UNIVERSIDAD COMPLUTENSE MADRID

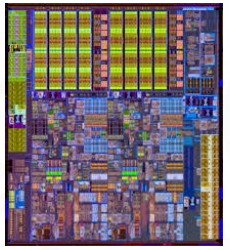
IoT Node Architecture

Boards, Modules, SoCs, *cores*

Dev Board

Module

System On Chip (SoC)



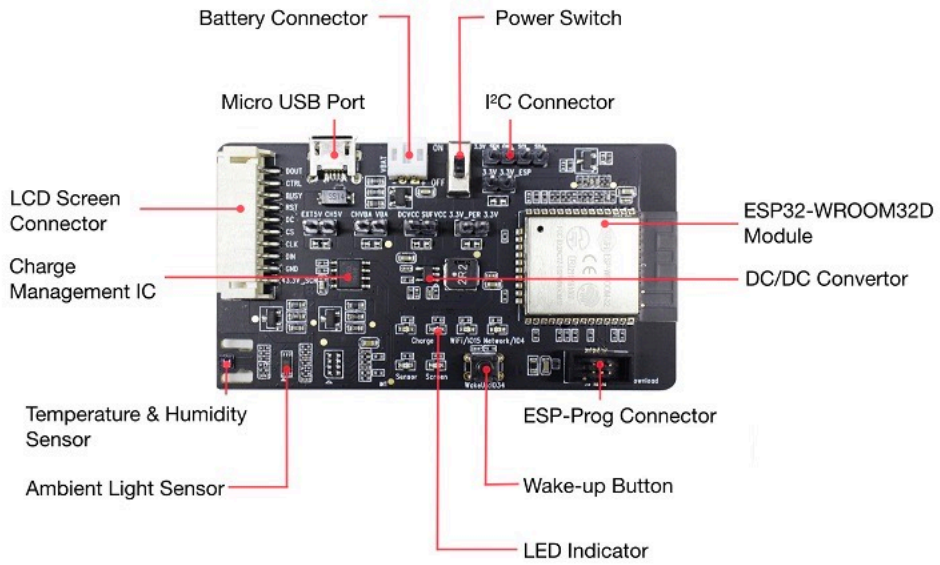
cores

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

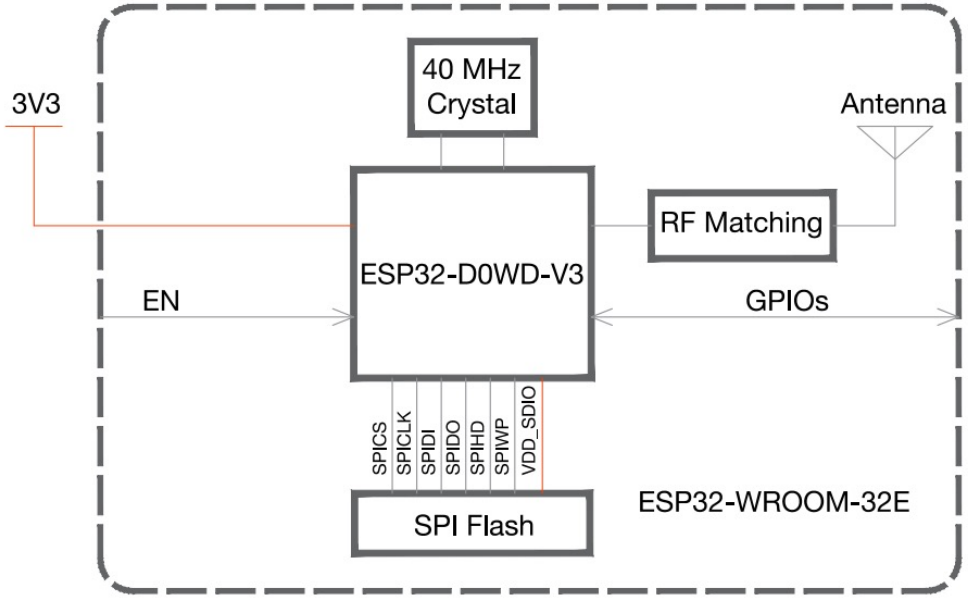
https://www.espressif.com/en/products/devkits/esp32-devkitc



