Overview of Embedded System Labs

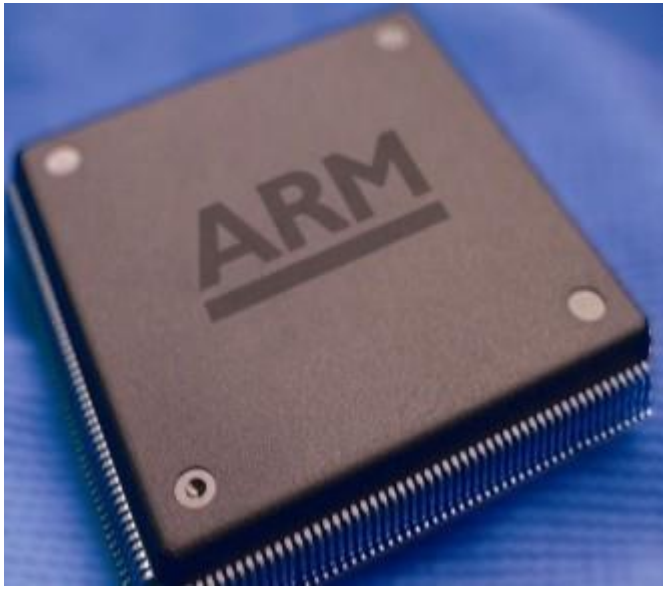
NTUEE

Embedded systems are computer systems that has built in MCU or MPU, such as home appliances, equipment for communication, entertainment, automobile, and industry, etc.

Course Outline

- Software/Hardware Integration
  - The outcomes of the course will let students know how to integrate embedded hardware, software, and middleware (such as OS libraries) to meet the functional and performance requirements of embedded applications.
  - RTOS API, multi-threading, optimization for performance and power communication protocols (wifi, BLE, serial protocols, …)
- Knowledge and Concepts
  - The course will start with an introduction to embedded systems, processors, input/output systems, hardware/software tools, concepts of operating systems.
- Laboratories and Projects
  - Laboratories are provided to guide students to be familiar with programming and debugging tools for embedded systems.

