



UNIVERSIDAD
COMPLUTENSE
MADRID

IoT Node Architecture

Boards, Modules, SoCs, *cores*



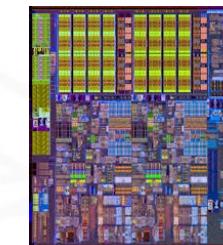
Dev Board



Module



System
On Chip
(SoC)



cores

Development Board

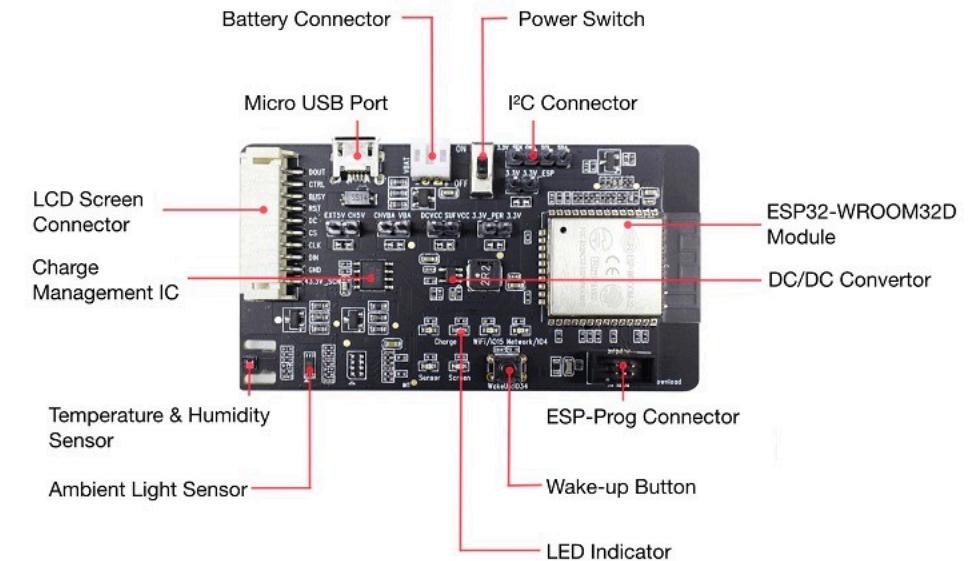
□ Development board (devKit....)

- Allows connecting several modules or SoC
- May expose certain SoC connection using pins
- May include buttons, LEDs, USB ports, FLASH memory
- May include logic to ease programming and debugging



ESP32 DevKitC

<https://www.espressif.com/en/products/devkits/esp32-devkitc>



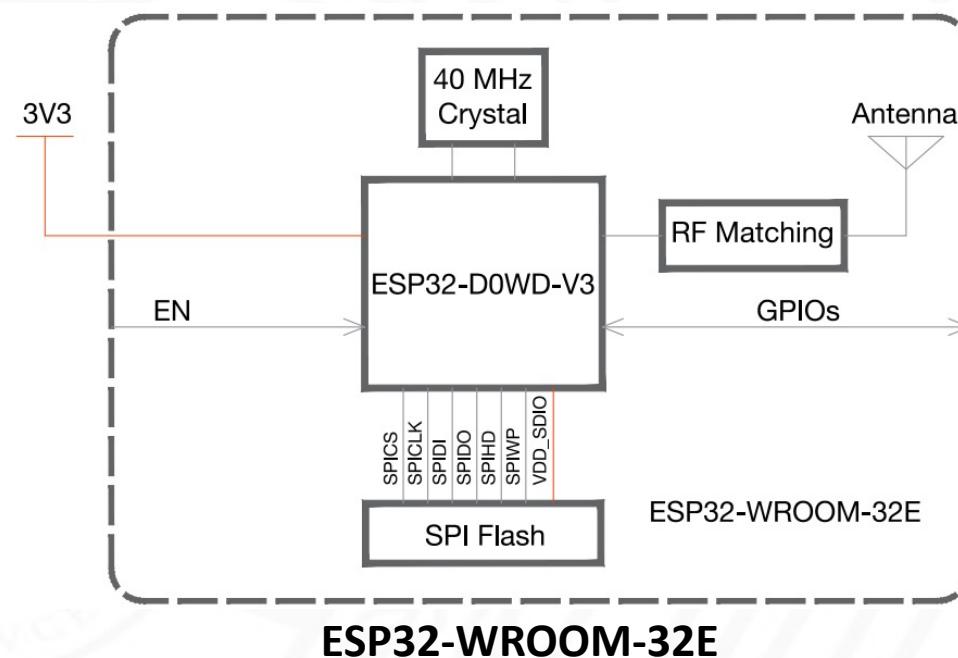
ESP32 Meshkit Sense

Module

❑ Module

- Supports several SoC models
- May include support for FLASH, GPIO, antennas
- May include quartz clock

