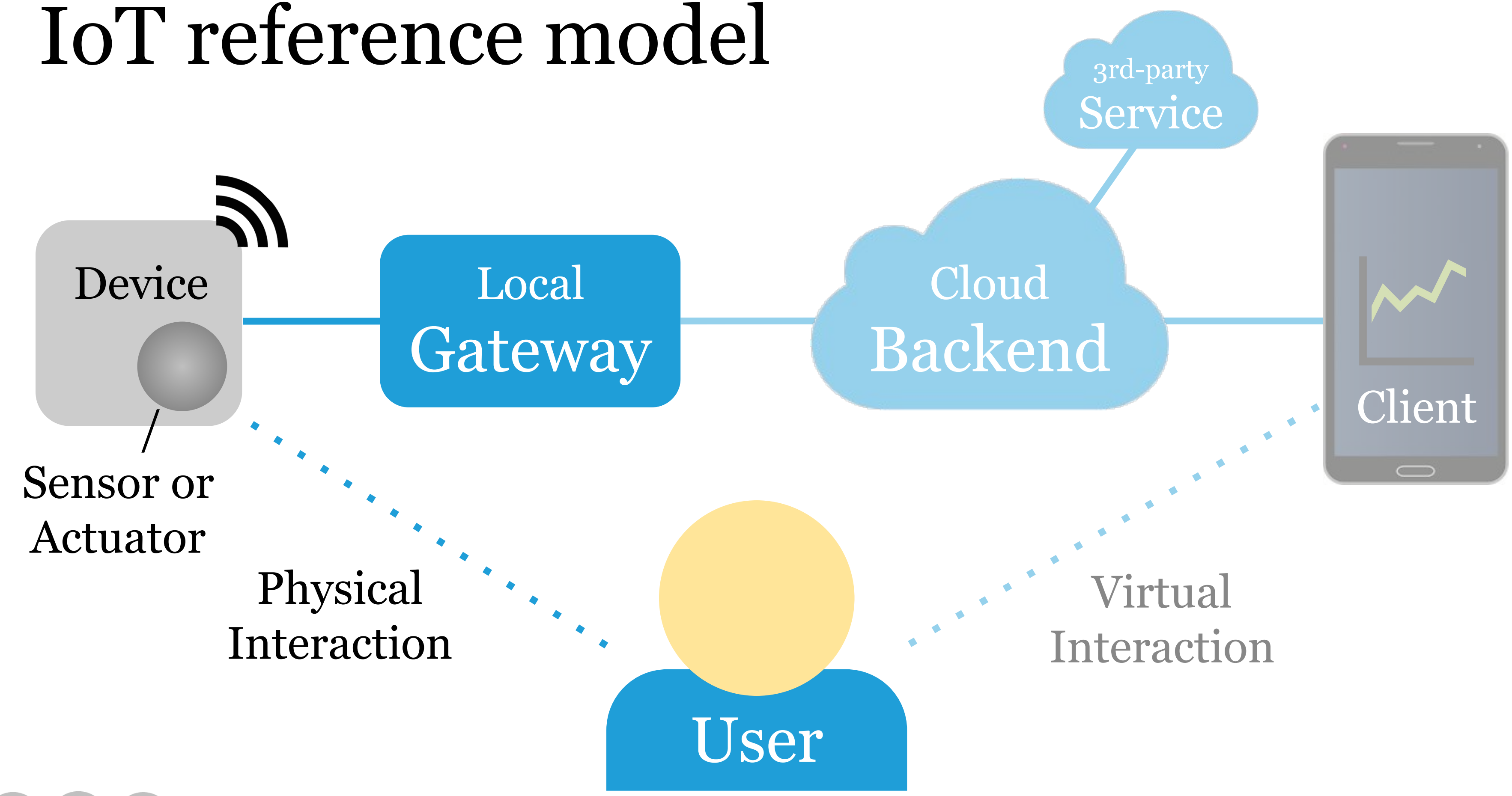
We'll use the Raspberry Pi with Node.js and Python.

To use Grove sensors a Grove base hat is required.

