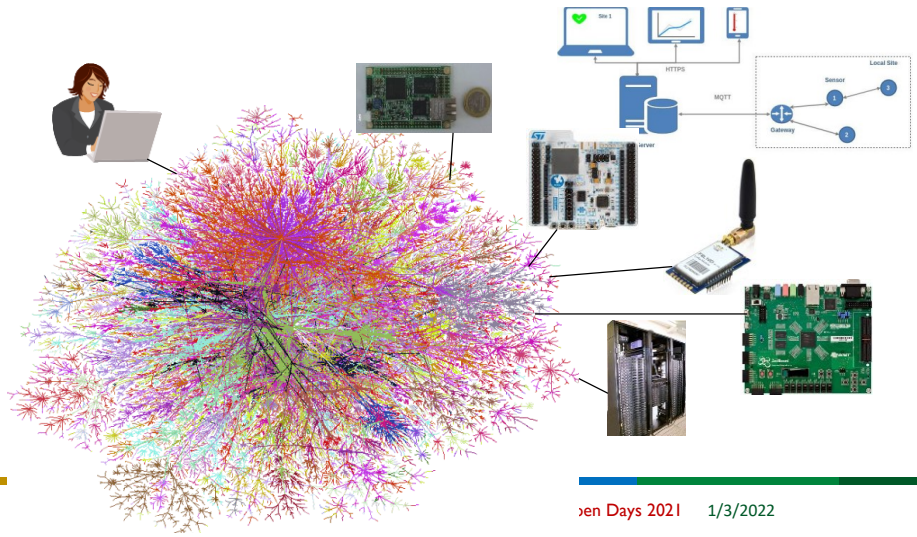
# Industrial IOT

Intro

1

## Internet of Things, Cloud, Image Processing, Machine Learning



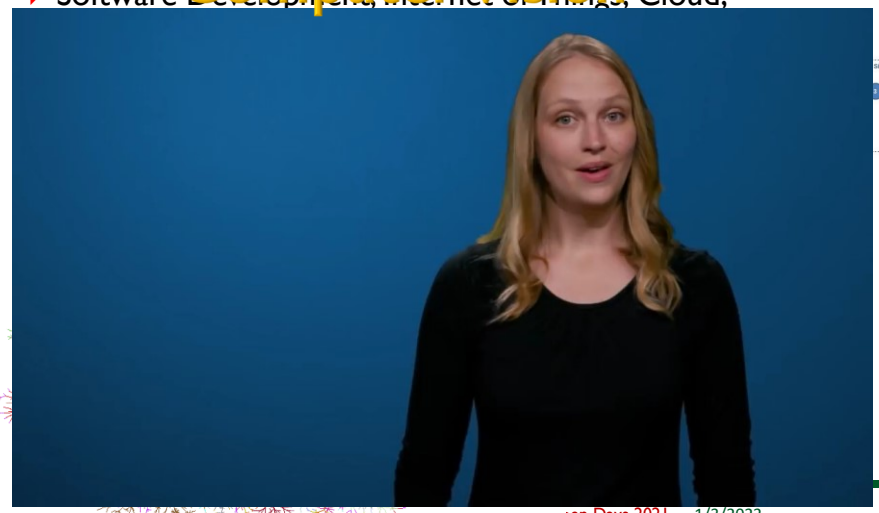



2

## R&D at the Department of Electrical and Computer Engineering

- Software Development, Internet of Things, Cloud,

Computer Vision

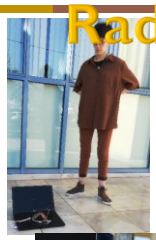


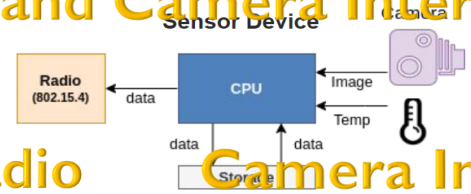


3

## R&D at the Department of Electrical and Computer Engineering

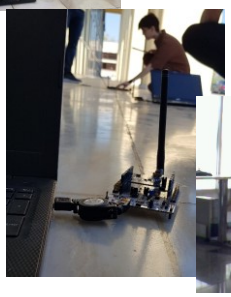
Radio and Camera Interface






Radio

Camera Interface

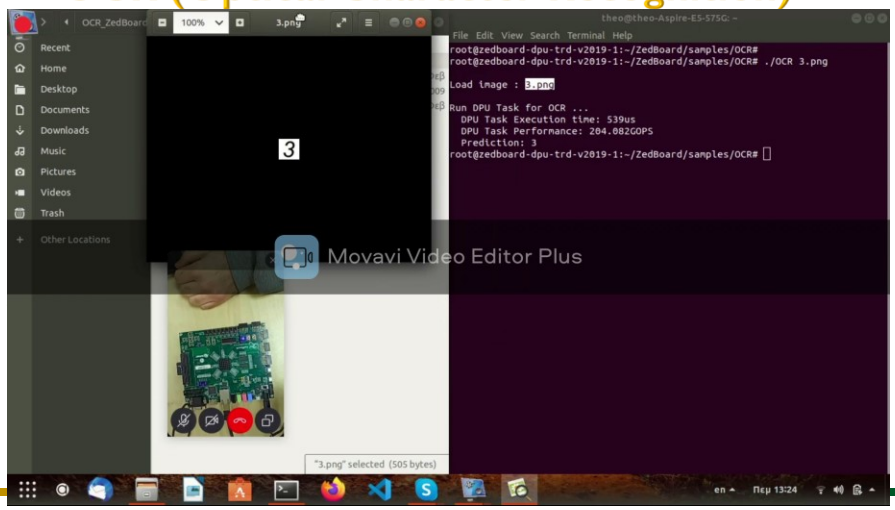




4