ESP32 Meshkit Sense

Module

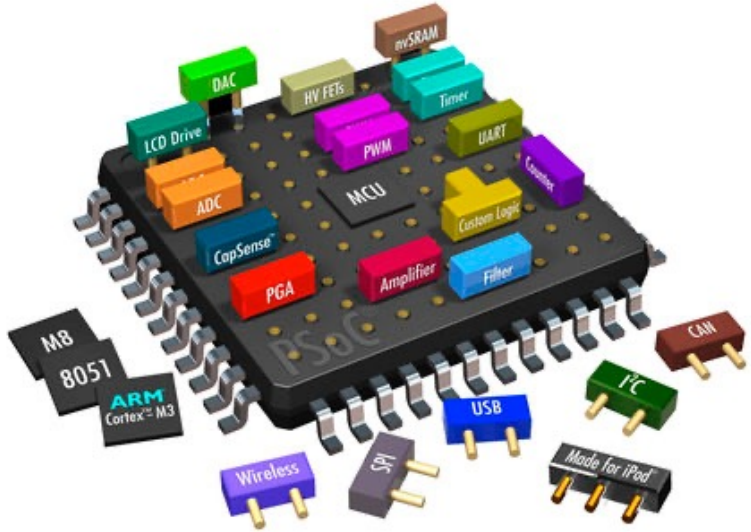
- Module
  - Supports several SoC models
  - May include support for FLASH, GPIO, antennas
  - May include quartz clock
- Sometimes, the term SoC is used for the whole package



