# Advanced Internet of Things Technologies

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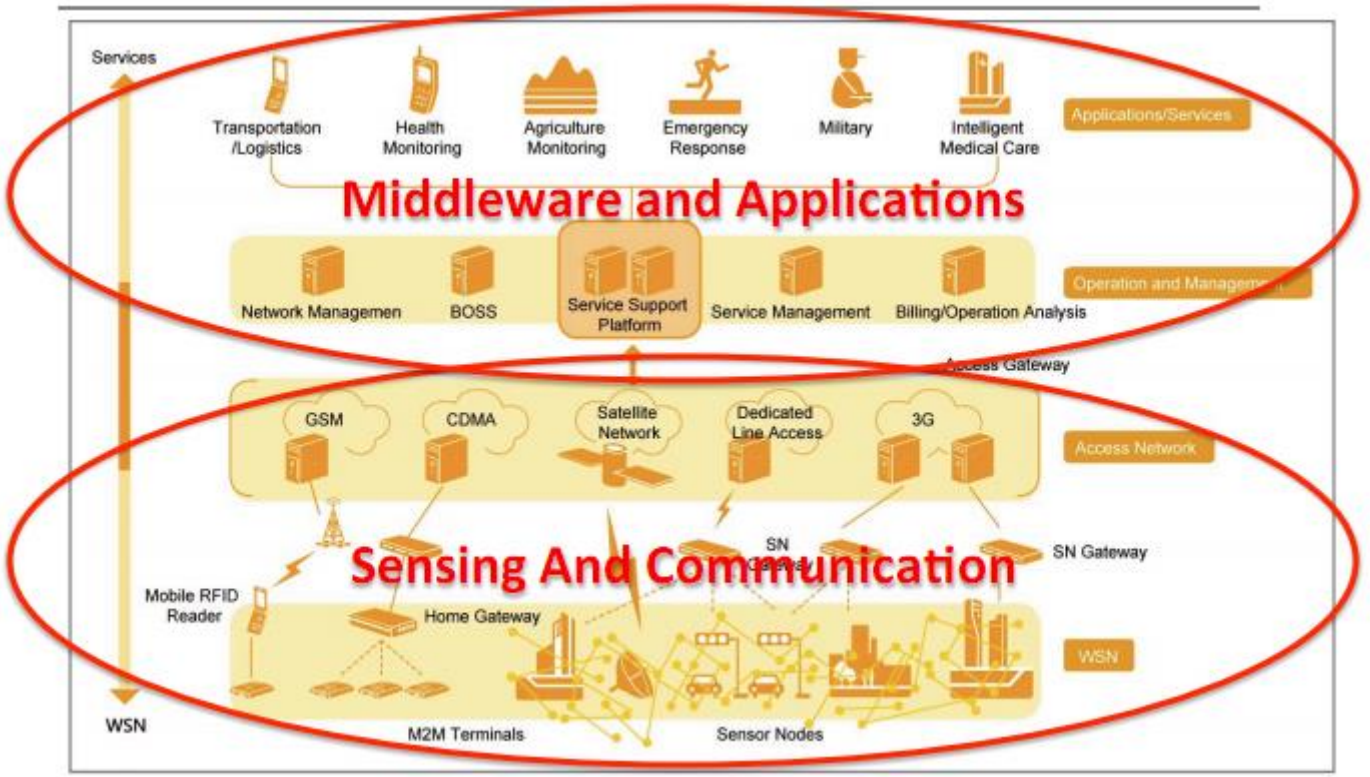
# Chapter 2: IoT Hardwares

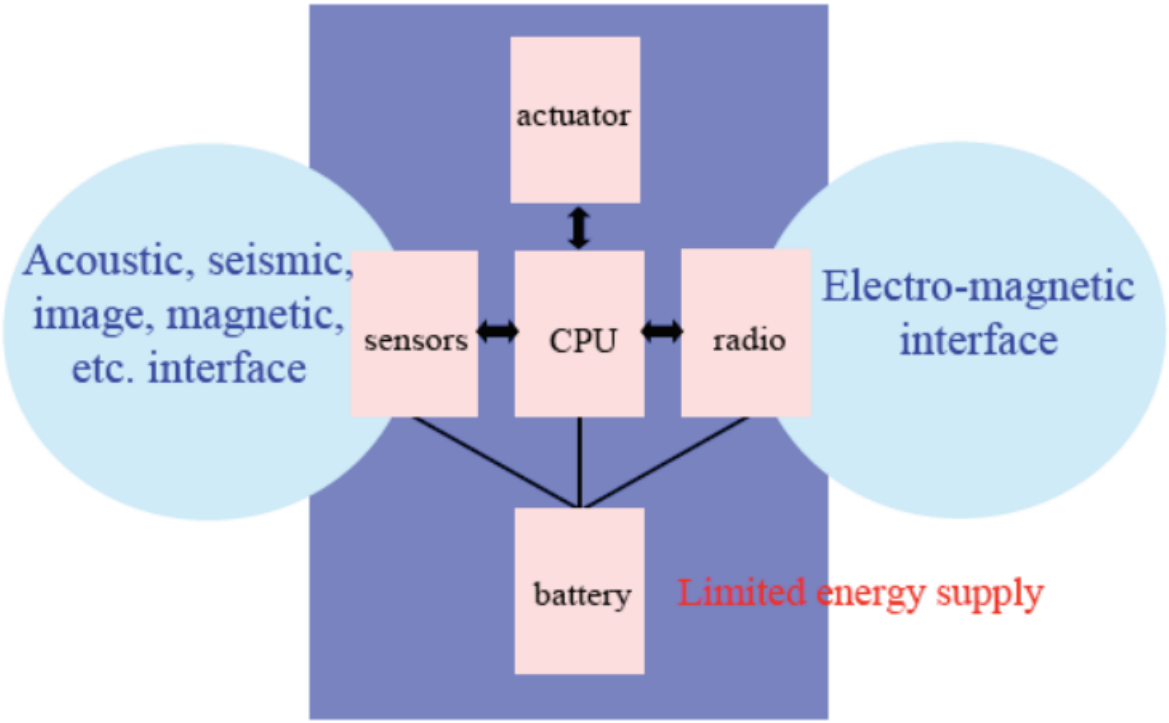
- Hardware Platforms
- Hardware Classes
- Some used hardwares
- Sensors and Actuators

