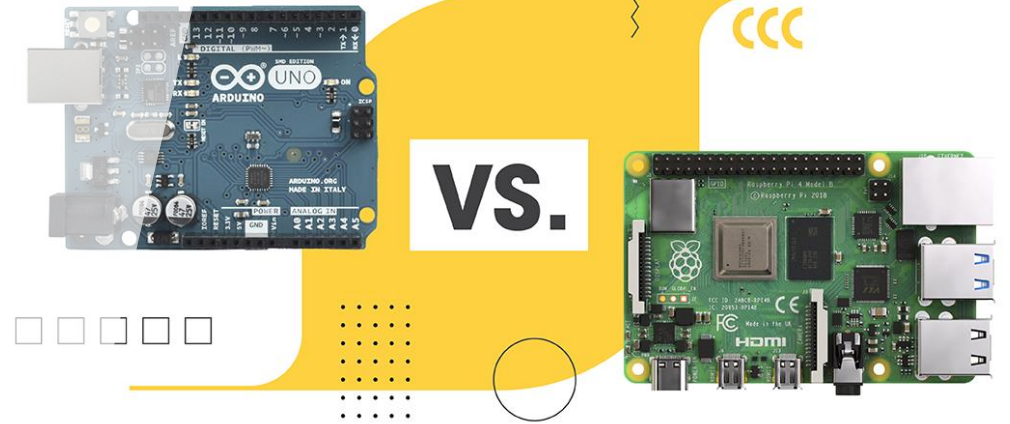National Taiwan University
Biomechatronics Engineering

NTU X COA

認識微控制器

Yan-Fu Kuo | 19, June 2023
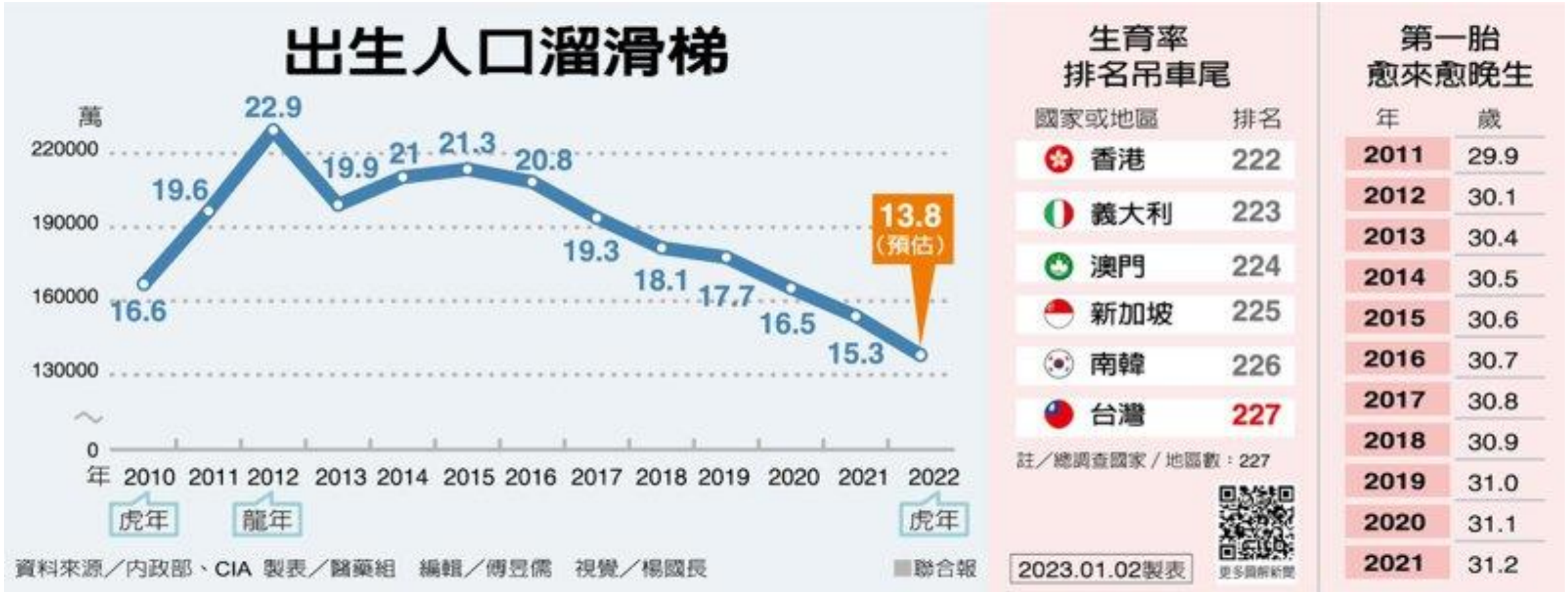
Food Security