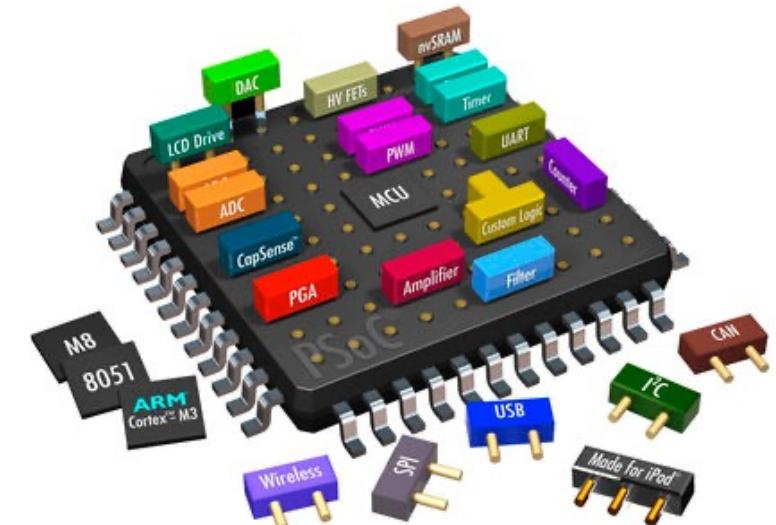
❑ Sometimes, the term SoC is used for the whole package



System-on-chip

□ *System-on-chip* (SoC) is a single chip integrating...

- One or more CPUs and other computing elements
- Memory
 - Usually NAND /NOR flash
- Several I/O devices
 - ADC / DAC
 - GPIO controller
 - PWM generators
 - Bus controllers: I2C, SPI, USB, CAN...



- Large number of companies in this sector
 - The investment/infrastructure is not as large as CPU design/fabrication
 - It is usually about *placing pieces* (CPUs, GPUS, interfaces...)
 - Links to know some relevant companies
 - <http://www.anandtech.com/show/8389/state-of-the-part-soc-manufacturers>
 - <https://www.bisinfotech.com/top-10-system-on-chip-soc-manufacturers-of-2020>
 - IP cores designers are also entering this market (ARM...)=
 - Or at least provide development tools to design custom SoC
 - <https://www.arm.com/develop/custom-system-on-chips>

STMicroelectronics

- Large company with years of experience
- <http://www.st.com/en/secure-mcus.html>
- <http://www.st.com/en/microcontrollers.html> (STM32 family)

Ultra-Low-Power

STM32L4 series – Ultra-Low-Power and Performance with DSP, FPU and ART Accelerator™

80 MHz Cortex-M4 CPU	Up to 1-Mbyte dual-bank Flash	Up to 320-Kbyte SRAM	USB 2.0 OTG FS	2x 16-bit advanced MC timer	DFSDM Op-amps	Quad-SPI FSMC SDIO	SHA-256 AES-256 TRNG	2x SAI 2x CAN Up to LCD 8x40	 STM32 L4
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STM32L1 series – Ultra-Low-Power