ESP32-WROOM-32E

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…



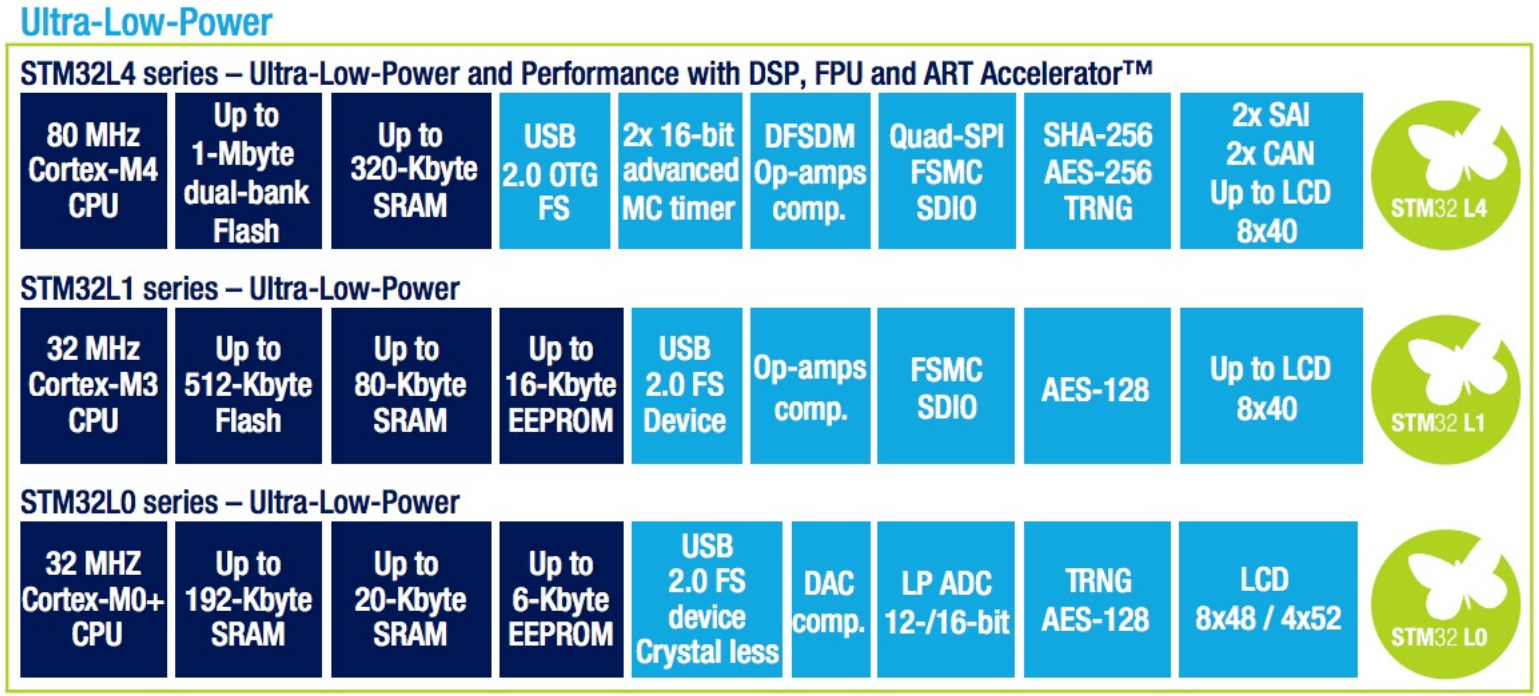
SoC market is very competitive

- 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