Embedded Processors



Qualcomm

Apple

MTK

Samsung

Nvidia

TI

STMicroelectronics

NXP

Infineon

Microchip

Cypress

Renesas

Broadcom

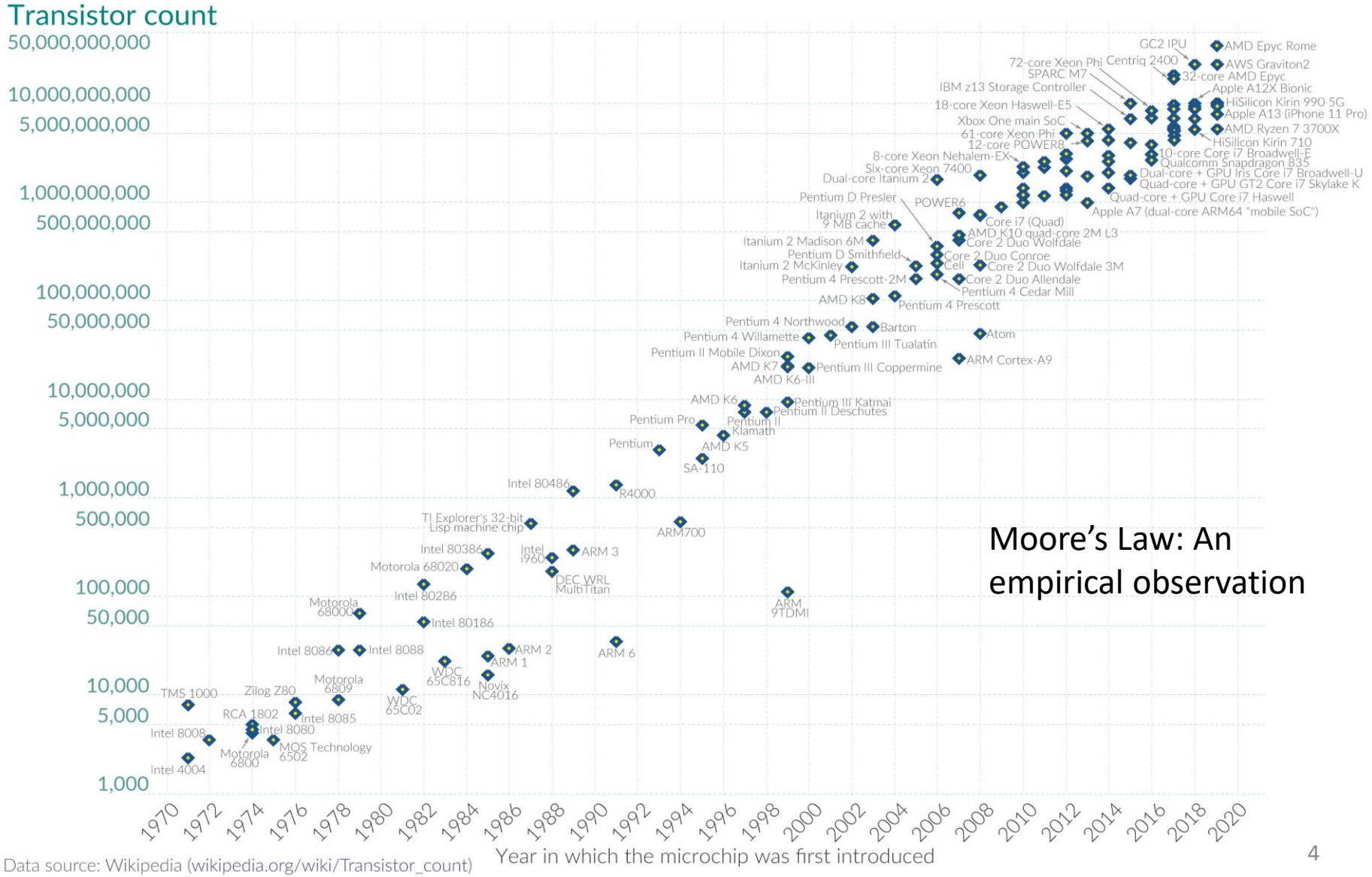
- Alternative development – Open ISA (Instruction Set Architecture)

RISC-V

Moore's Law: The number of transistors on microchips doubles every two years

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important for other aspects of technological progress in computing – such as processing speed or the price of computers.

Our World in Data



Moore's Law: An empirical observation

Data source: Wikipedia (wikipedia.org/wiki/Transistor_count)

OurWorldinData.org – Research and data to make progress against the world's largest problems.