Traditional Farming

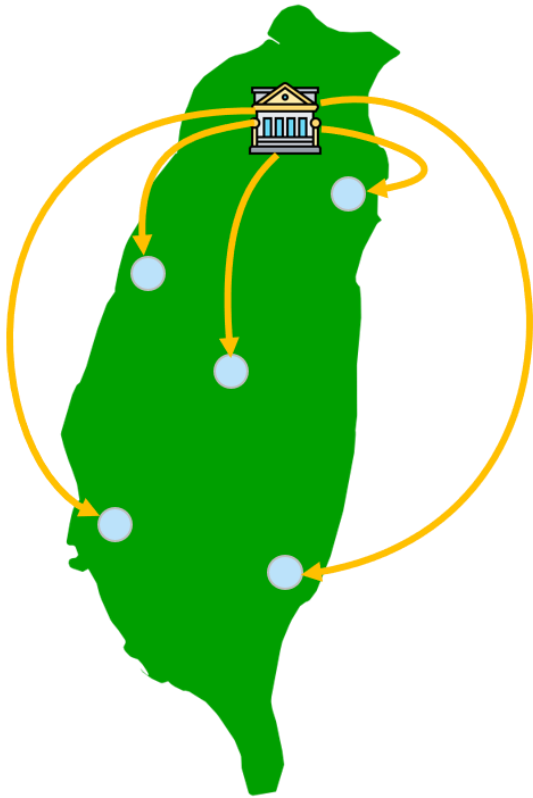# Labor Shortage and Farmer Aging

Source: 聯合報

Smart Agriculture

Information and communication technology, IoT, big data, smart machine

Yan-Fu Kuo
Dept. of Biomechatronics Engineering

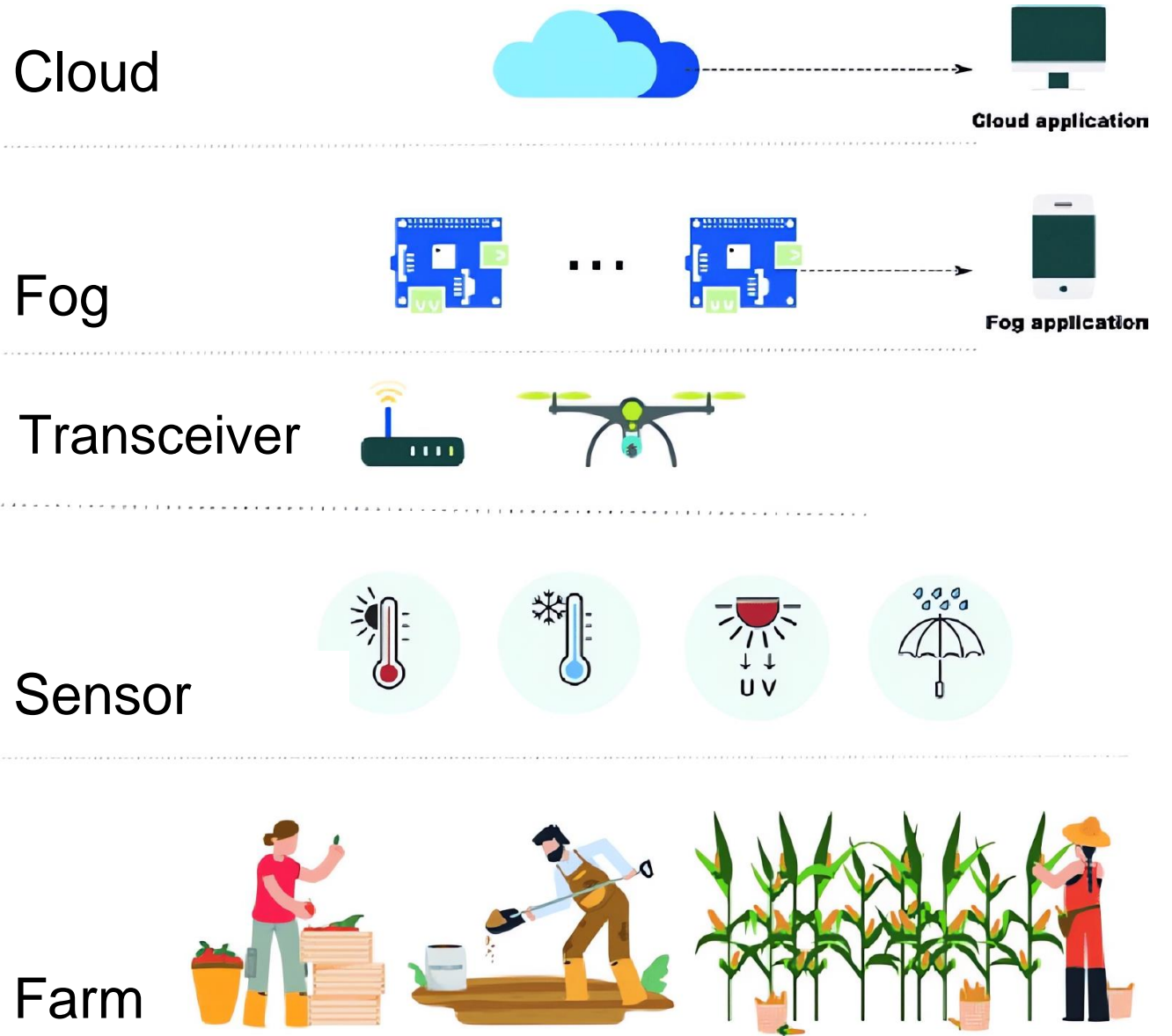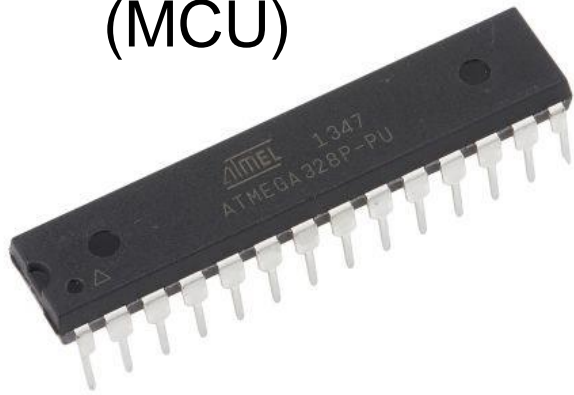Source: Council of Agriculture, Executive Yuan. 2022.