SoC providers

STMicrolectronics

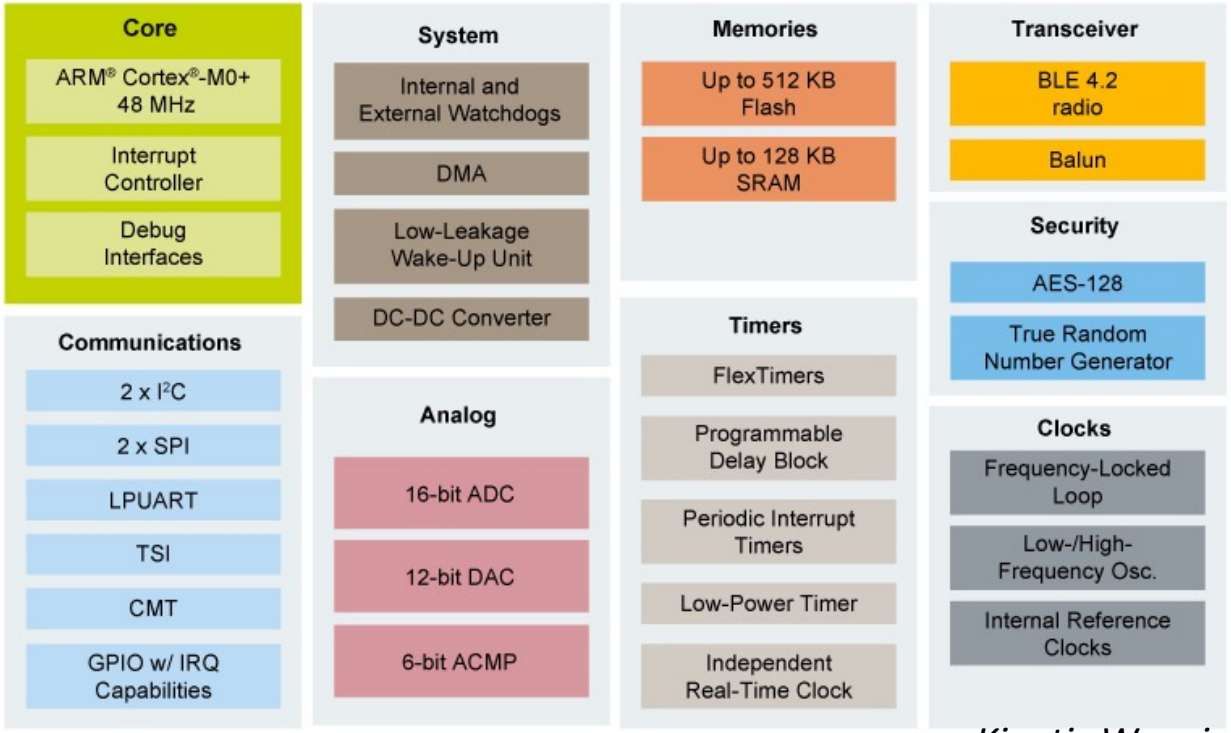
- Large company with years of experience
- http://www.st.com/en/secure-mcus.html
- http://www.st.com/en/microcontrollers.html (STM32 family)