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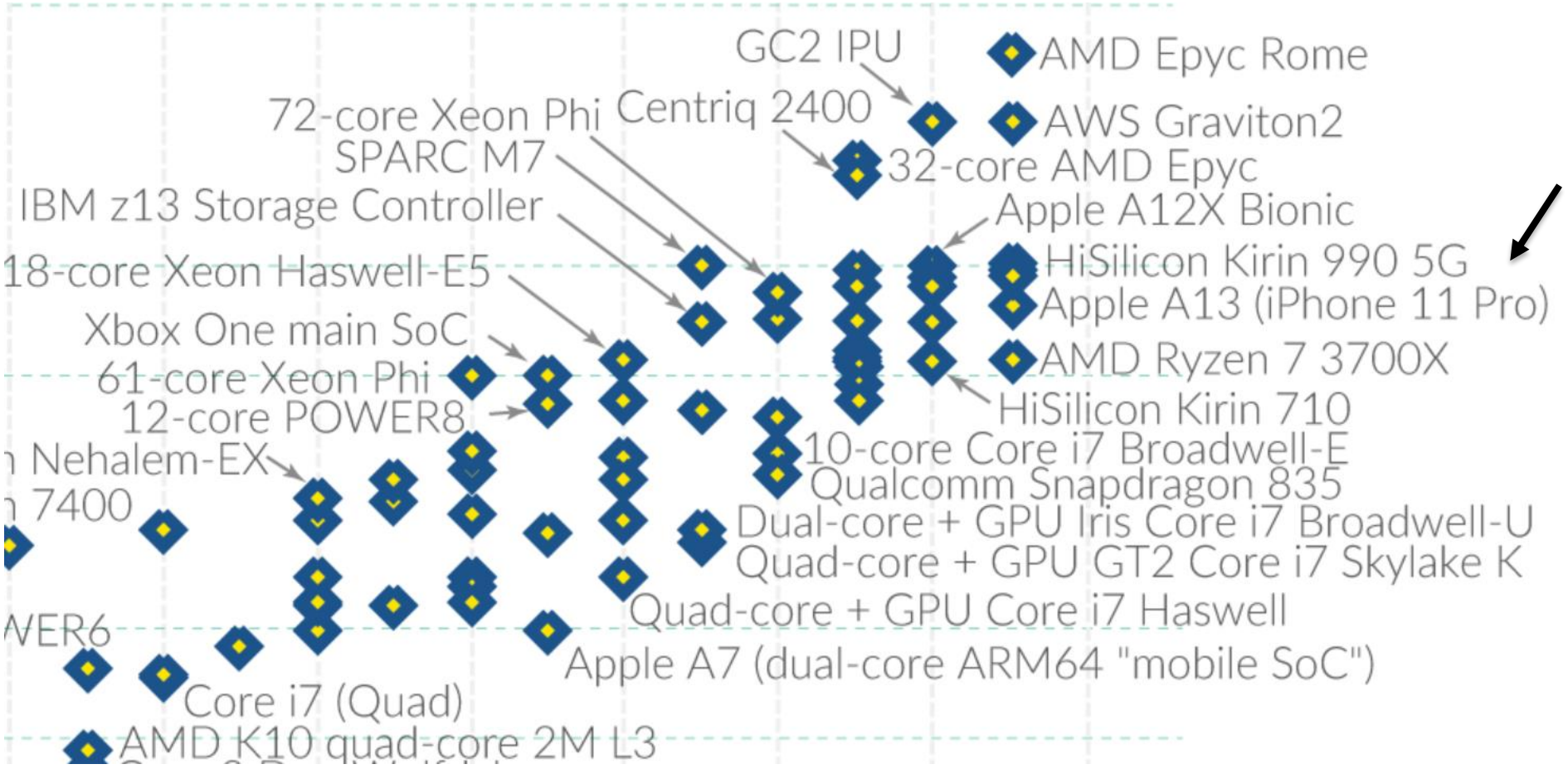