# IoT Layered Architecture




- Source: ZTE

# IoT Hardware Platforms

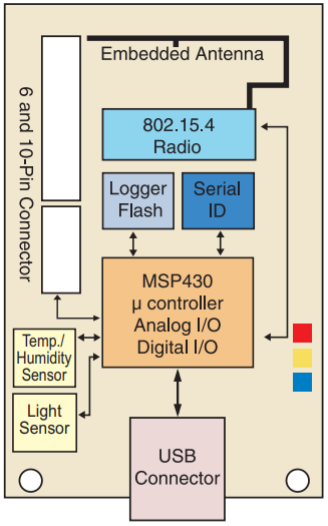


# IoT Hardware Classes

- Class0 devices have the smallest resources (<<10kB of RAM and <<100kB Flash); e.g., a specialized mote in a Wireless Sensor Network (WSN).
- Class1 devices have medium-level resources (≈10kB of RAM and ≈100kB Flash)
- Class2 devices have more resources, but are still very constrained compared to high-end IoT devices and traditional Internet hosts

# TelosB

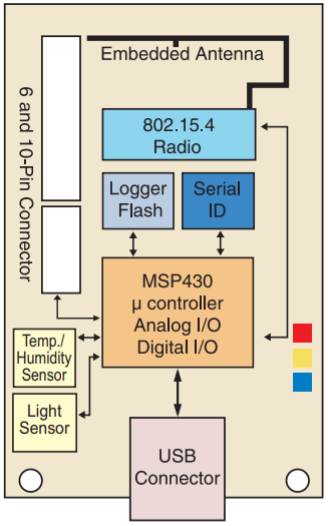
- IEEE 802.15.4 Compliant
- 250 kbps, High Data Rate Radio
- 2.4 to 2.4835 GHz, a globally compatible ISM band
- TI MSP430 Microcontroller with
- 10kB RAM
- Integrated Onboard Antenna
- Data Collection and Programming via USB Interface
- Open-source Operating System
- Integrated Temperature, Light and Humidity Sensor




TPR2420CA Block Diagram

# TelosB

- Support TinyOS 1.1, 2.0 and 2.1
- Power: 2 Pin AA 1.5V
- Communication to Gateway/PC via USB connector



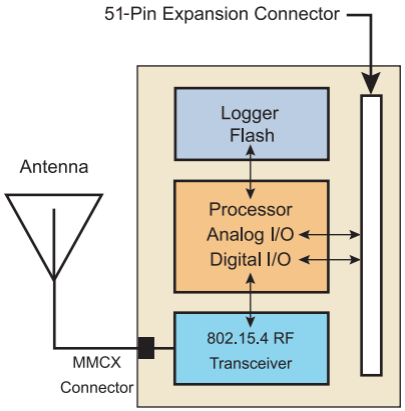

TPR2420CA Block Diagram

# TelosB

- Applications:
  - Platform for Low Power Research Development
  - Wireless Sensor Network Experimentation

# MicaZ

- IEEE 802.15.4 compliant RF transceiver
- 2.4 to 2.48 GHz, a globally compatible ISM band
- 250 kbps data rate
- Expansion Connector for Light, Temperature, RH, Barometric Pressure, Acceleration/Seismic, Acoustic, Magnetic and other MEMSIC Sensor Boards

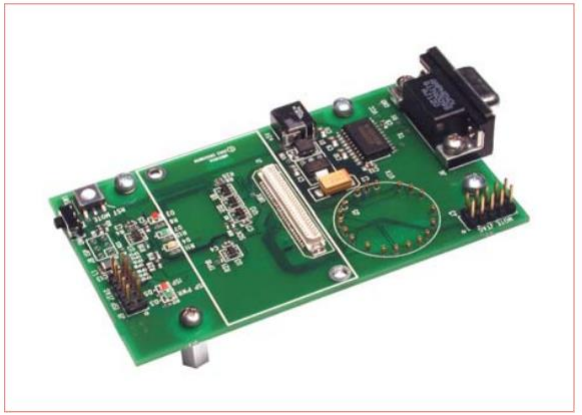


MPR2400 Block Diagram

# MicaZ

- Applications:
  - Indoor Building Monitoring and Security
  - Acoustic, Video, Vibration and Other High Speed Sensor Data
  - Large Scale Sensor Networks (1000+ Points)