SoC providers

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

SoC providers

Qualcomm

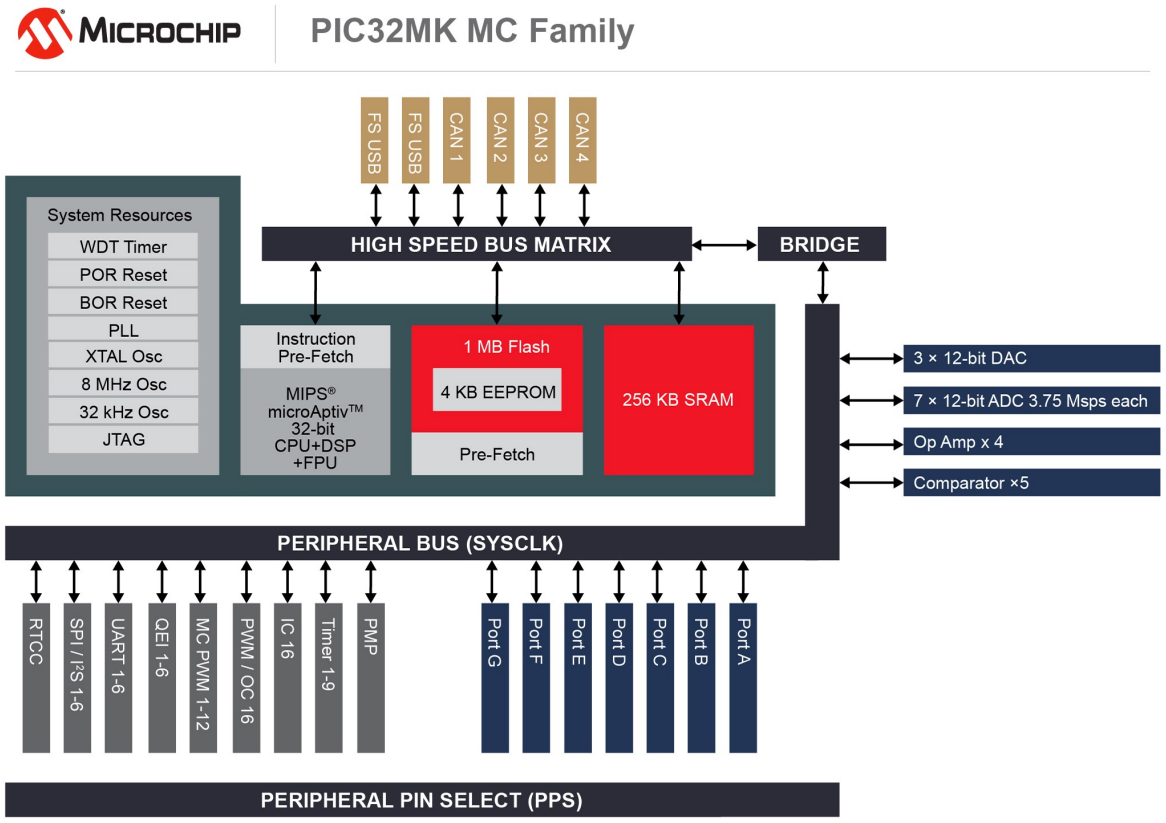
- Snapdragon designers (using ARM tech)
  - They designed their own cores (*Krait*) with ARM ISA
- https://www.qualcomm.com/products/embedded-processors
- https://www.qualcomm.com/news/onq/2016/09/28/snapdragon-600e-and-410e-processors-help-iot-manufacturers-design-build-and (Arrow Microelectronics)

SoC providers

Microchip

– Delivers ARM and MIPS cores

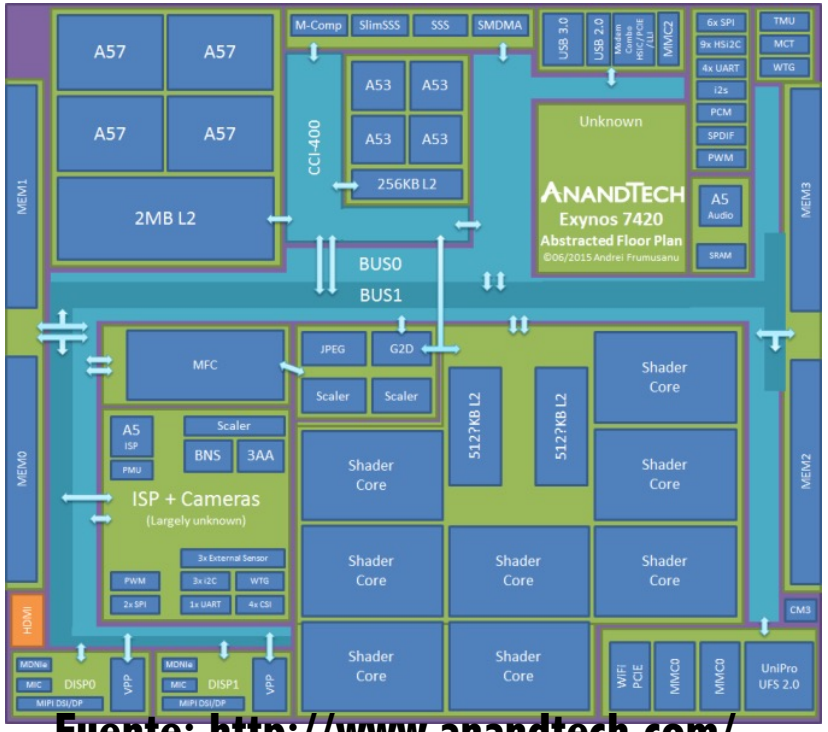
http://www.microchip.com/design-centers/32-bit/architecture/pic32mk-family