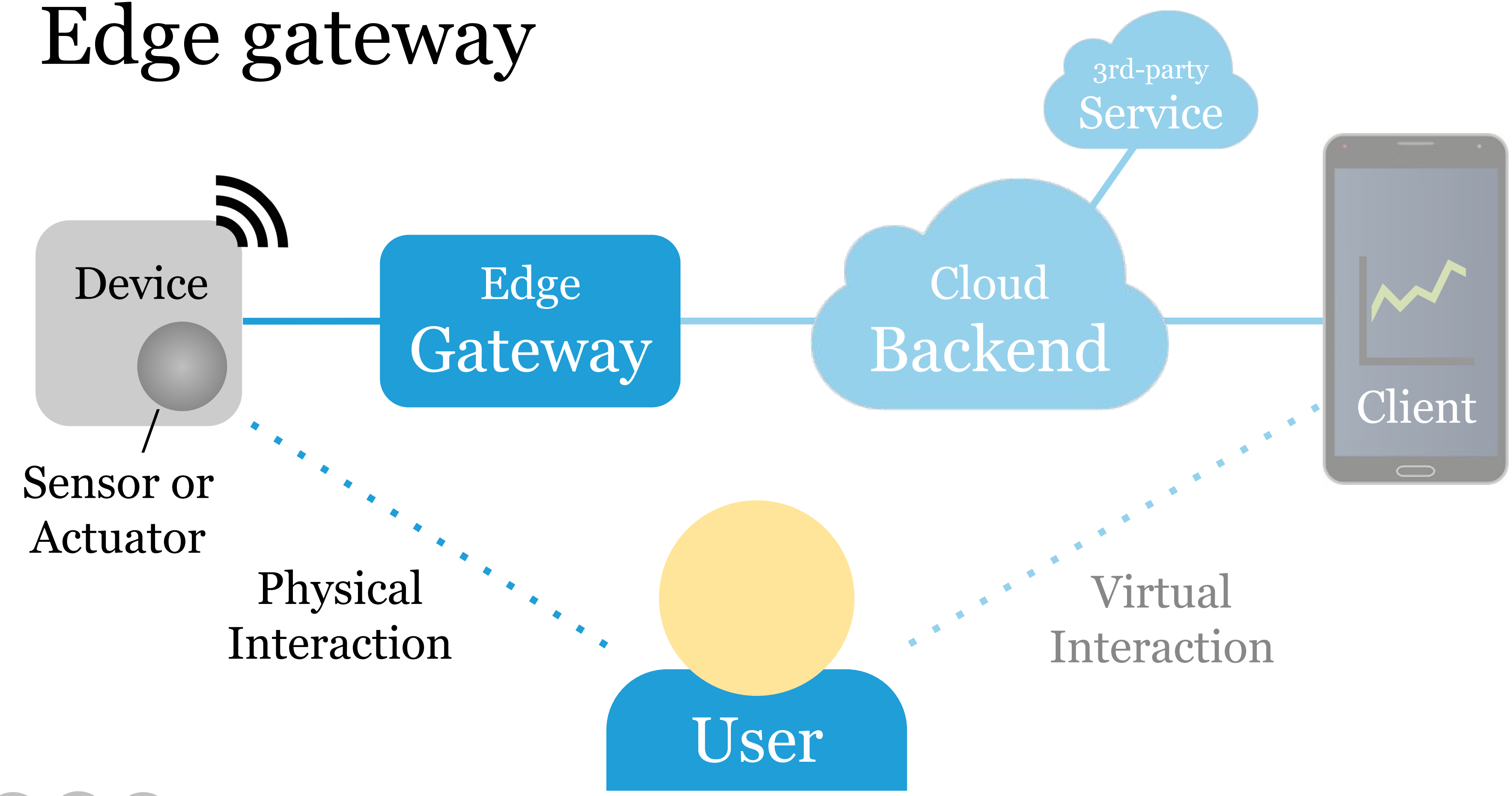
A Raspberry Pi cam and Coral TPU can be used.

Note: Slides are in beta.