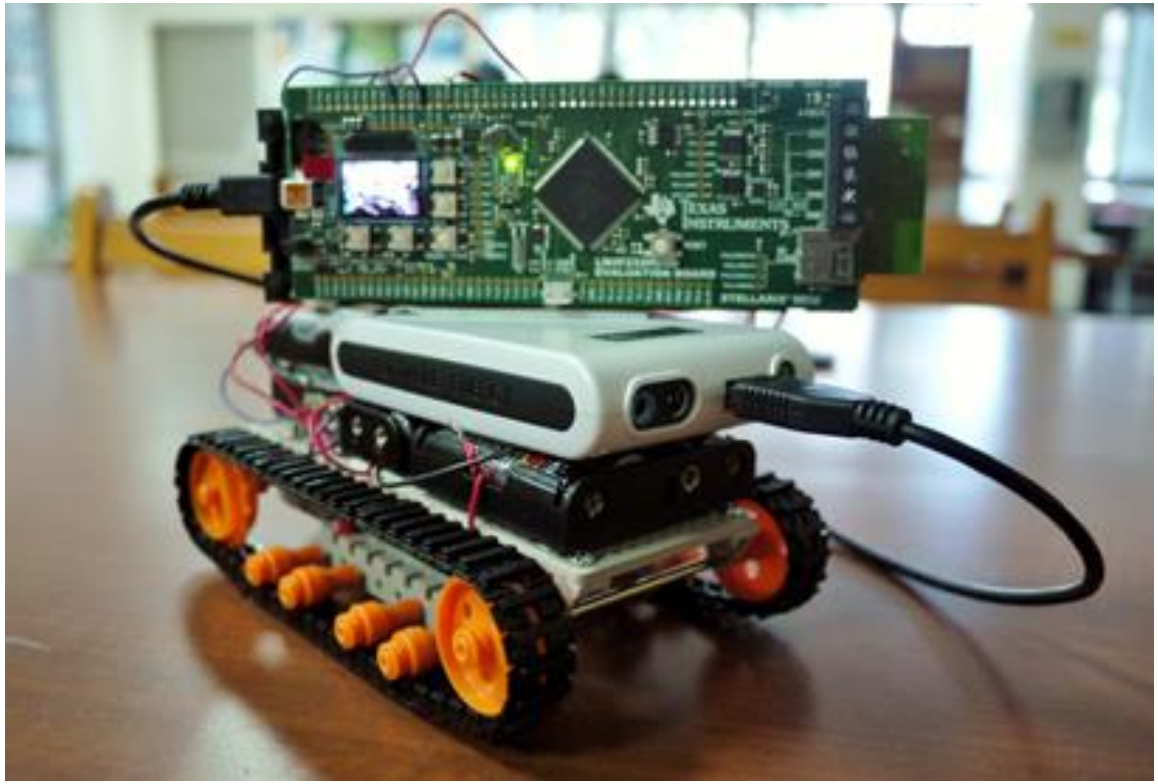
A close view