What is a Microcontroller (MCU)?

- Programmable small computer

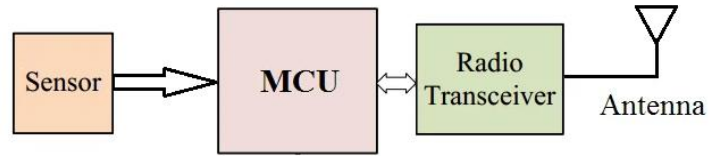- In the form of an integrated circuit (IC)
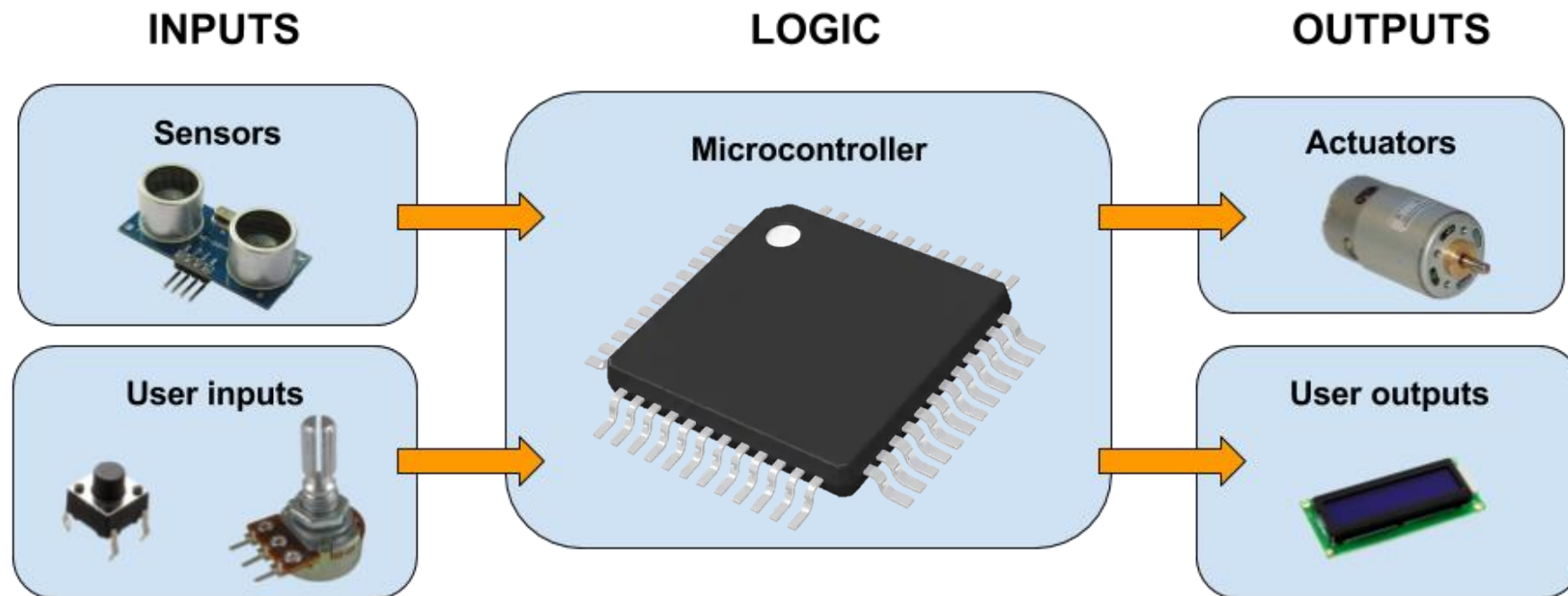
MCU in IoT of Smart Agriculture