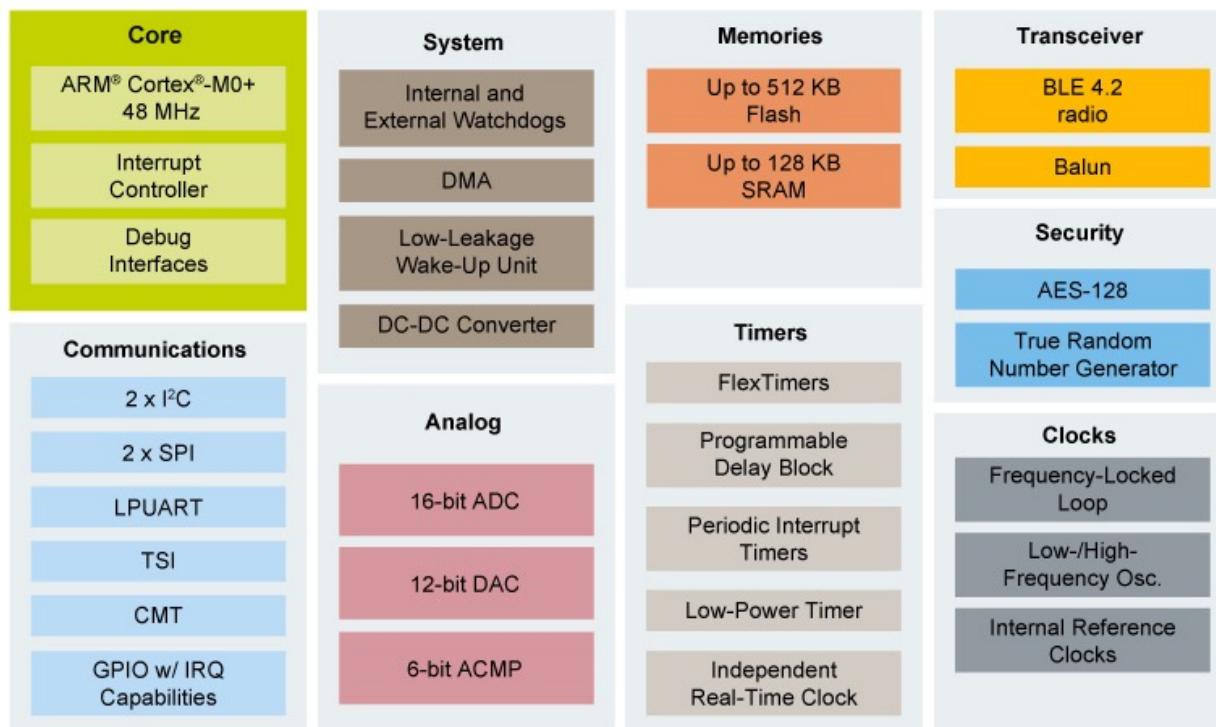
32 MHz Cortex-M3 CPU	Up to 512-Kbyte Flash	Up to 80-Kbyte SRAM	Up to 16-Kbyte EEPROM	USB 2.0 FS Device	Op-amps comp.	FSMC SDIO	AES-128	Up to LCD 8x40	 STM32 L1
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STM32L0 series – Ultra-Low-Power

32 MHZ Cortex-M0+ CPU	Up to 192-Kbyte SRAM	Up to 20-Kbyte SRAM	Up to 6-Kbyte EEPROM	USB 2.0 FS device Crystal less	DAC comp.	LP ADC 12-/16-bit	TRNG AES-128	LCD 8x48 / 4x52	 STM32 L0
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NXP

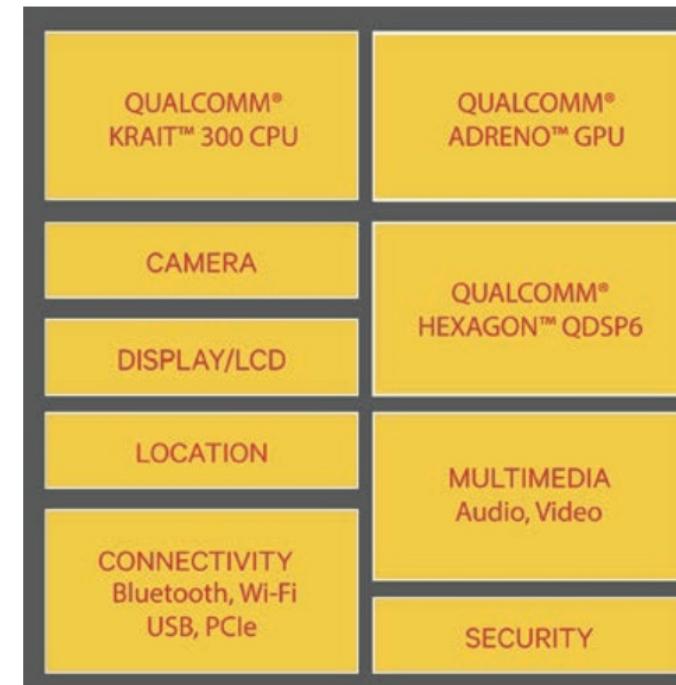
- Formerly Philips,
- <http://www.nxp.com/products/microcontrollers-and-processors/arm-based-processors-and-mcus:ARM-ARCHITECTURE>
- <http://www.nxp.com/products/microcontrollers-and-processors/power-architecture-processors:POWER-ARCHITECTURE> (based on IBM Power cores)