▼ MIB510CA Mote Interface Board



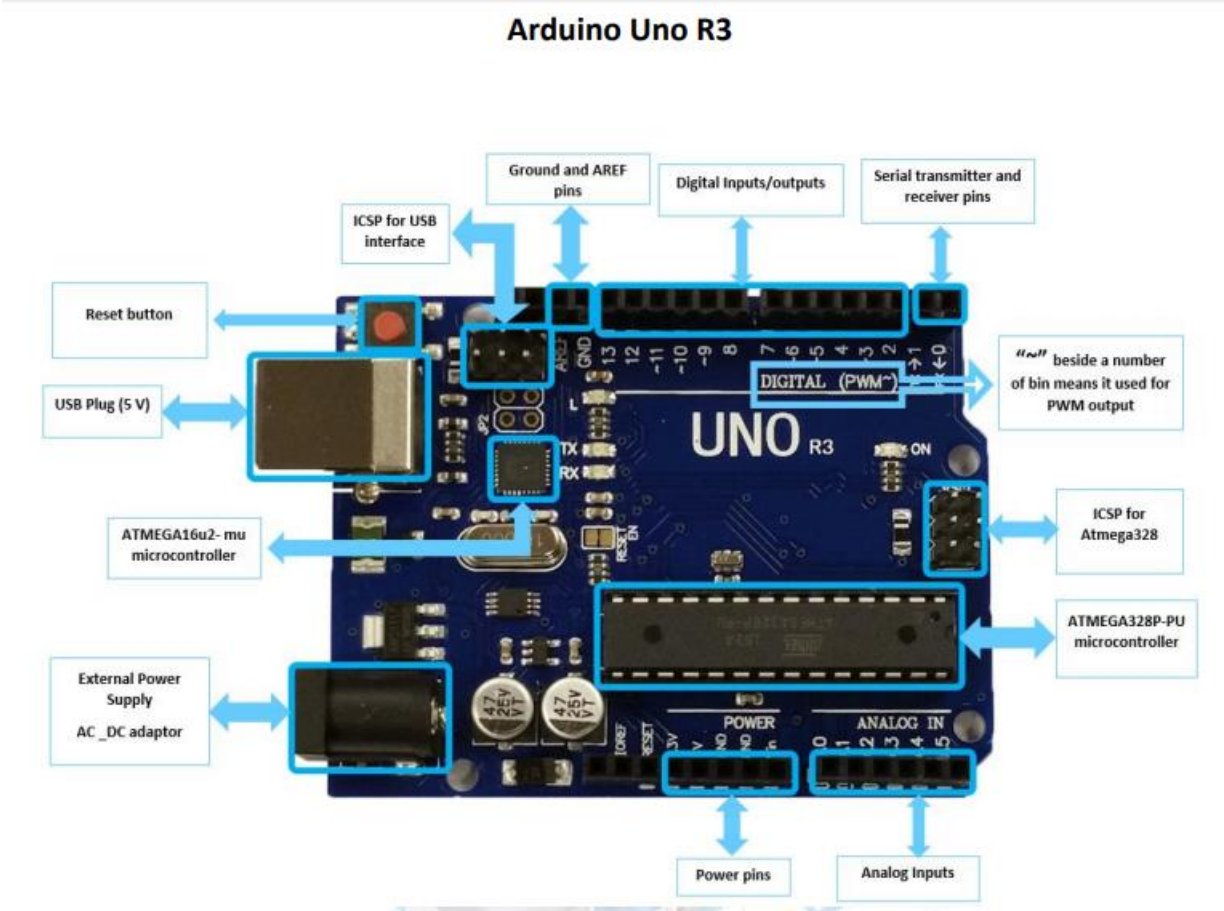
# Arduino UNO R3

- Microcontroller ATmega328
- Operating Voltage 5V
- Input Voltage (recommended) 7-12V
- Input Voltage (limits) 6-20V
- Digital I/O Pins 14 (of which 6 provide PWM output)

# Arduino UNO R3

- Analog Input Pins 6
- DC Current per I/O Pin 40 mA
- DC Current for 3.3V Pin 50 mA
- Flash Memory 32 KB (ATmega328) of which 0.5 KB used by bootloader
- SRAM 2 KB (ATmega328)
- EEPROM 1 KB (ATmega328)
- Clock Speed 16 MHz

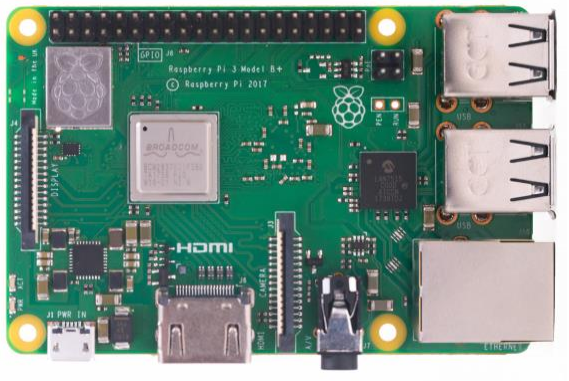
# Arduino UNO R3



# Arduino UNO R3

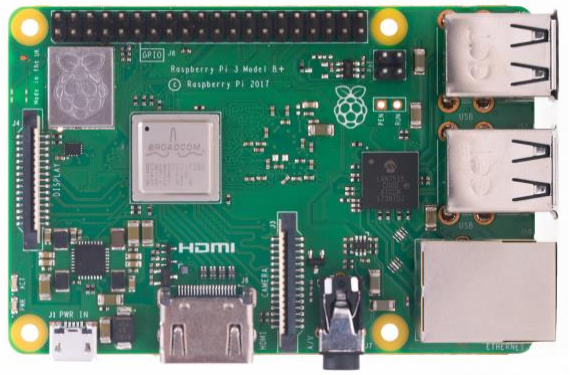
- Communication:
  - Ethernet Shield
  - Zigbee Shield
  - LoRa Shield
  - Wifi Shield (ESP8266)
  - Arduino GSM, GPRS, GPS, Bluetooth SIM808 Shield

# Raspberry PI 3



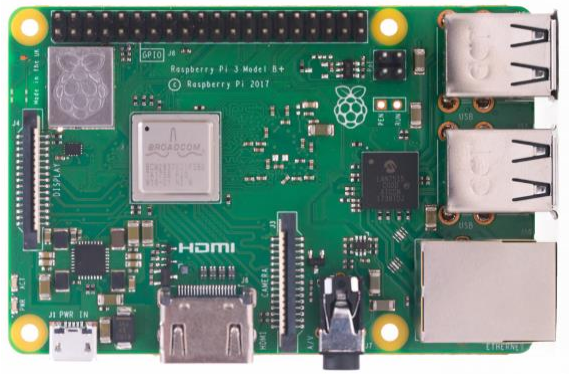
- Processor:
  - Broadcom BCM2837B0,
    quad-core A53 (ARMv8)
    64-bit SoC @1.4GHz
- RAM: 1GB LPDDR2 SDRAM
- Connectivity:
  - 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE
  - Gigabit Ethernet over USB 2.0 (maximum throughput 300Mbps)
  - 4 × USB 2.0 ports