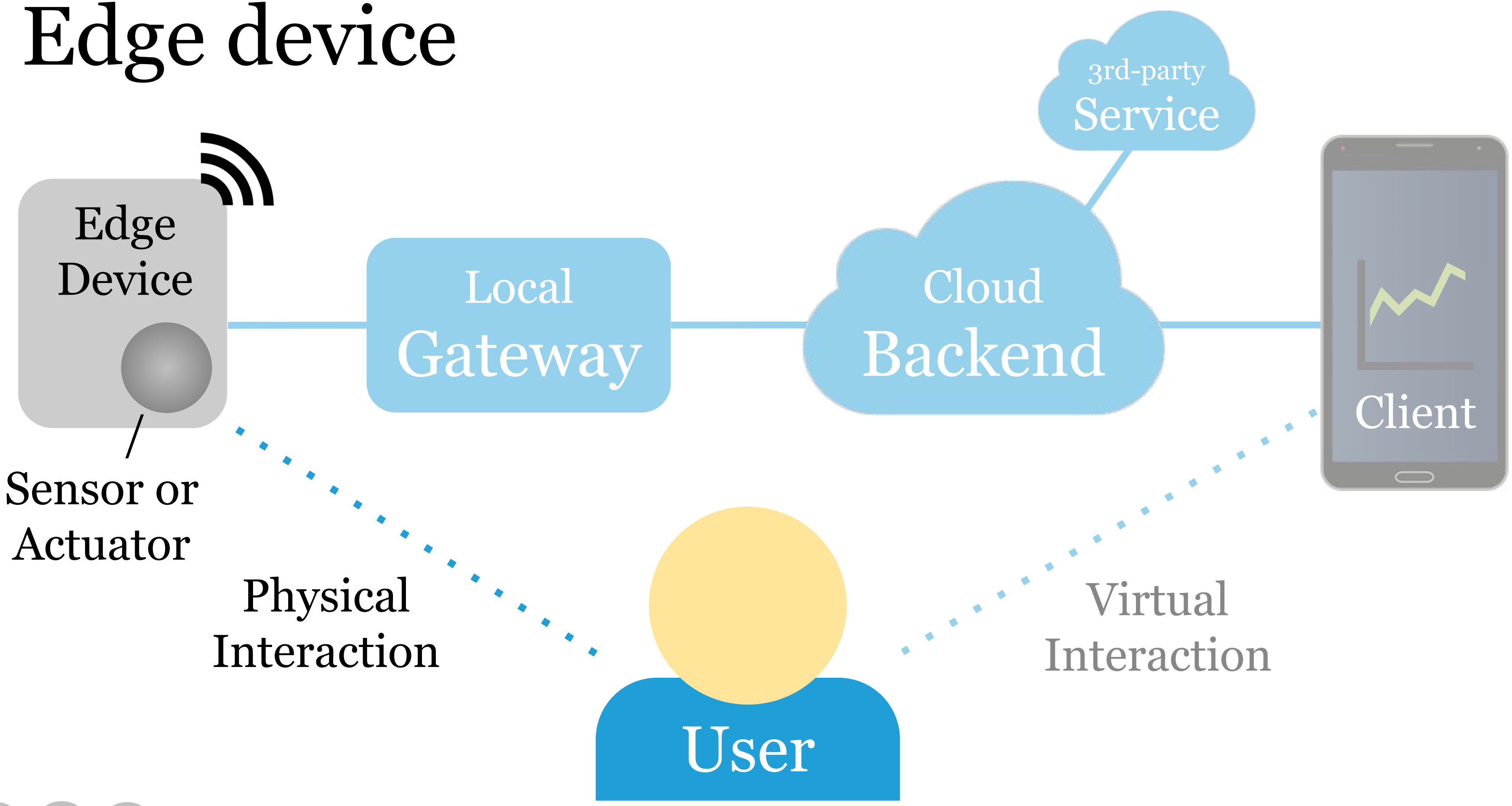
IoT reference model



Edge gateway



Edge device


Edge
Device
Sensor or
Actuator
Local
Gateway
Cloud
Backend
3rd-party
Service
Client
Physical
Interaction
Virtual
Interaction
User

Edge computing

"*Edge computing* or fog computing [...] represents a shift in architecture in which intelligence is pushed from the cloud to the edge, localizing certain kinds of analysis and decision-making." — The edge of the IoT

"[It] enables quicker response times, unencumbered by network latency, as well as reduced traffic, selectively relaying [...] data to the cloud." — (as above)

Edge computing patterns

Sensor → Device → Edge GW → Device → Actuator.

Sensor → Edge Device → Actuator.

Use cases: Low latency decisions, or lots of data.

E.g. cloudless voice recognition unlocks a door.

Or FFT over local machine data triggers alerts.

Edge device/gateway

A device/gateway with *substantial* computing power.