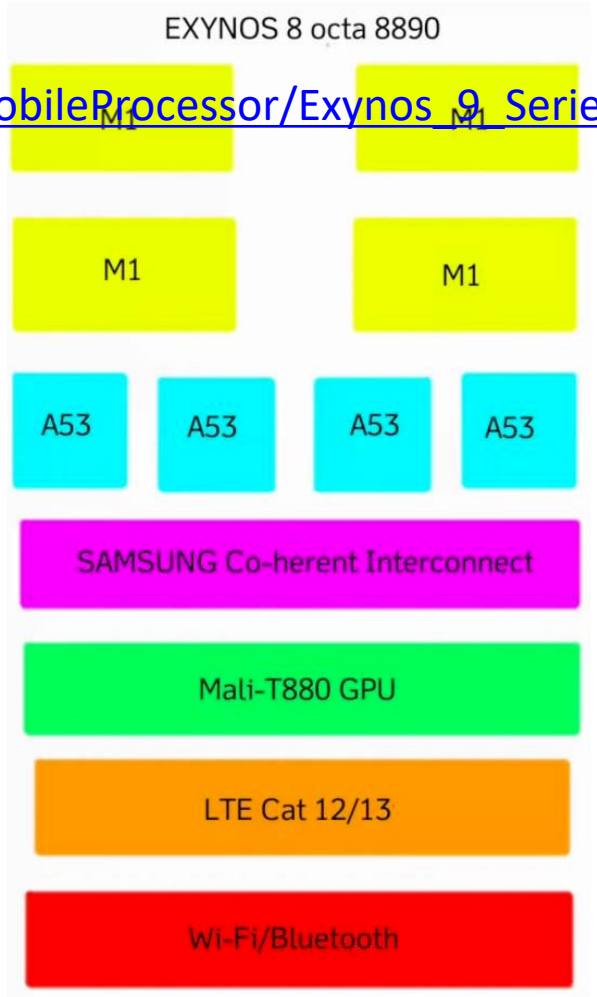
SoC providers

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



Fuente: http://www.anandtech.com/



Other actors in SoC market

- Broadcom
  - Rapsberry 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/

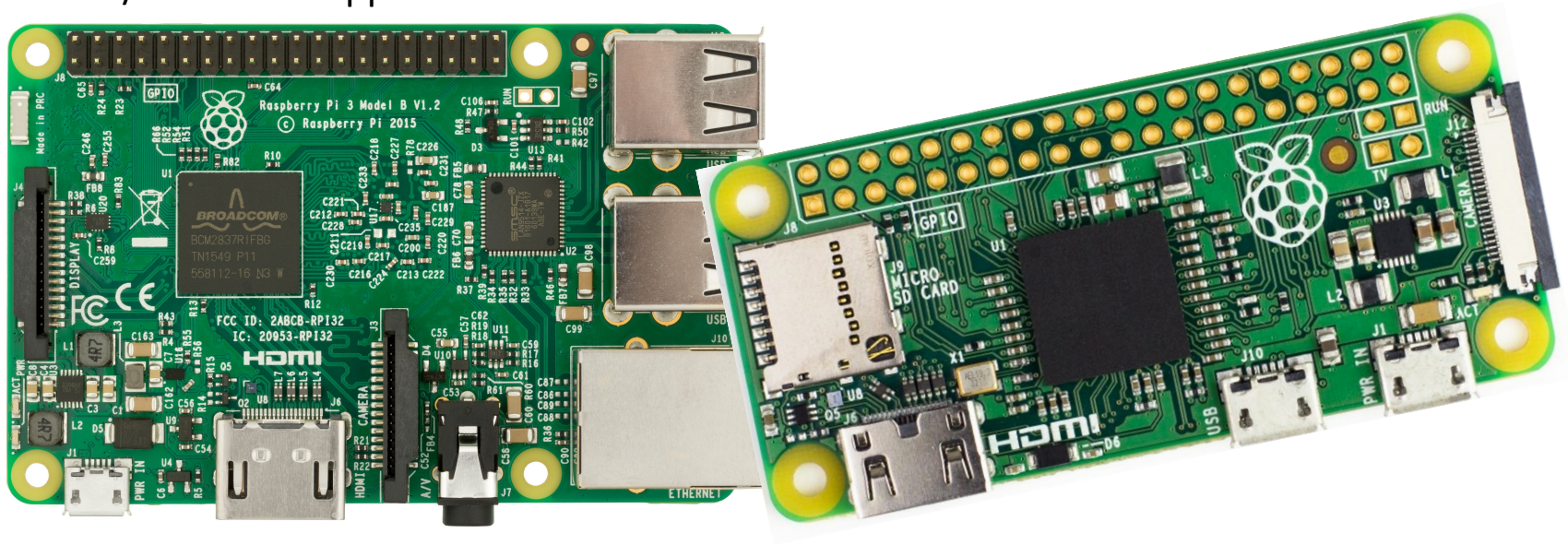
(Dev) Boards

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

Some well-known boards

Raspberry Pi

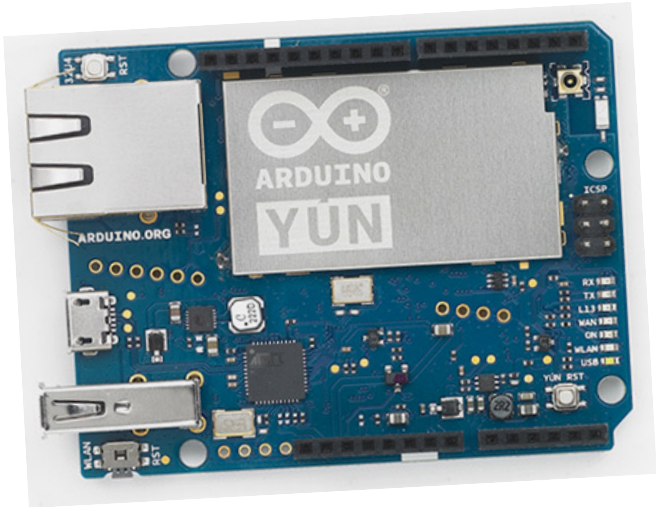
- Currently iin the 4th version
  - SoC Broadcom BCM2711
  - Core ARMv8 Cortex A72 Quadcore 1.5 GHz
  - 2 - 8 GiB LPDDR4 SDRAM
  - Power consumption 3W (idle) – 6.25W (maximum)
- Raspberry Pi Zero,
  - SoC Broadcom BCM2835
  - Core ARM 1176JZF-S 1 GHz
  - 512 MiB LPDDR2
  - < 1W
- Linux/Windows supported