# Raspberry PI 3



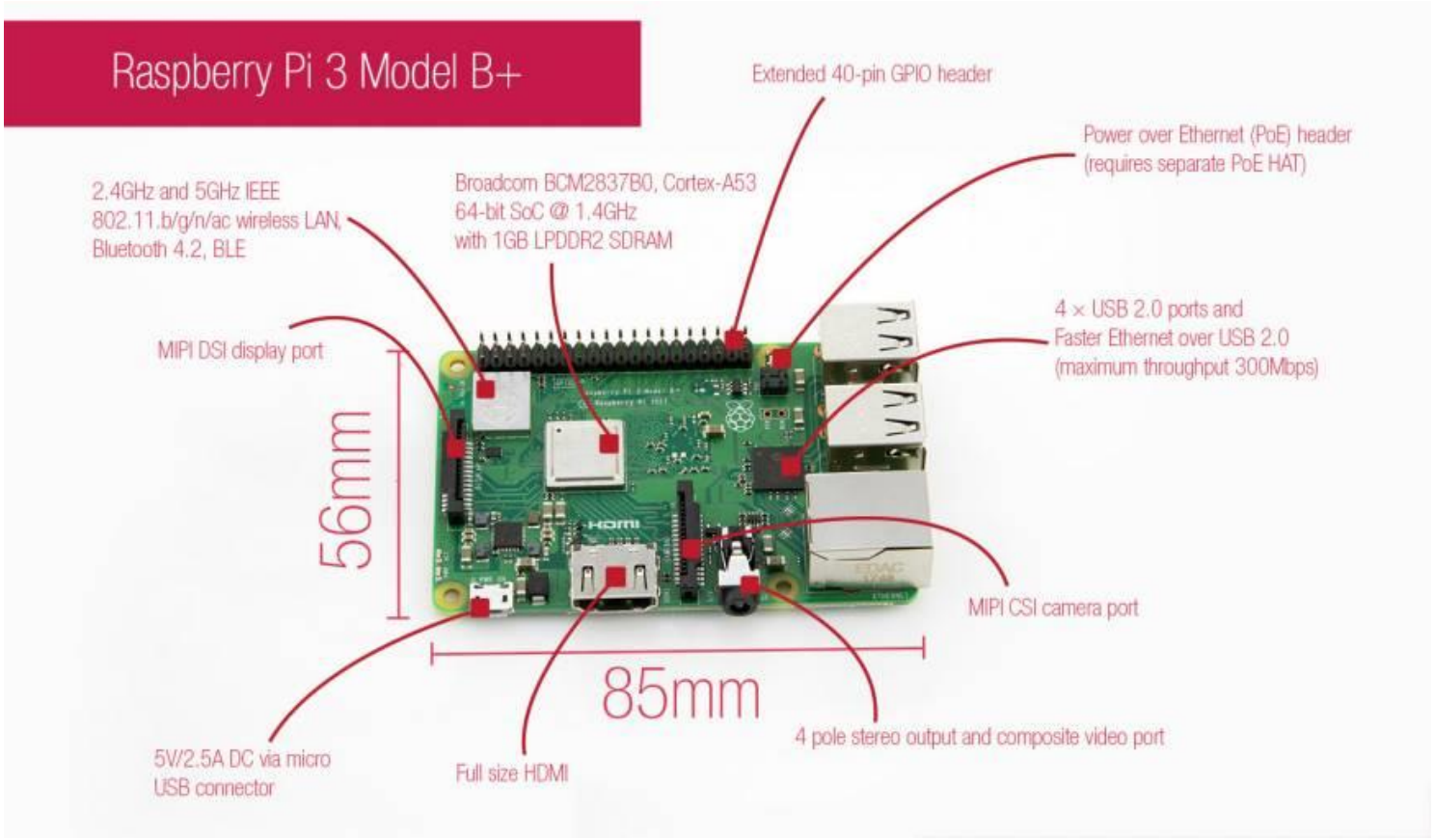

- Access:
  - Extended 40-pin GPIO header
- Video & sound:
  - 1 × full size HDMI
  - MIPI DSI display port
  - MIPI CSI camera port
  - 4 pole stereo output and composite video port
- SD card support:
  - Micro SD format for loading operating system and data storage

# Raspberry PI 3



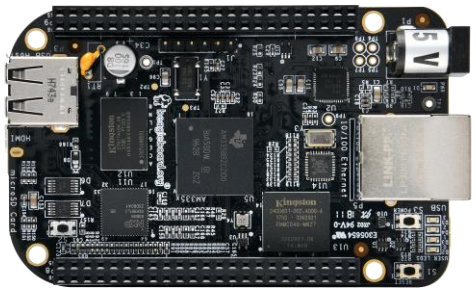
- Raspberry PI 3 can be used as
  - End devices
  - Edge/Fog/Gateway
- Operating system:
  - Raspbian
- Programming Languages:
  - Python, C/C++, JAVA, HTML5, JavaScript, …
- Some libraries:
  - TensorFlow
  - OpenCV

# Raspberry PI 3



# Beaglebone Black Rev C

- Processor:
  - Sitara AM3358BZCZ100 1GHz
- RAM:
  - 512MB DDR3L 800MHZ
- Flash:
  - 4GB, 8bit Embedded MMC
- Connectivity:
  - USB Client for power and communications
  - USB Host
  - Ethernet
  - Micro HDMI



# Beaglebone Black Rev C

- Access:
  - Extended 40-pin GPIO header
- Video & sound:
  - HDMI
- SD card support:
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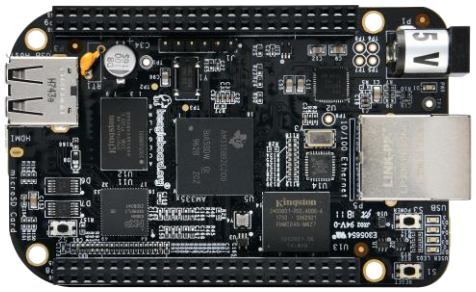
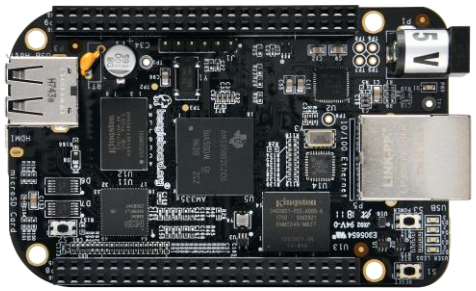


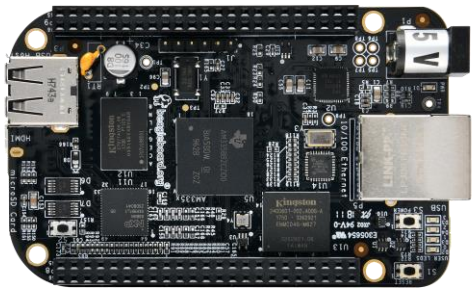
# Beaglebone Black Rev C

- Can be used as
  - End devices
  - Edge/Fog/Gateway
- Operating system:
  - Angstrom Linux
  - Android
  - Ubuntu
  - Cloud9 IDE on Node.js with BoneScript