R&D at the Department of
Electrical and Computer Engineering

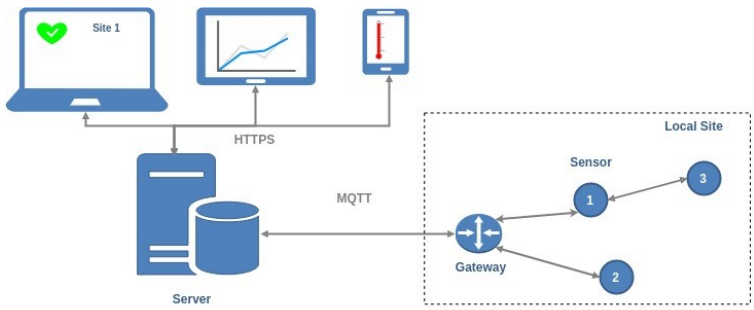
## OCR (Optical Character Recognition)






5

## IOT System example

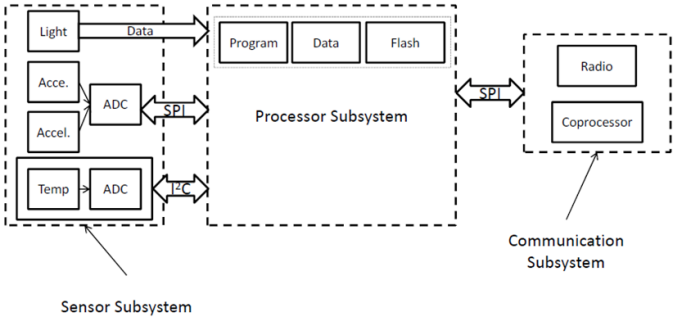



At this IOT system example, a set of sensor devices is deployed to a local site (e.g. a building), monitors the environment and collects sensor data (temperature, humidity, etc). These sensor devices and an IP enabled gateway (a device that has internet access) create a local network that is called Wireless Sensor Network (WSN) and use it to send their data to the cloud for further processing and analysis.