Kinetis W series

Qualcomm

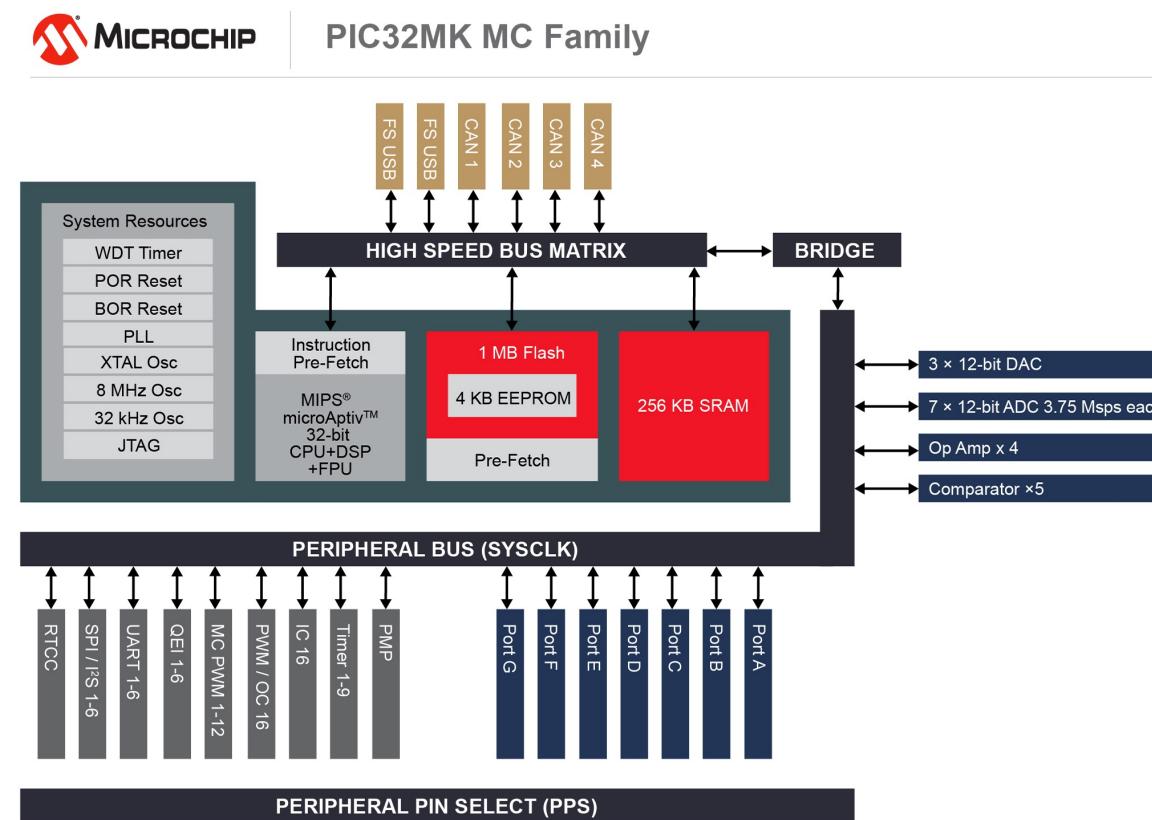
- Snapdragon designers (using ARM tech)
 - They designed their own cores (*Krait*) with ARM ISA
- <https://www.qualcomm.com/products/embedded-processors>
- <https://www.qualcomm.com/news/onq/2016/09/28/snapdragon-600e-and-410e-processors-help-iot-manufacturers-design-build-and> (Arrow Microelectronics)