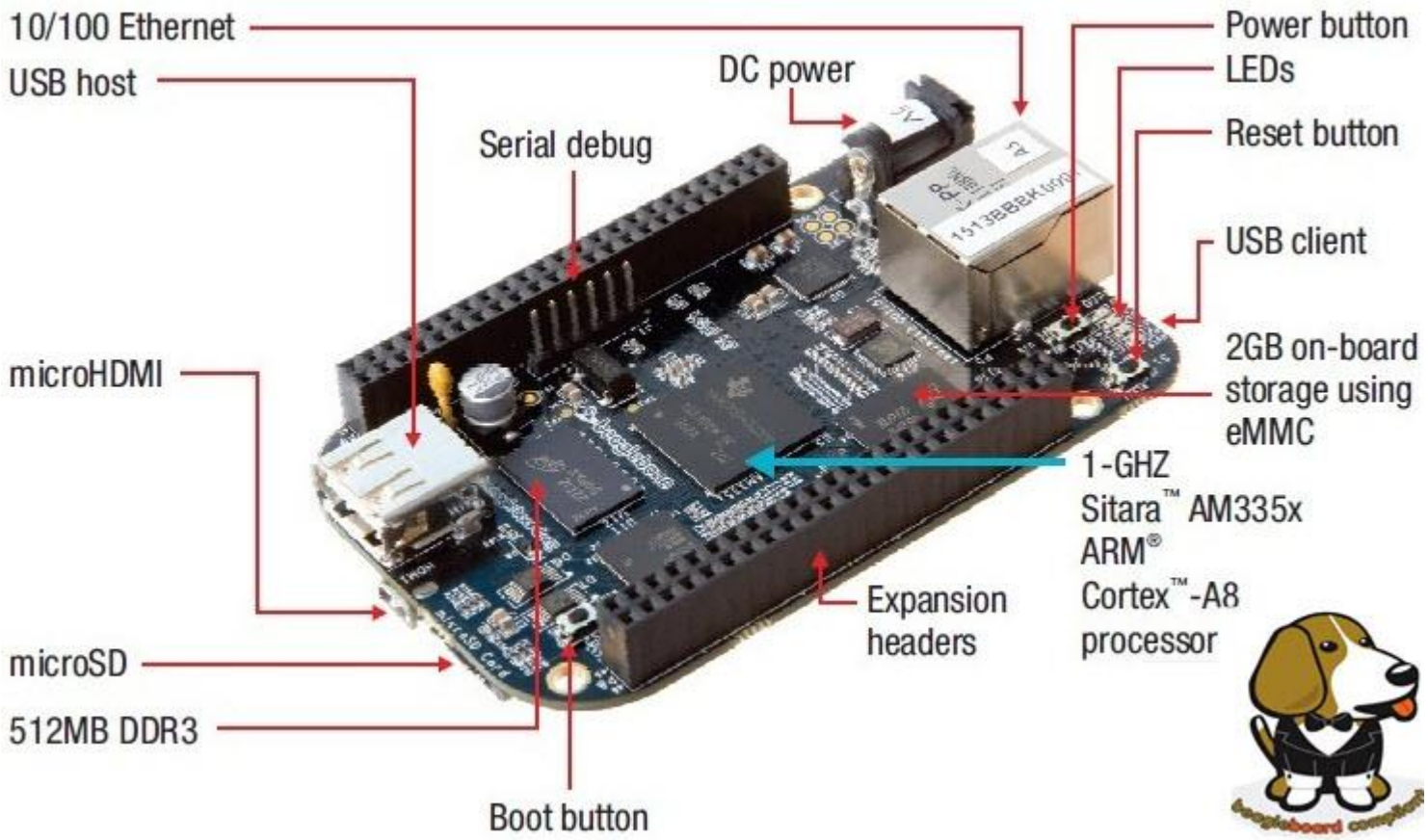


# Beaglebone Black Rev C

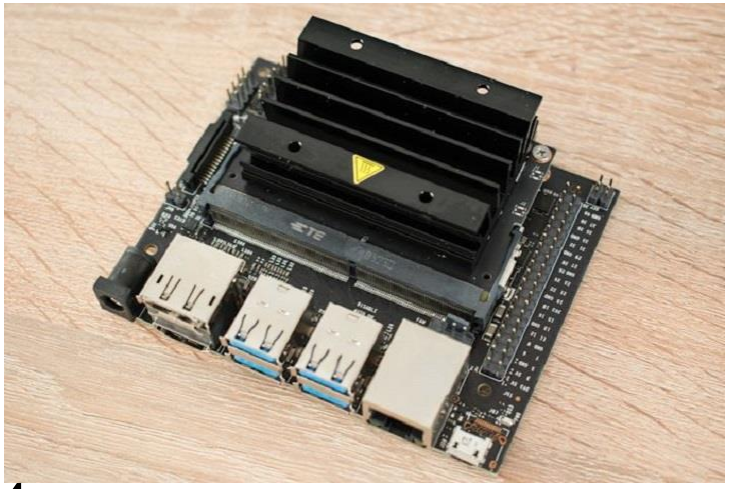
- Programming Languages:
  - C, C++, Python, Perl, Ruby, Java, or even a shell script, …
- Some libraries:
  - OpenCV