Some well-known boards

Arduino

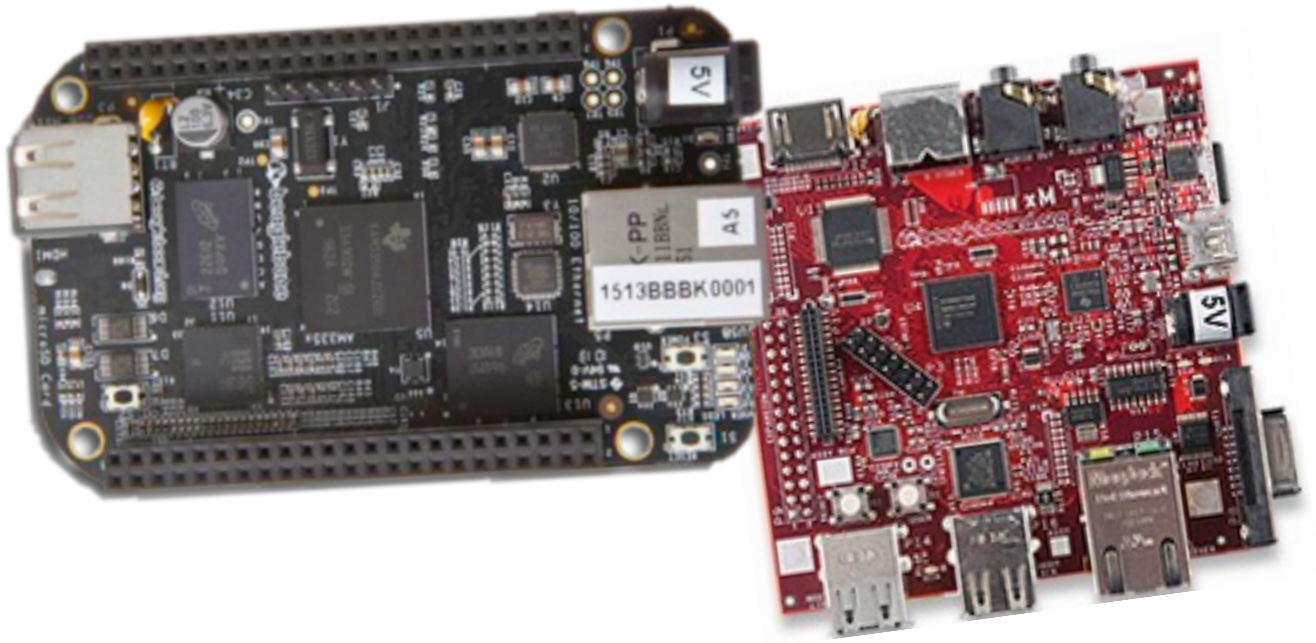
- Not just a board, but a whole familiy from several vendors
- They all share the same programming framework and common sockets that allow to add more boards (shields)
- *Wiring* programming (C/C++)
- Some models ship Atmel cores. Others, ARM core.
- Great community of makers with many examples



Some well-known boards

Beagleboard

- **Beaglobone X-15**
  - Similar to Raspberry Pi, but more I/O oriented
  - SoC de Texas Instruments (Sitara AM5728)
  - 2 ARM Corext-A15@1.5GHz, 2 Cortex-M4@212MHz , 2 TI C66x DSP@700MHz
- **PocketBeagle**
  - Similar to BeagleBone Black but with smaller factor