6

6

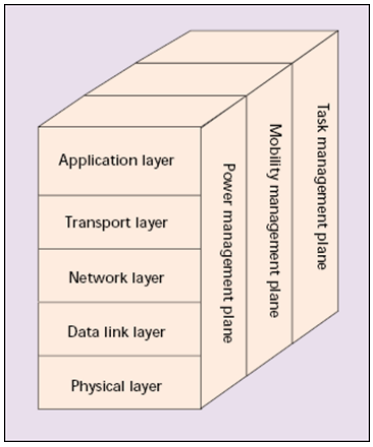
# Wireless Sensor Node: Components




The basic architecture of a WSN node includes a microcontroller unit (processor subsystem) which collects several types of data (temperature, humidity, light) from a sensor subsystem and forwards them to a transceiver (communication subsystem), who transmits them using radio frequencies (RF)

7

# Wireless Sensor Network Protocols



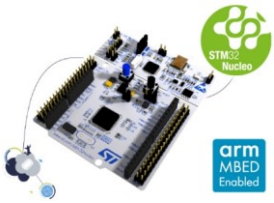

- The sensor networks protocol stack.
  - This protocol stack combines:
    - Power
    - Routing awareness
    - Integrates data with networking protocols, communicates power efficiently and promotes cooperative efforts of sensor nodes

The massive majority of commercial WSN protocols, like LoRa, ZigBee and Bluetooth implement the physical, the data link and the network layer.
The user can implement his own logic in the application layer.

8

# STEVAL-FKI868

S2LP
Transceiver



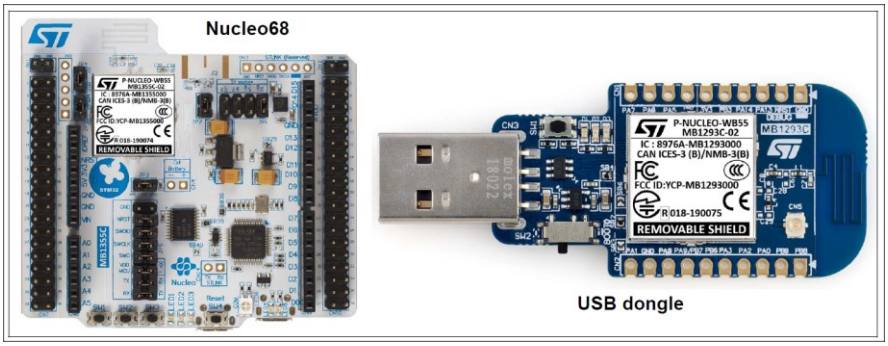

ST Nucleo MCU

STEVAL-FKI868
Development Kit

The STEVAL-FKI868 (from STMicroelectronics) Development Kit consists of a microcontroller unit and a transceiver, that are serially connected with a serial interface (SPI). Through the microcontroller the user can configure several parameters of the transceiver like the modulation scheme, the signal's bandwidth, the data rate and more. In practice, the user is able to implement his own physical, data link and network layers according to the requirements of the application.

9

# P-NUCLEO-WB55

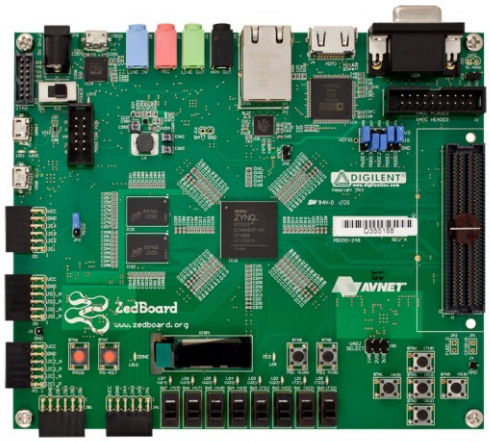



The P-NUCLEO-WB55 pack is a multi-protocol wireless and ultra-low-power device embedding a powerful and ultra-low-power radio compliant with the Bluetooth® Low Energy (BLE) SIG specification v5.0 and with IEEE 802.15.4-2011.