Microchip

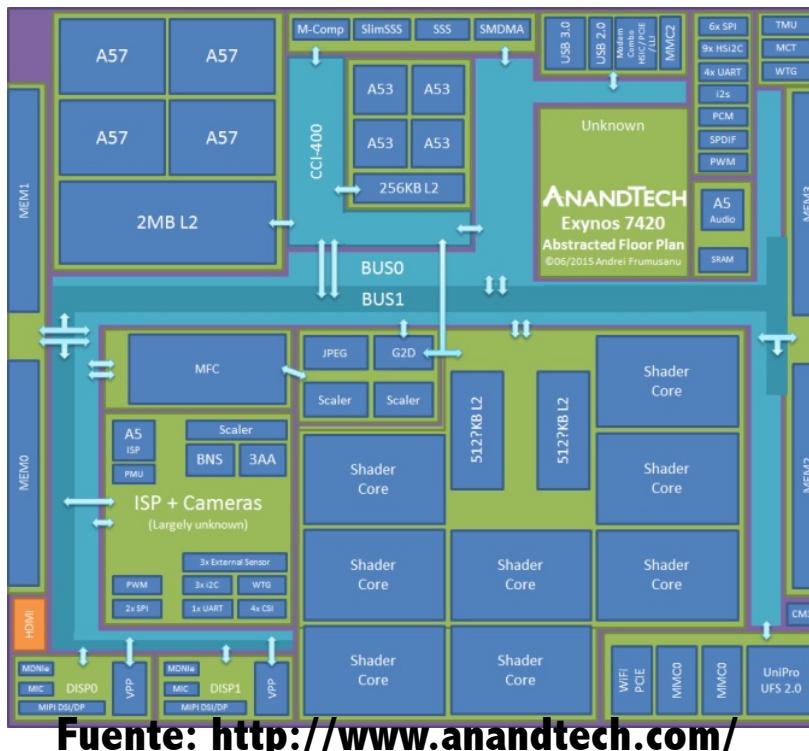
- Delivers ARM and MIPS cores

<http://www.microchip.com/design-centers/32-bit/architecture/pic32mk-family>



Samsung

- ARM based SoCs and their own (*Exynos M*) with ARM ISA
- Like Intel does, they build their own chips
- http://www.samsung.com/semiconductor/minisite/Exynos/Solution/MobileProcessor/Exynos_9_Series_8895.html



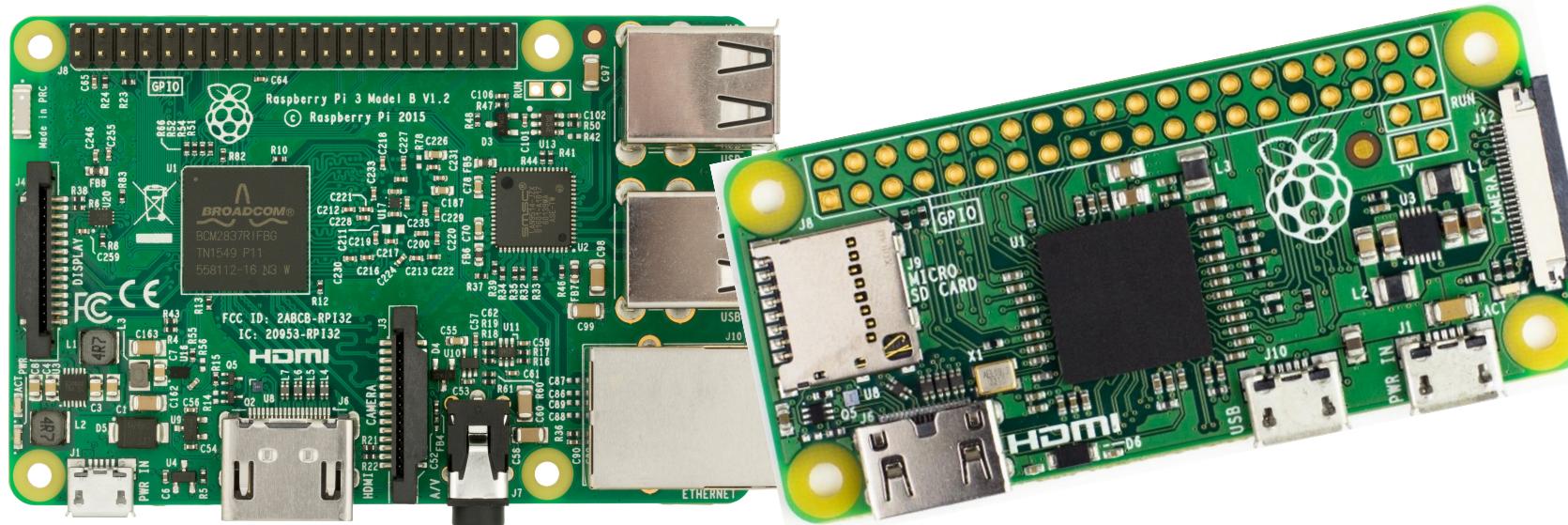
- Broadcom
 - Raspberry Pi
 - <https://www.broadcom.com/>
- Marvell
 - <https://www.marvell.com/>
- Mediatek
 - <https://www MEDIATEK.com/>
- Allwinner
 - Banana Pi
 - <http://www.allwinnertech.com/>
- Espressif
 - More IoT oriented
 - <http://espressif.com/>
- Silicon Labs
 - <https://www.silabs.com/>