Supports high bandwidth sensors, e.g. audio, video.

Enables *local* data analysis and decision-making.

Reduces decision latency and network traffic.

Historically, the term has been used in networking.

Raspberry Pi as an edge device

The Raspberry can be used as a edge device/gateway.

It has (digital) GPIO pins to read data from sensors.

A camera connector enables taking pictures & video.

Add-on *hats* enable additional hardware capabilities.

Raspberry Pi GPIO with Node.js

Check the Raspberry Pi pinout, pins are 3.3V, *not* 5V.

To read/write GPIO pins, install rpi-gpio:

```
$ npm install rpi-gpio
```

Or johnny-five with raspi-io:

```
$ npm install johnny-five raspi-io
```

Or gpio-stream:

```
$ npm install gpio-stream
```

Digital output with Node.js

.js

```
const gpio = require("rpi-gpio");
const pin = 29; // BCM pin 5, D5
let state = false;
gpio.setup(pin, gpio.DIR_OUT, () => {
  setInterval(() => {
    state = !state;
    gpio.write(pin, state, (err) => {
      console.log(err);
    });
  }, 500); // ms
});
```

Digital input with Node.js

.js

```
const gpio = require("rpi-gpio");
const pin = 16; // BCM pin 16, D16

gpio.setMode(gpio.MODE_BCM);
gpio.setup(pin, gpio.DIR_IN, gpio.EDGE_BOTH);
gpio.on("change", (pin, value) => {
  console.log("pin " + pin + ": " + value);
});
console.log("watching pin " + pin + "...");
```

Raspberry Pi Grove GPIO with Python

To use Grove and read analog input, use a Grove hat.

Seeed provides a library and examples* for Grove.

```
$ sudo apt-get install python-pip python3-pip
$ curl -sL https://github.com/Seeed-Studio/\
grove.py/raw/master/install.sh | sudo bash -s -
```

*Both are available in Python only.

Raspberry Pi Grove GPIO w/ Node-RED

Node-RED supports GPIO if it runs on a Raspberry Pi.

See Running on Raspberry Pi and Accessing GPIO.

There are several nodes based on grove.py, e.g.

- node-red-grovepi-nodes
- node-red-contrib-grovepi
- node-red-contrib-grove

Hands-on, 15': Raspberry Pi GPIO

Use the Grove hat to connect Grove sensors to the Pi.

Install the grove.py library and use it with Node-RED.

Check the Grove hat pinout, use 3.3V modules only.

No hat? Use wires, check the Raspberry Pi pinout.

Photo/video with Pi cam in Node.js .js

```
// $ sudo raspi-config > Ifc. options > Camera
// $ npm install raspicam
const RaspiCam = require("raspicam");

const cam = new RaspiCam({
    mode: "photo", // or "video" by default 5s
    output: "./photo.jpg" // or "./video.h264"
});
cam.start();
```

Edge computing use cases

Categories* of use cases enabled by edge computing:

- Analytics
- Sensor fusion
- Embedded vision
- Embedded machine learning

*There might be some overlap.

AWS IoT GreenGrass

AWS IoT GreenGrass is Amazon's edge gateway offer.

"AWS IoT Greengrass seamlessly extends AWS onto physical devices so they can act locally on the data they generate, while still using the cloud for management, analytics, and durable storage."

See AWS IoT GreenGrass documentation for details, including a Raspberry Pi (3B+) GPIO Connector.

Azure IoT Edge

Azure IoT Edge is Microsoft's edge gateway project.

"Cloud intelligence deployed [...] on IoT edge devices"

The gateway code, used as a template, is open source.

It runs on a Raspberry Pi, but not on the Pi Zero W.

See the Azure IoT Edge documentation for details.

Baetyl

Baetyl by Baidu is an edge gateway to "extend cloud computing, data & service seamlessly to edge devices"

It integrates with the Baidu cloud management suite.

The gateway code is open source and runs on the Pi.

See the Baetyl docs and LFEdge.org docs for details.

Eclipse Kura

Eclipse Kura is an open source IoT Edge Framework.

It's based on Java/OSGi, runs on Raspberry Pi (2/3), and offers API access to Serial ports, GPIOs, I2C, etc.

Local *field protocols* include Modbus, OPC-UA and S7, transformed to MQTT with flow programming.

See the Eclipse Kura documentation for details.