# Beaglebone Black Rev C



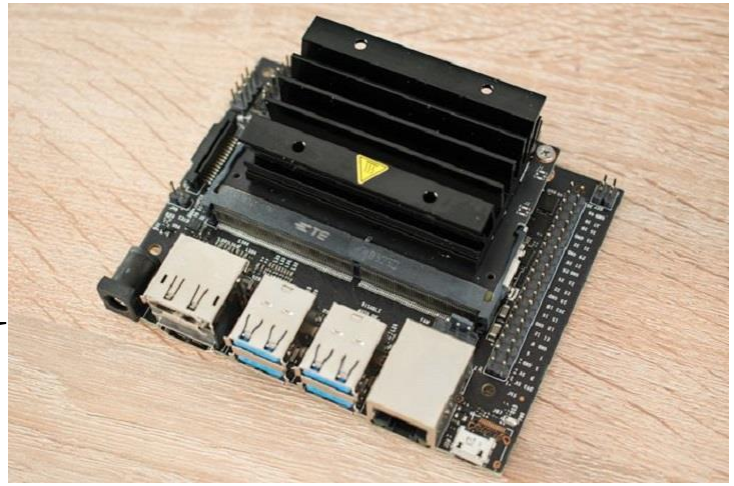
# Jetson Nano



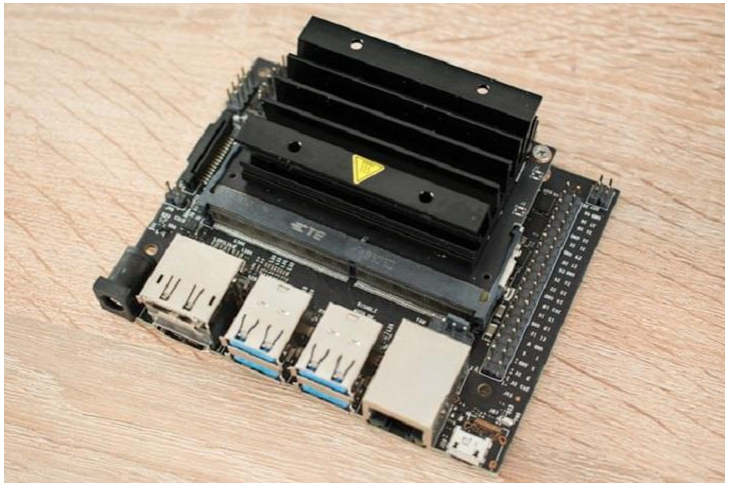
- GPU:
  - 128-core Maxwell™ GPU
- CPU:
  - ARM® Cortex®-A57 CPU
- RAM: 4GB 64-bit LPDDR4
- Storage:
  - microSD (devkit)
  - 16GB eMMC flash

# Jetson Nano

- Video:
  - Encode: 4K @ 30 (H.264/H.265)
  - Decode: 4K @ 60 (H.264/H.265)
- ARM® Cortex®-A57 CPU

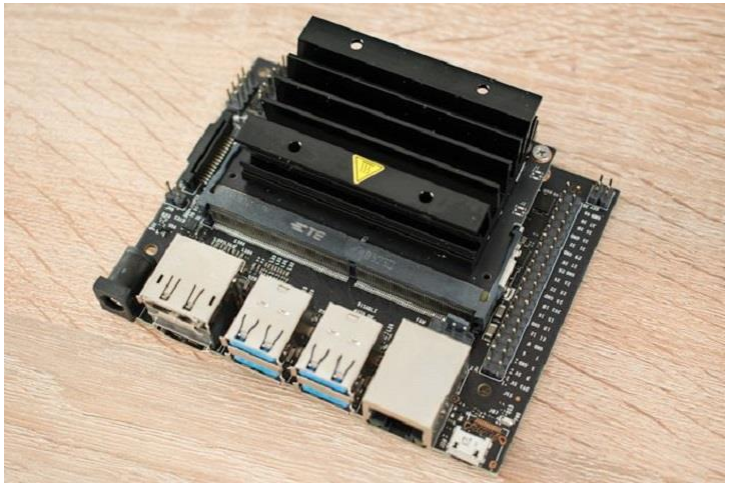


# Jetson Nano



- Interfaces:
  - GigaEthernet
  - Camera: 12-ch (3x4 OR 4x2) MIPI CSI-2 DPHY 1.1 (1.5Gbps)
  - Display: HDMI 2.0, DP (DisplayPort)
  - USB: 4x USB 3.0, USB 2.0 (Micro USB)
  - Others: GPIO, I2C, I2S, SPI, UART

# Jetson Nano



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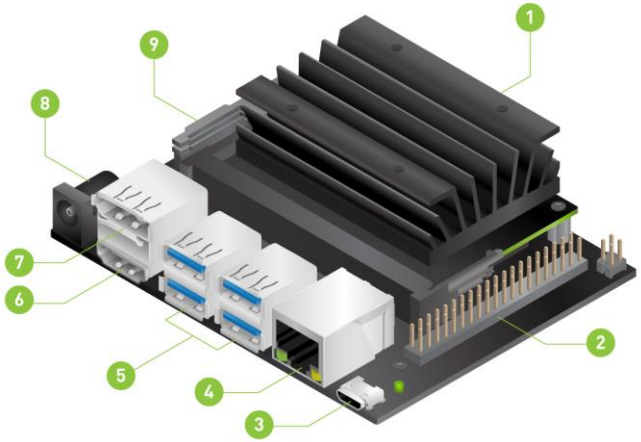
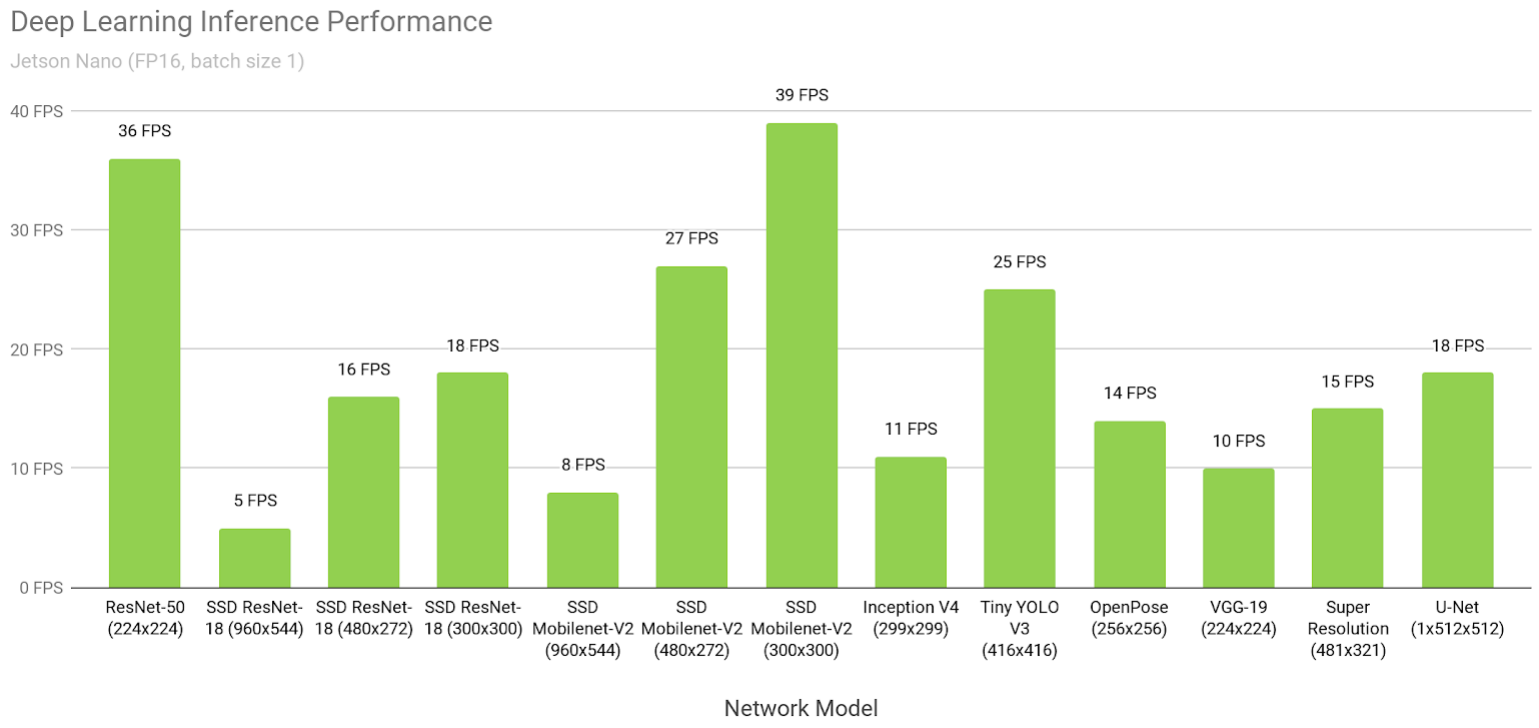
# Jetso Nano