Microcontroller
(MCU)

Cloud

Fog

Transceiver

Sensor

Farm

Microcontroller in IoT
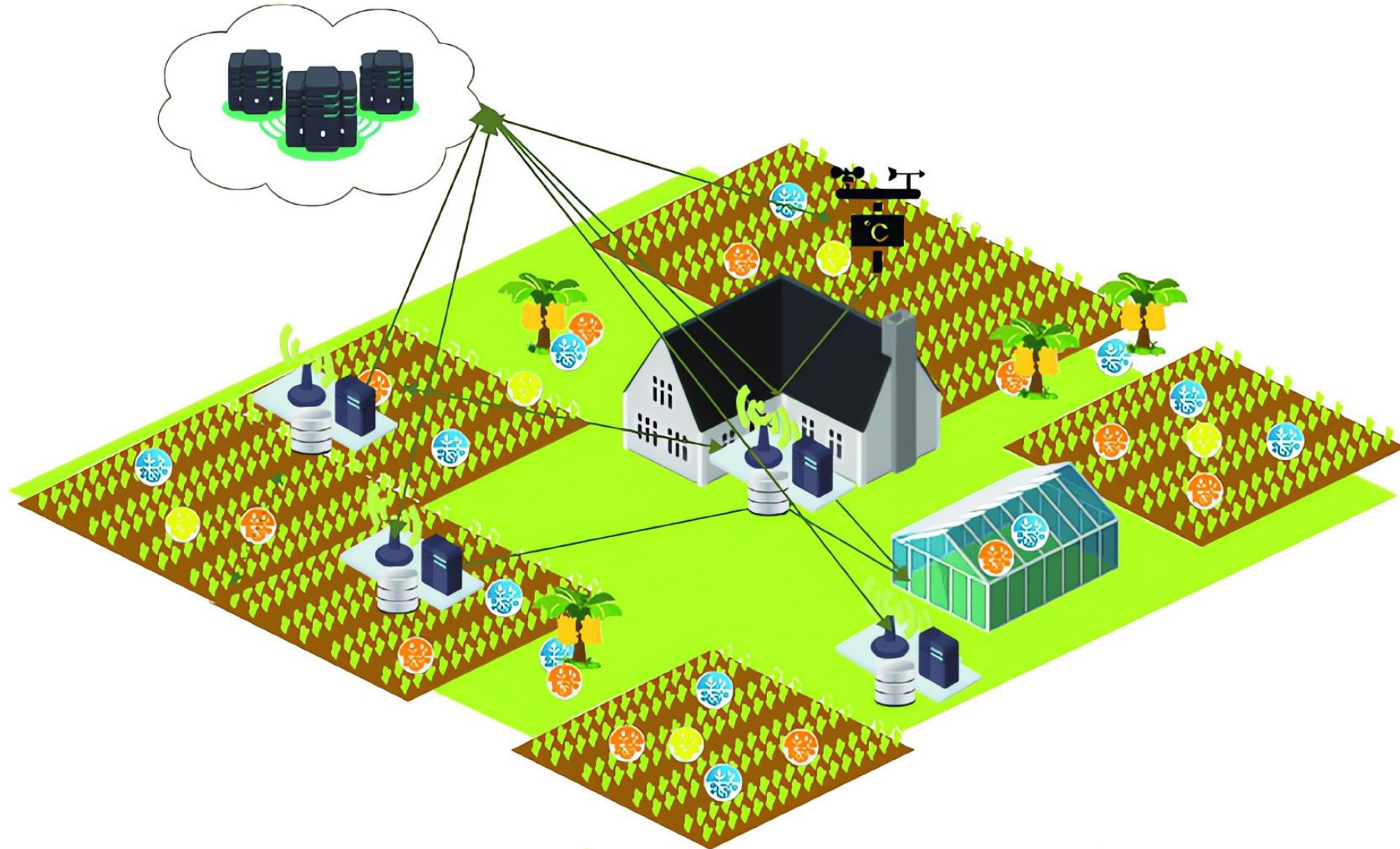
Smart Agriculture