EdgeX Foundry

EdgeX Foundry is a "open platform for the IoT edge"

The edge gateway microservice code is open source.

Communication is based on ZeroMQ, services in Go.

See the EdgeX Foundry documentation for details.

Hands-on, 10': Edge gateways

Chose one of the edge gateway projects and analyse it.

Which protocol is used to transmit data to the cloud?

How are updates deployed to the gateway, by whom?

How can a proprietary local protocol be integrated?

Be prepared to present your results.

Embedded vision/machine learning

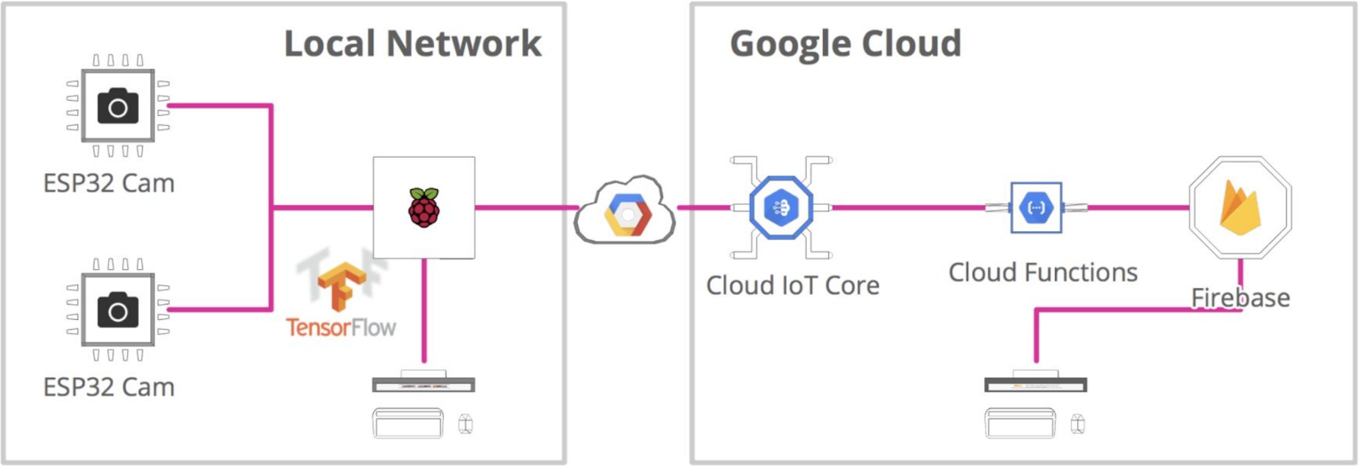
Devices like Nvidia Jetson Nano, Coral Dev Board and Raspberry Pi add-ons like the Intel Movidius or the Coral USB accelerator bring ML to "the edge".

Smaller devices with integrated cameras, like JeVois, Pixy, OpenMV cam, or Sipeed MAix let "things" see.

Machine learning here means *inference*, but *training* models gets easier, too — e.g. with EdgeImpulse.

Asset Tracking using Cameras, ×

A Medium Corporation [US] | https://medium.com/google-cloud/image-tracking-using-iot-machine-learning-and-edge-computing-8ad7e298b041



Asset Tracking using Cameras, IoT, Machine Learning and Edge Computing.

Synthetic Sensors

Synthetic Sensors is a nice edge-computing example.

It uses a mic and machine learning to "hear" events.

And also sensor fusion to further reduce uncertainty.

The setup and features are described in this paper.

Consider watching the video.

JeVois (2017)

The JeVois is an open source machine vision camera.

It is self-contained, with a 4 core CPU, USB & UART.

It runs OpenCV, TensorFlow, Caffe, Darknet < 50$.

It processes video and outputs Serial ASCII strings.

It can detect faces, barcodes, and "salient" events.

Google AIY (2017)

Google AIY is a Do-it-Yourself machine learning kit.

It's based on a Raspberry Pi Zero W with a "bonnet".

A Intel Movidius VPU processes video from a Pi cam.

It detects "joy".

Or cat/dog/etc.

See ML models.