- Finally, SoCs are integrated in a board (PCB) which may include more components: external flash, standard ports...
- Most SoC companies also deliver their own development boards
 - Pre-designed PCB with support from the company
 - Very useful for initial prototypes
 - If, once tested, that PCB does not fit our requirements, we may design our own PCB reusing the SoC



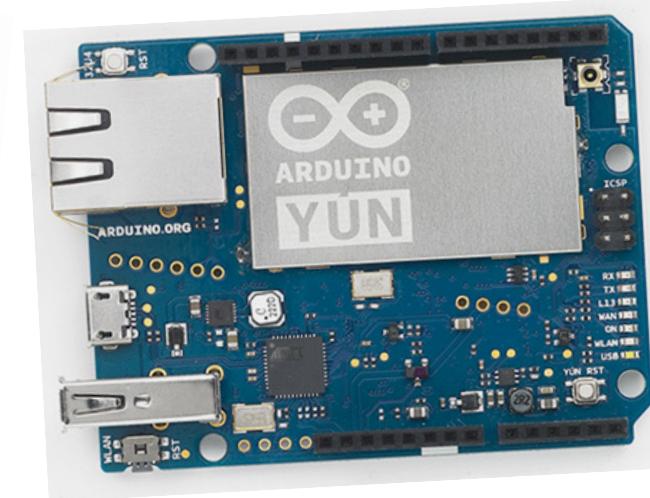
Raspberry Pi

- Currently in the 4th version
 - SoC Broadcom BCM2711
 - Core ARMv8 Cortex A72 Quadcore 1.5 GHz
 - 2 - 8 GiB LPDDR4 SDRAM
 - Power consumption 3W (idle) – 6.25W (maximum)
- Raspberry Pi Zero,
 - SoC Broadcom BCM2835
 - Core ARM 1176JZF-S 1 GHz
 - 512 MiB LPDDR2
 - < 1W
- Linux/Windows supported



Arduino

- Not just a board, but a whole family from several vendors
- They all share the same programming framework and common sockets that allow to add more boards (shields)
- *Wiring* programming (C/C++)
- Some models ship Atmel cores. Others, ARM core.
- Great community of makers with many examples