GC2 IPU
AMD Epyc Rome
72-core Xeon Phi
Centriq 2400
AWS Graviton2
SPARC M7
32-core AMD Epyc
IBM z13 Storage Controller
Apple A12X Bionic
18-core Xeon Haswell-E5
HiSilicon Kirin 990 5G
Apple A13 (iPhone 11 Pro)
Xbox One main SoC
AMD Ryzen 7 3700X
61-core Xeon Phi
12-core POWER8
HiSilicon Kirin 710
Nehalem-EX
10-core Core i7 Broadwell-E
7400
Qualcomm Snapdragon 835
Dual-core + GPU Iris Core i7 Broadwell-U
Quad-core + GPU GT2 Core i7 Skylake K
Quad-core + GPU Core i7 Haswell
Apple A7 (dual-core ARM64 "mobile SoC")
Core i7 (Quad)
AMD K10 quad-core 2M L3

Example Embedded Systems - Tank

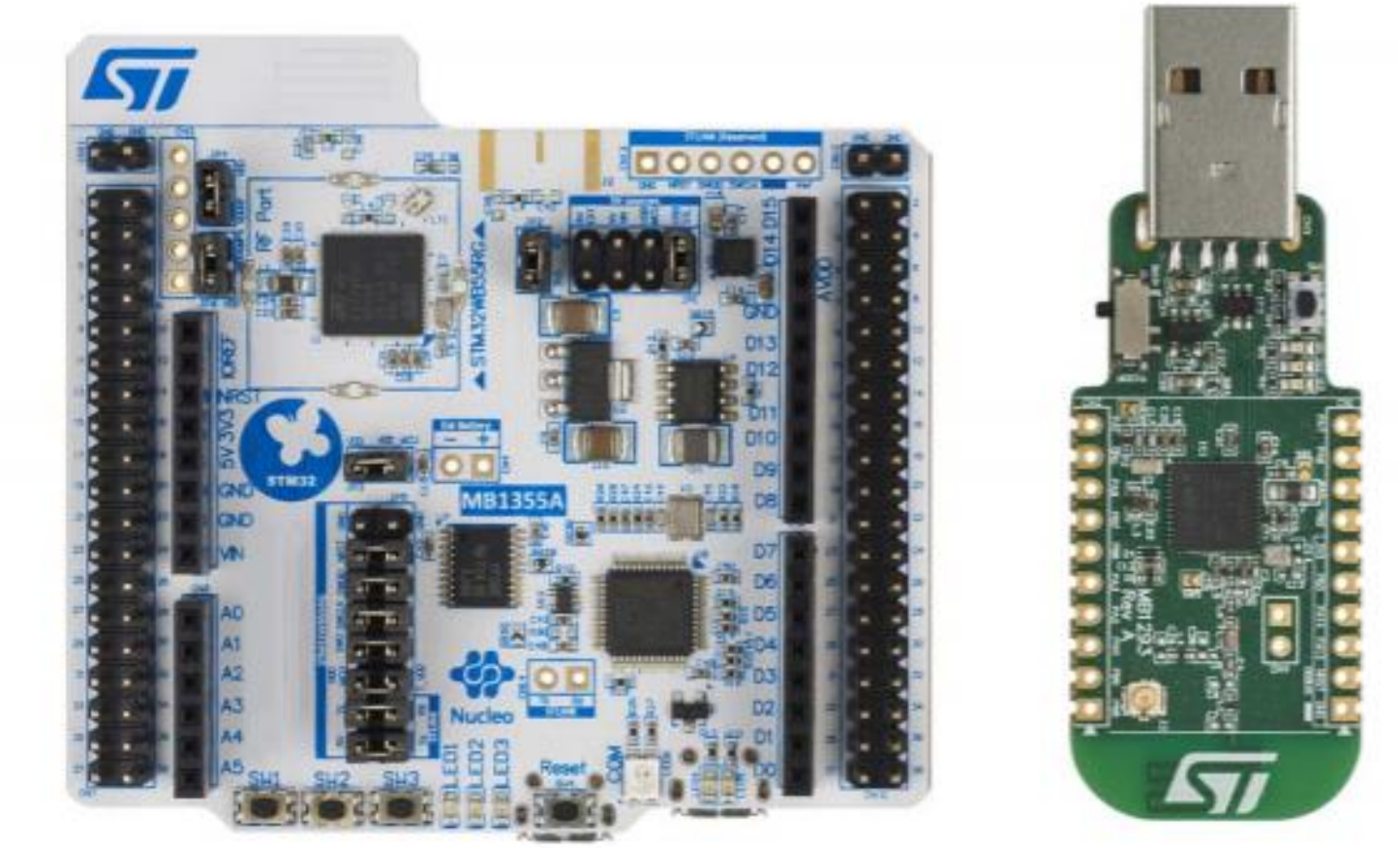


Example Embedded System: Android TV

android

Example embedded system: Network Routers

Development Boards: STM32WB Nucleo-68 pack for wireless solutions

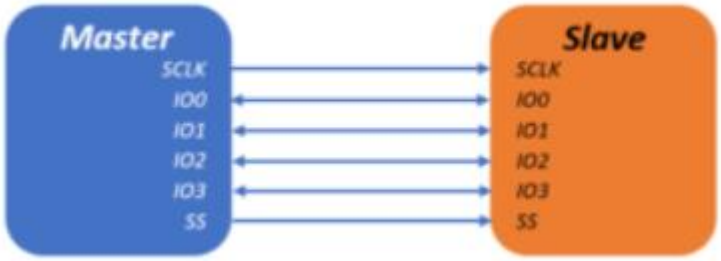


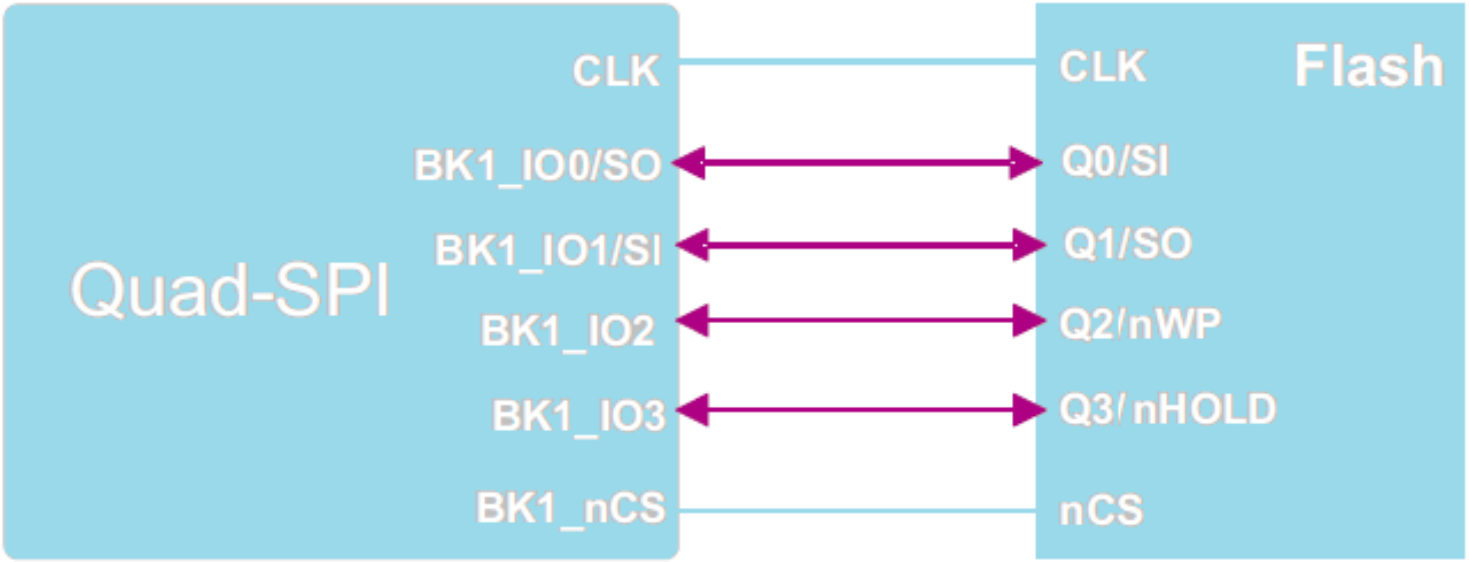
Example: STM32 Discovery kit for IoT

Features STM32 Discovery kit for IoT

- Ultra-low-power STM32L4 Series MCUs based on Arm® Cortex®-**M4** core with 1 Mbyte of Flash memory and 128 Kbytes of SRAM, in LQFP100 package
- 64-Mbit Quad-SPI (Macronix) Flash memory
- Bluetooth® V4.1 module (SPBTLE-RF)
- Sub-GHz (868 MHz or 915 MHz) low-power-programmable RF module (SPSGRF-868 or SPSGRF-915)
- 802.11 b/g/n compliant Wi-Fi® module from Inventek Systems (ISM43362-M3G-L44)
- Dynamic NFC tag based on M24SR with its printed NFC antenna
- 2 digital omnidirectional microphones (MP34DT01)
- Capacitive digital sensor for relative humidity and temperature (HTS221)
- High-performance 3-axis magnetometer (LIS3MDL)
- 3D accelerometer and 3D gyroscope (LSM6DSL)
- 260-1260 hPa absolute digital output barometer (LPS22HB)
- Time-of-Flight and gesture-detection sensor (VL53L0X)
- 2 push-buttons (user and reset)

What is Quad-SPI (qspi)?