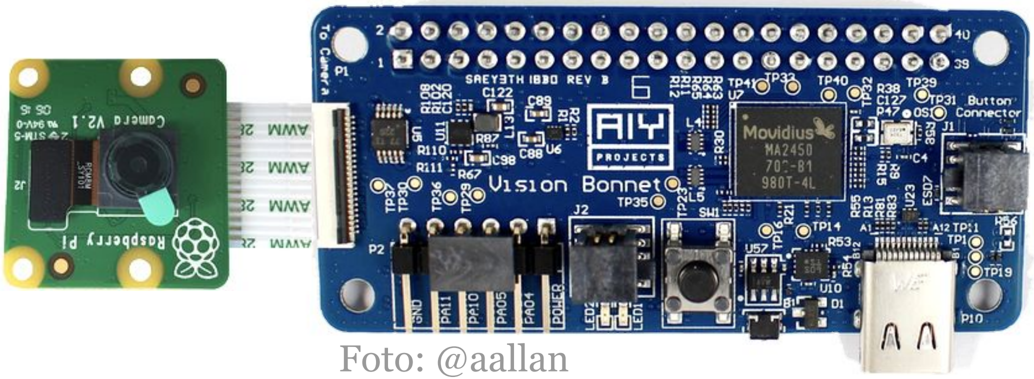


Foto: @aallan

Snips.ai (2018)

Snips.ai is a simple, private-by-design voice assistant.

The hardware kit is a Raspberry Pi with a mic array.

Intents are formatted similar to AWS Alexa intents.

Inference happens on the device, not in the cloud.

Federated learning allows gradual improvement.

Google explains federated learning in this post.

Coral Edge TPU (2019)

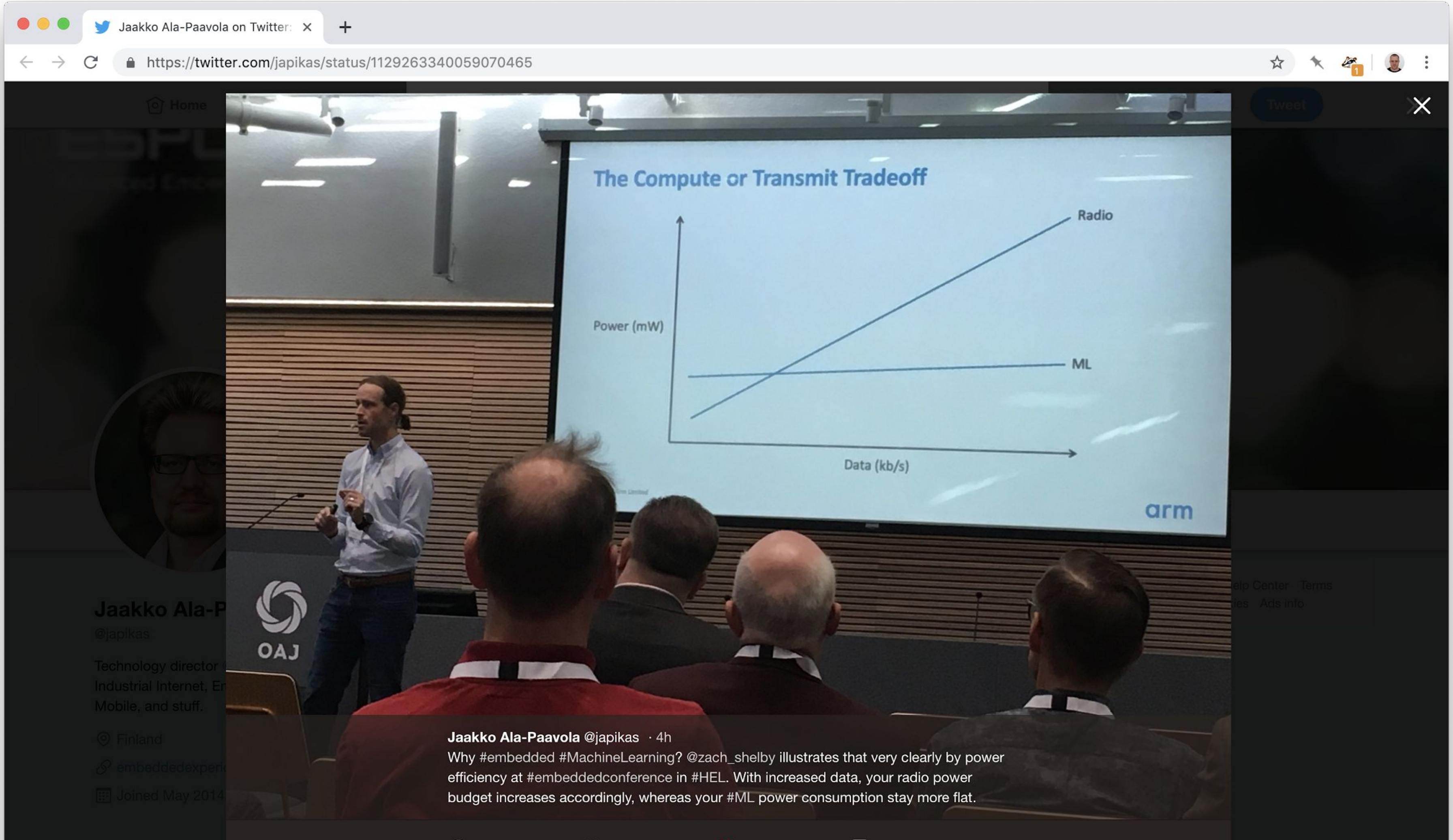
The Coral Edge TPU is available as a *USB accelerator*.