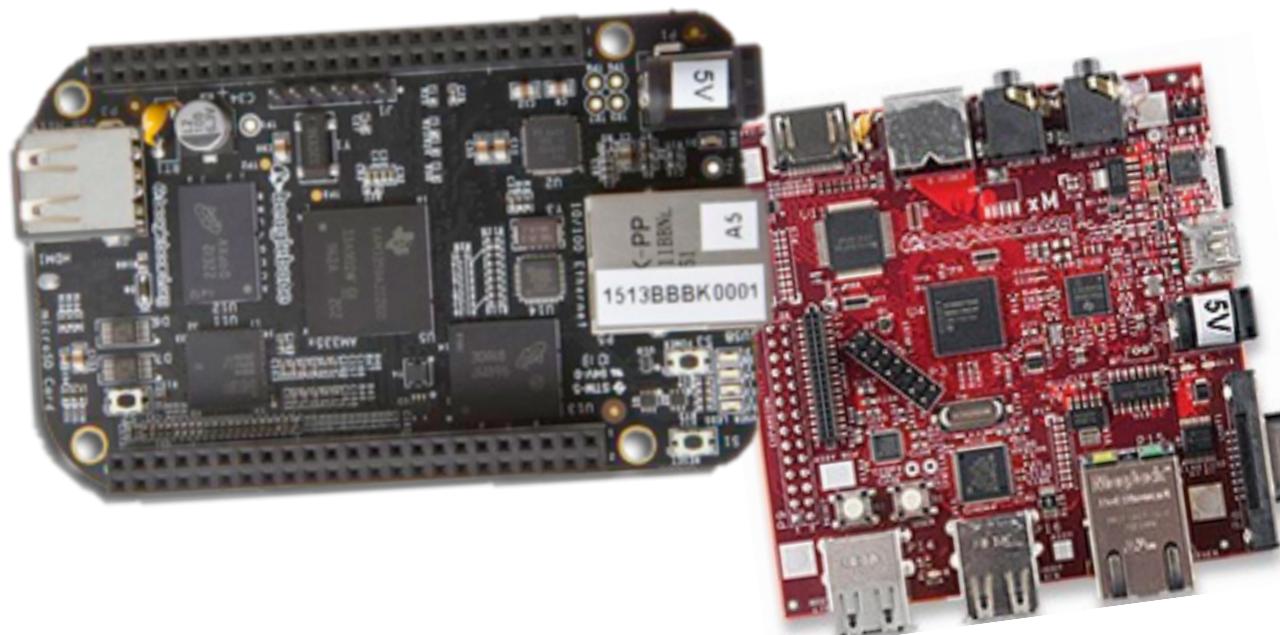
Beagleboard

– Beaglobone X-15

- Similar to Raspberry Pi, but more I/O oriented
- SoC de Texas Instruments (Sitara AM5728)
- 2 ARM [Coreext-A15@1.5GHz](#), 2 Cortex-M4@212MHz , 2 TI C66x DSP@700MHz

– PocketBeagle

- Similar to BeagleBone Black but with smaller factor



STMicroelectronics

- Large european semidconductot company
- Huge set of products (sensors, analg...)
- Focus on IoT and automotive
- ARM based SoC