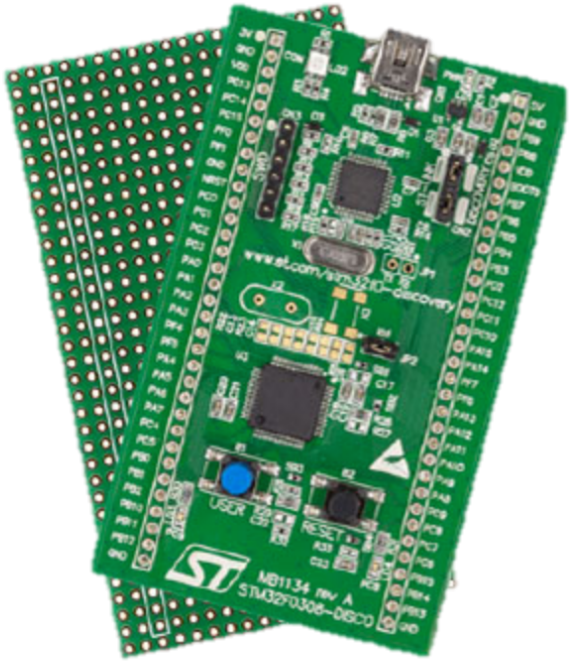


Maybe less well-known

STMicroelectronics

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

STM32 Nucleo Dev. Board

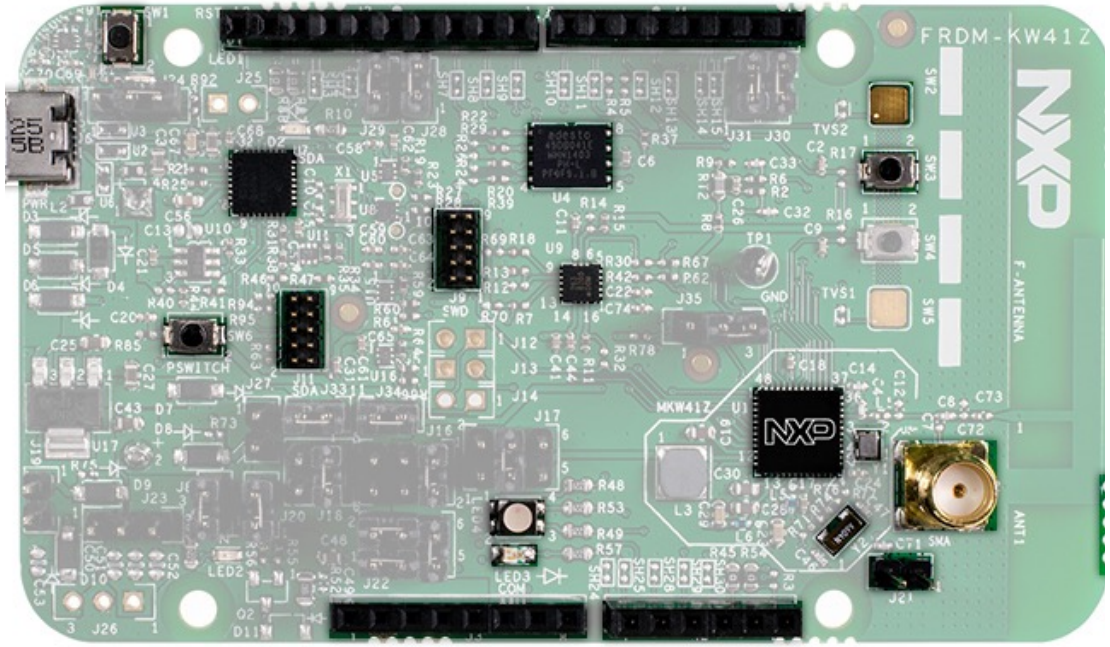


STM32 Discovery Kit

Maybe less well-known

NXP

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

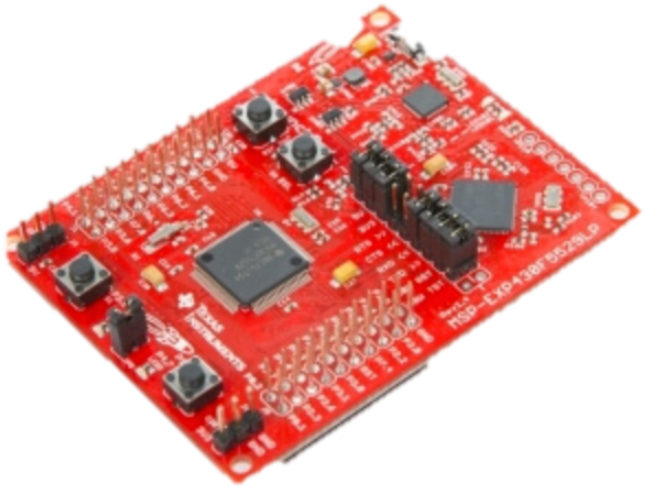


Freedom Development Kit

Maybe less well-known

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 a likely the best
- TI OMAP familiy was used in many high-end mobile series
- The launched SensorTag a few years ago to enter IoT market



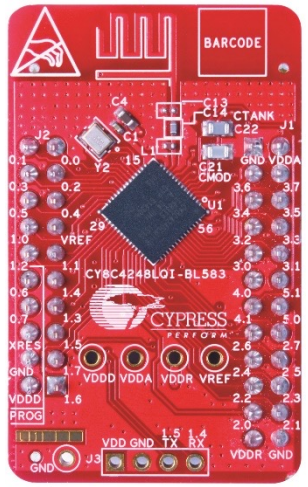
MSP Launchpad Dev. Kit

SensorTag

Y many more...

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

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



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

About boards, reviews....

- 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

Choosing SoC – Board

- 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

Individual *paper project* (december)

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

Let's do some web search

- Which SoC do you have in your smartphone?
- How many cores does it have?
- Which cores?
  Does it have GPU?
- Other accelerators?
- Memory?
- ....
- Interesting links
  - https://nanoreview.net/en/soc-list/rating
  - https://en.wikichip.org/