1. microSD card slot for main storage
2. 40-pin expansion header
3. Micro-USB port for 5V power input or for data
4. Gigabit Ethernet port
5. USB 3.0 ports (x4)
6. HDMI output port
7. DisplayPort connector
8. DC Barrel jack for 5V power input
9. MIPI CSI camera connector


Deep Learning Inference Performance
Jetson Nano (FP16, batch size 1)
40 FPS
30 FPS
20 FPS
10 FPS
0 FPS
36 FPS
5 FPS
16 FPS
18 FPS
8 FPS
27 FPS
39 FPS
11 FPS
25 FPS
14 FPS
10 FPS
15 FPS
18 FPS
ResNet-50 (224x224)
SSD ResNet-18 (960x544)
SSD ResNet-18 (480x272)
SSD ResNet-18 (300x300)
SSD Mobilenet-V2 (960x544)
SSD Mobilenet-V2 (480x272)
SSD Mobilenet-V2 (300x300)
Inception V4 (299x299)
Tiny YOLO V3 (416x416)
OpenPose (256x256)
VGG-19 (224x224)
Super Resolution (481x321)
U-Net (1x512x512)
Network Model

# Jetson Nano

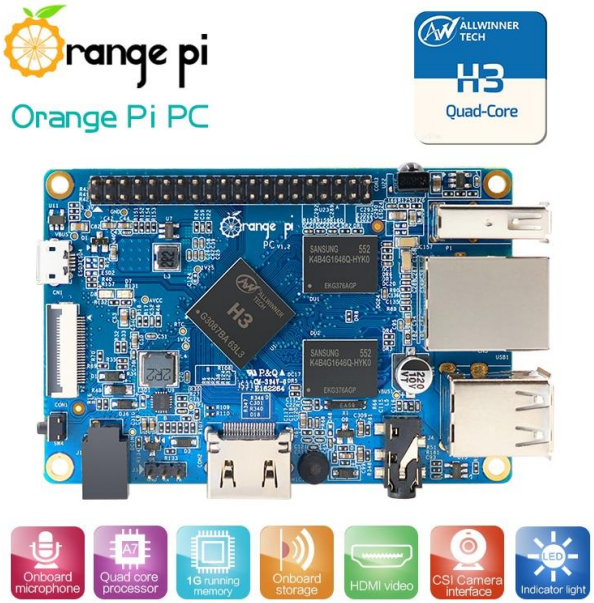
- AI model:
  - Object Detection
  - Semantic Segmentation
  - Semantic Segmentation – legacy,
  - Image processing

# Jetson Nano

```
khanhthuat@khanhthuat-desktop: ~/jetson-inference/build/aarch64/bin
networks/bvlc_googlenet.caffemodel initialized.
class 0941 - 0.012485  (acorn squash)
class 0954 - 0.976454  (banana)
image is recognized as 'banana' (class #954) with 97.645438% confidence


[TRT]   ------------------------------------------------
[TRT]   Timing Report networks/bvlc_googlenet.caffemodel
[TRT]   ------------------------------------------------
[TRT]   Pre-Process   CPU   0.25308ms  CUDA   2.09417ms
[TRT]   Network       CPU 122.99757ms  CUDA 120.21057ms
[TRT]   Post-Process  CPU   1.13659ms  CUDA   1.11083ms
[TRT]   Total         CPU 124.38725ms  CUDA 123.41557ms
[TRT]   ------------------------------------------------

[TRT]   note -- when processing a single image, run 'sudo jetson_clocks' before
                to disable DVFS for more accurate profiling/timing measurements

jetson.utils -- PyFont_New()
jetson.utils -- PyFont_Init()
jetson.utils -- PyFont_Dealloc()
jetson.utils -- freeing CUDA mapped memory
PyTensorNet_Dealloc()
```

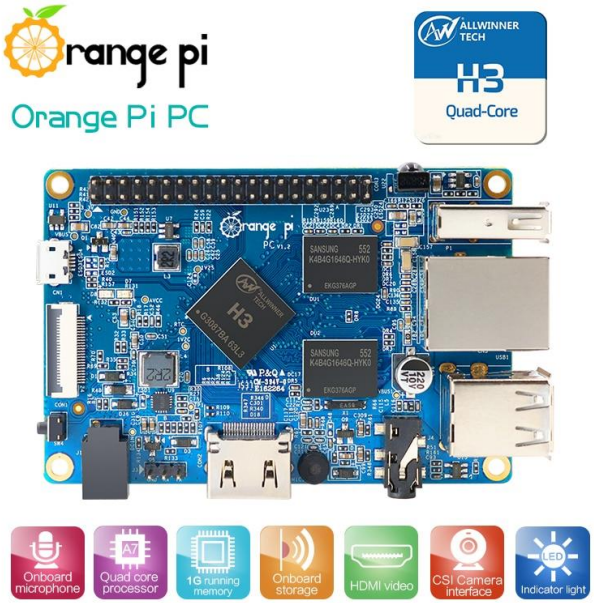
# Orange PI

- CPU
  - H3 Quad-core Cortex-A7 H.265/HEVC 4K
- GPU
  - Mali400MP2 GPU @600MHz
  - Supports OpenGL ES 2.0
- SDRAM
  - 1GB DDR3 (shared with GPU)
- Onboard storage
  - 8GB EMMC Flash