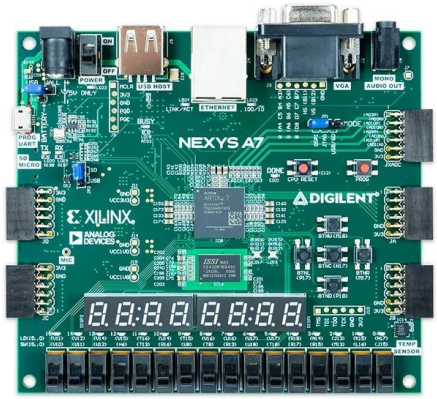
10

# FPGA for Edge IoT

https://www.xilinx.com/products/boards-and-kits/1-8dyf-11.html

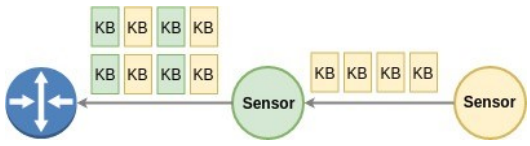


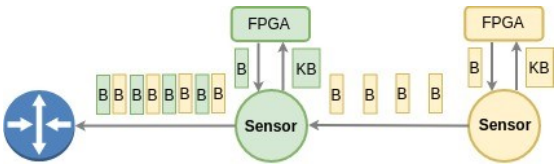

https://store.digilentinc.com/nexys-a7-fpga-trainer-board-recommended-for-ece-curriculum/




11

# FPGA Analytics - Example 1




Usually, these sensor devices transfer a large amount of data that must be forwarded to the cloud.

When a sensor device is upgraded with an FPGA, it can process the sensor data locally and instead send a smaller amount of data (the result of the analysis) to the cloud.

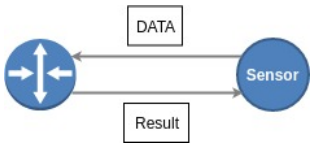
**Benefits**

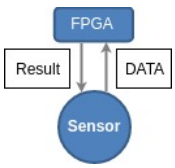
- Data compression
- Power efficiency
- Larger network capacity

12

12

# FPGA Analytics - Example 2




There are specific cases where the result of the analysis must be transferred back to the sensor device in order to notify the user based on the outcome.

For example, the sensor device should notify the user (using a LED) to do a specific action when the temperature exceeds a specific threshold.

In this case, the FPGA enables the device to locally process the data and to avoid the data roundtrip.

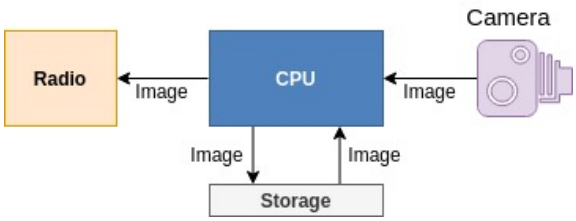
**Benefits**

- Skip unneeded RF communication
- Increased reliability when lossy RF communication
- Decreased latency
- Power efficiency
- Autonomy

13

13

# Image Processing - CPU only solution

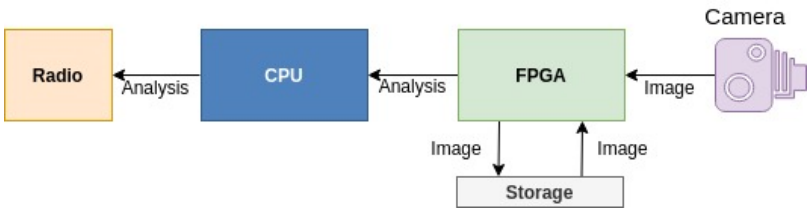



This is a standard IOT image processing solution, where the CPU collects images from a camera, temporarily stores them to a local storage (e.g. flash) and later on forwards them to another device to be processed.

14

14

# Image Processing - FPGA analytics



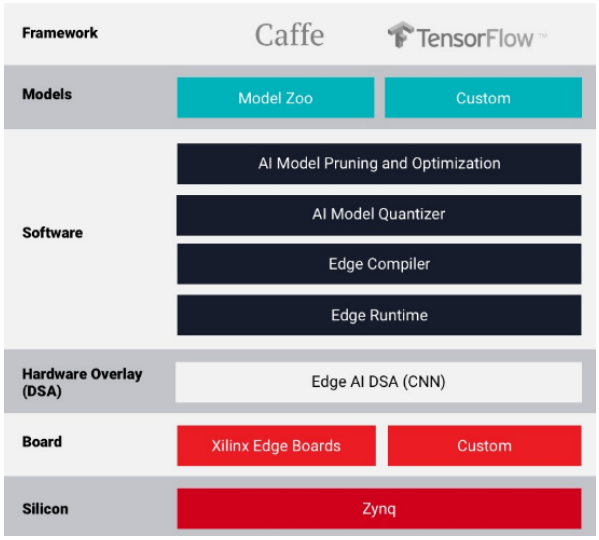

This is alternative solution for IOT image processing, where the device uses an FPGA to directly process the images and forwards the result of the analysis instead of the actual image. This solution has various benefits compared to the previous one:

- The **Analysis Result** transfer instead of the **Input Image** reduces power the consumption and the transfer delay (usually the analysis is way smaller than the image).
- Local analysis can now be used for local actions (e.g. the device can now notify the user that there is an issue using a *siren* or a *LED*).
- The system has better performance because the FPGA can sample images in a faster pace while in parallel can store them at the storage.

15

15

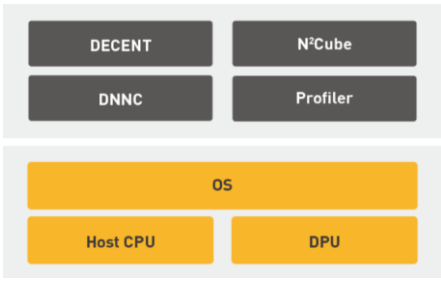
# Xilinx DNNDK (Deep Neural Network Development Kit)

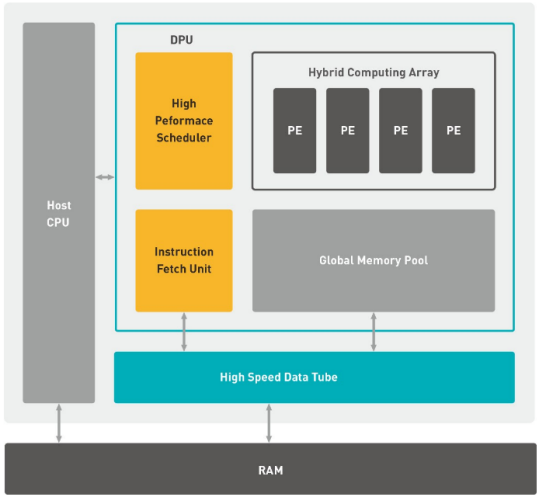



16

16

# Xilinx DNNDK

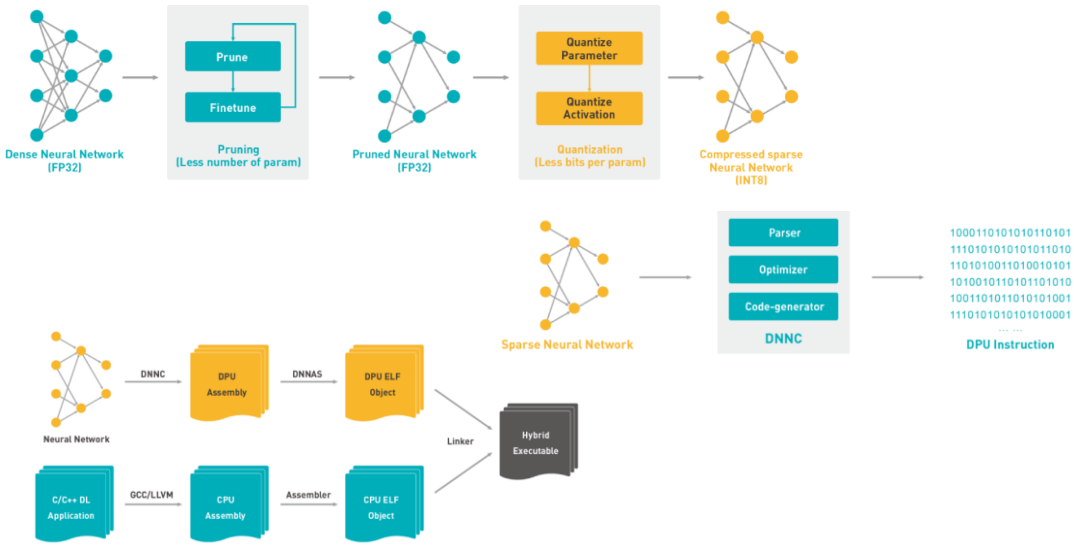



17

17

# Xilinx DNNDK




18

18