https://os.mbed.com/docs/mbed-os/v6.16/apis/spi-apis.html

NVIDIA Jetson Nano

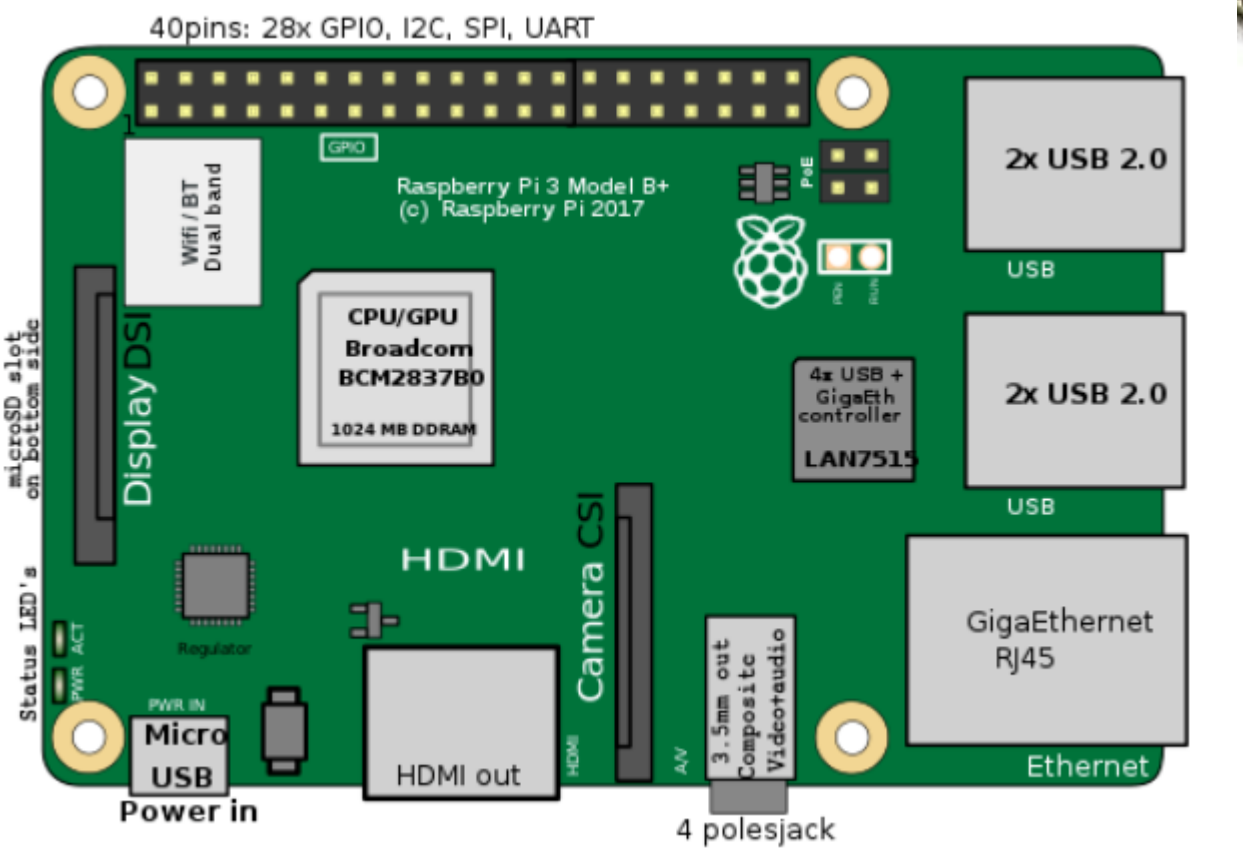
- NVIDIA Jetson Nano Developer Kit is a small, powerful computer
- Can run multiple neural networks in parallel for applications like image classification, object detection, segmentation, and speech processing.

Cortex-A based SOC

GPU	128-core Maxwell
CPU	Quad-core ARM **A57** @ 1.43 GHz

Raspberry Pi 2/3/4

- Broadcom SOC
  - Based on Cortex-A



Grading

- **[Final Projects]**
  - Team with 2~3 people.
  - Topic: Embedded Systems and Applications (Topics: IoT applications and Data Processing）
- **[Grading]**
  - Homeworks + Labs 33%,
  - Term projects 33%,
  - Quiz/Exam/Lab Practice/Discussions 33%,
  - Course Participation (Including Discussions and Equipment Maintenance) 1%