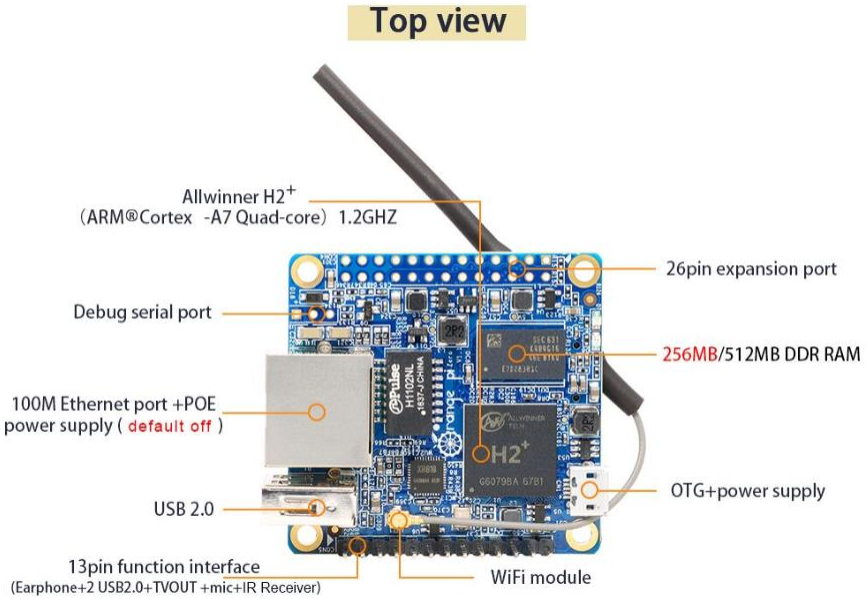


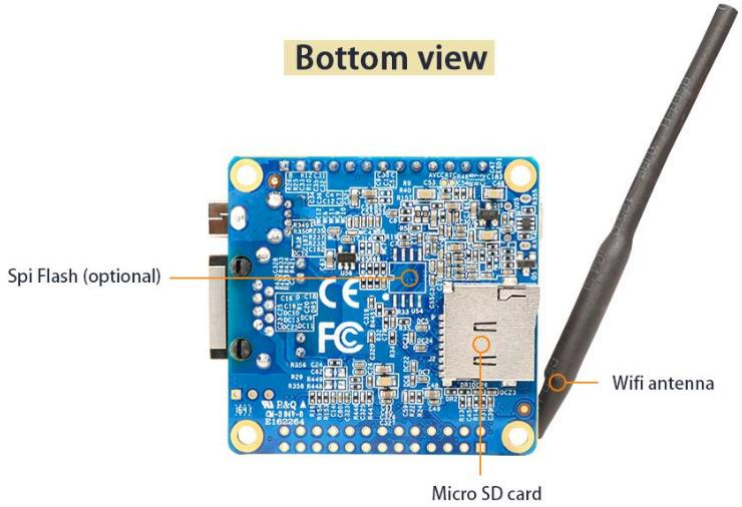
# Orange PI

- Network:
  - 10/100 Ethernet RJ45
- Operating System
  - Android
  - Ubuntu
  - Debian
  - Armbian



# Orange PI


Top view
Allwinner H2+
(ARM®Cortex -A7 Quad-core) 1.2GHZ
Debug serial port
100M Ethernet port +POE
power supply ( default off )
USB 2.0
13pin function interface
(Earphone+2 USB2.0+TVOUT +mic+IR Receiver)
26pin expansion port
256MB/512MB DDR RAM
OTG+power supply
WiFi module


Bottom view
Spi Flash (optional)
Wifi antenna
Micro SD card

| Model | Application | Framework | NVIDIA Jetson Nano | Raspberry Pi 3 | Raspberry Pi 3 + Intel Neural Compute Stick 2 | Google Edge TPU Dev Board |
|---|---|---|---|---|---|---|
| ResNet-50 (224×224) | Classification | TensorFlow | 36 FPS | 1.4 FPS | 16 FPS | DNR |
| MobileNet-v2 (300×300) | Classification | TensorFlow | 64 FPS | 2.5 FPS | 30 FPS | 130 FPS |
| SSD ResNet-18 (960×544) | Object Detection | TensorFlow | 5 FPS | DNR | DNR | DNR |
| SSD ResNet-18 (480×272) | Object Detection | TensorFlow | 16 FPS | DNR | DNR | DNR |
| SSD ResNet-18 (300×300) | Object Detection | TensorFlow | 18 FPS | DNR | DNR | DNR |
| SSD Mobilenet-V2 (960×544) | Object Detection | TensorFlow | 8 FPS | DNR | 1.8 FPS | DNR |
| SSD Mobilenet-V2 (480×272) | Object Detection | TensorFlow | 27 FPS | DNR | 7 FPS | DNR |
| SSD Mobilenet-V2 (300×300) | Object Detection | TensorFlow | 39 FPS | 1 FPS | 11 FPS | 48 FPS |
| Inception V4 (299×299) | Classification | PyTorch | 11 FPS | DNR | DNR | 9 FPS |
| Tiny YOLO V3 (416×416) | Object Detection | Darknet | 25 FPS | 0.5 FPS | DNR | DNR |
| OpenPose (256×256) | Pose Estimation | Caffe | 14 FPS | DNR | 5 FPS | DNR |
| VGG-19 (224×224) | Classification | MXNet | 10 FPS | 0.5 FPS | 5 FPS | DNR |
| Super Resolution (481×321) | Image Processing | PyTorch | 15 FPS | DNR | 0.6 FPS | DNR |
| Unet (1x512x512) | Segmentation | Caffe | 18 FPS | DNR | 5 FPS | DNR |

# Sensors

- Acceleration
- Gyroscope
- Magnetometer
- Temperature
- Pressure
- Image/Optical
- Rain
- Proximity
- Hall-effect
- Push-button/switch

# Actuators

- Indicators (LEDs, bulbs, LCDs)
- Motors
- Relays
- Speakers/Buzzers
- Heaters


Q & A