It speeds up ML inference on Linux / Raspberry Pi.

The USB "coprocessor" runs TensorFlow Lite models.

A Python API allows performing image classification, object detection, and transfer-learning on your device.

There is Coral documentation to get started.


Jaakko Ala-Paavola on Twitter:
https://twitter.com/japikas/status/1129263340059070465
Home
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The Compute or Transmit Tradeoff
Radio
Power (mW)
ML
Data (kb/s)
arm
OAJ
Jaakko Ala-Paavola @japikas · 4h
Why #embedded #MachineLearning? @zach_shelby illustrates that very clearly by power efficiency at #embeddedconference in #HEL. With increased data, your radio power budget increases accordingly, whereas your #ML power consumption stay more flat.
Technology director
Mobile, and stuff.
Finland

SparkFun Edge Development B ×

SparkFun Electronics [US] | https://www.sparkfun.com/products/15170

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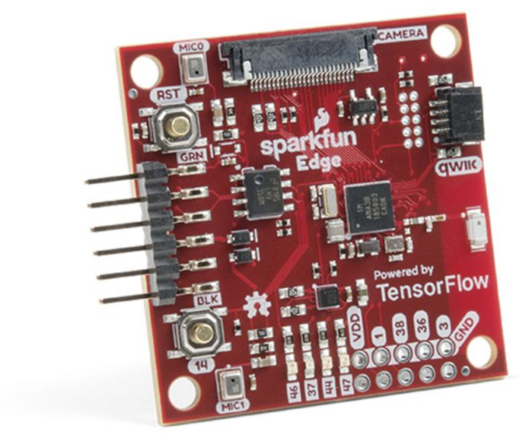
HOME / PRODUCT CATEGORIES / MACHINE LEARNING AND AI / SPARKFUN EDGE DEVELOPMENT BOARD - APOLLO3 BLUE



SparkFun Edge Development Board - Apollo3 Blue

DEV-15170

★★★☆☆ 6

$14.95

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Click here for info

Notify Me We do not currently have an estimate of when this product will be back in stock.

- 1 +   BACKORDER

Stock availability

DESCRIPTION   FEATURES   DOCUMENTS

Edge computing is here! You've probably heard of this latest entry to the long lineage of tech buzzwords like "IoT," "LoRa," and "cloud" before it, but what is "the edge" and why does it matter? The cloud is impressively powerful but all-the-time connection requires power and connectivity that may not be available. Edge computing handles discrete tasks such as determining if someone said "yes" and responds accordingly. The audio analysis is done at the edge rather than on the web. This dramatically reduces costs and complexity while limiting potential data privacy leaks.

In collaboration with Google and Ambiq, SparkFun's Edge Development Board is based around the

Hands-on, 10': Embedded ML use cases

Assuming a devices can know your face, voice, mood.

Which new use cases become possible with edge ML?

Try to take a "thing centered" perspective, as a device.

Be prepared to present your results.

Summary

We defined edge-computing as "local intelligence".

We learned to access GPIO pins on a Raspberry Pi.

We looked at and compared edge gateway projects.

We understand main use cases of edge computing.

Next: From prototype to connected product.

Feedback or questions?

Write me on Teams or email

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Thanks for your time.