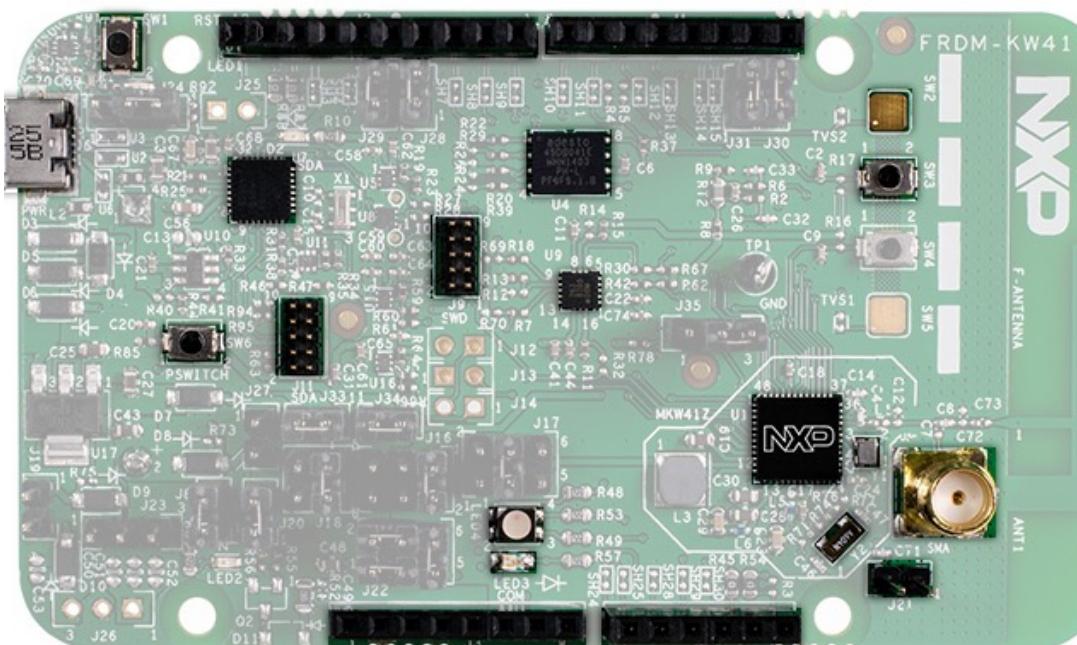
STM32 Nucleo Dev. Board



STM32 Discovery Kit

NXP

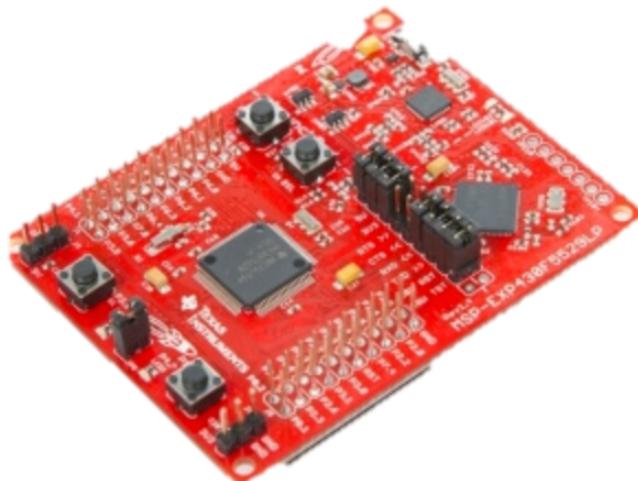
- Split from Philips, focused on microelectronics
 - SoCs basado en ARM y Power



Freedom Development Kit

Texas Instruments

- US tech giant on DSPs and electronics
- Always topped DSP market with own designs, now including ARM in their SoCs
 - DSP compilers are likely the best
- TI OMAP family was used in many high-end mobile series
- Launched SensorTag a few years ago to enter IoT market

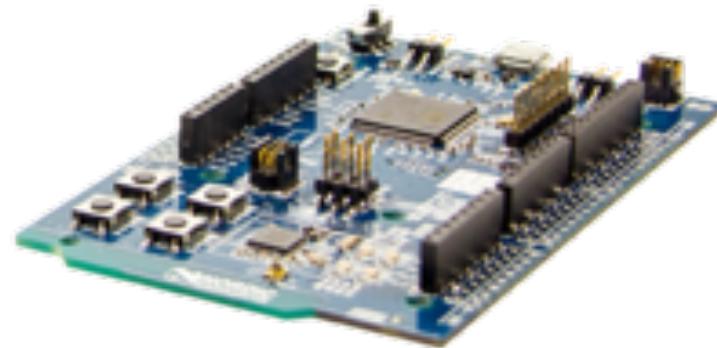


MSP Launchpad Dev. Kit



SensorTag

- Nordic
 - Focused on Low power and connectivity
 - ARM based. Used to be mbed compatible



- Cypress
 - ARM cores together with in-house programmable technologies
 - PSoC series with programmable HW programmable (*analog blocks*)



- PyCom
 - Ships their own ESP32 based boards
 - Full connectivity: WiFi, Lora y Sigfox , BLE
 - micrPython based programming



- Useful links (not all of them IoT)
 - [Postscapes \(específica para IoT\)](#)
 - <http://www.eurotech.com/en/products/embedded+boards>
 - [Arrow](#)
 - <https://www.board-db.org/>
 - [Adafruit](#)
 - [Wikipedia](#)
 - [Allaboutcircuits](#)

- The huge offer makes harder the choice
- Some key aspects
 - System connectivity (SoC – Board).
 - Interfaces to external sensors or other devices?
 - Network interfaces? (WiFi, BLE...)
 - Power and energy consumption. Low power modes
 - Max currents? Autonomy?
 - Powering the system (battery, supercap, solar panel...)
 - Which will be the node environment?
 - *Energy harvesting*
 - Available Clock/RTC to keep sincro
 - Available RTOS (Board-Soc supported?)
 - Available IDE (Integrated Development Environments)
 - Study the target application/domain: computation requirements?
Memory? Storage?
- [Check this guide about this topic](#)

- Imagine a specific scenario where IoT could help
- Perform a theoretical study about the required HW components:
 - Sensor nodes: microcontrollers, sensors
 - Would *edge computing* be required?
 - RTOS and IDE to be used
 - Communication requirements
 - Energy consumption estimation. Powering mechanisms
 - Final packaging
 - Total budget
- NO code development. Just a paper work
- REPORT: write a report (PDF) describing your research
- DEADLINE: 20th december