Microcontroller in Local Control

Future Agriculture

Combine Harvester

Security Bot

Farm Drone

Farm Data

SMART FARMING

Self-driving Tractor

Field Sensor

Watering System

Agricultural APP
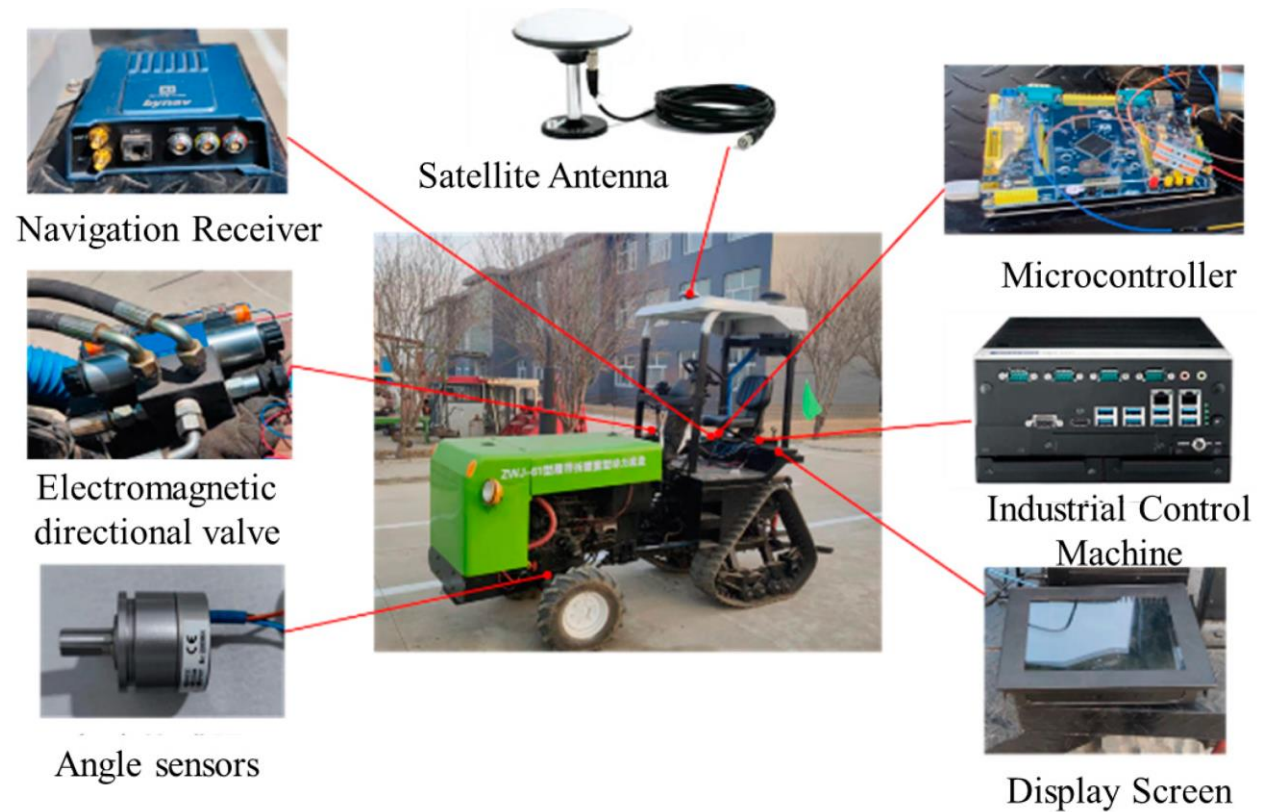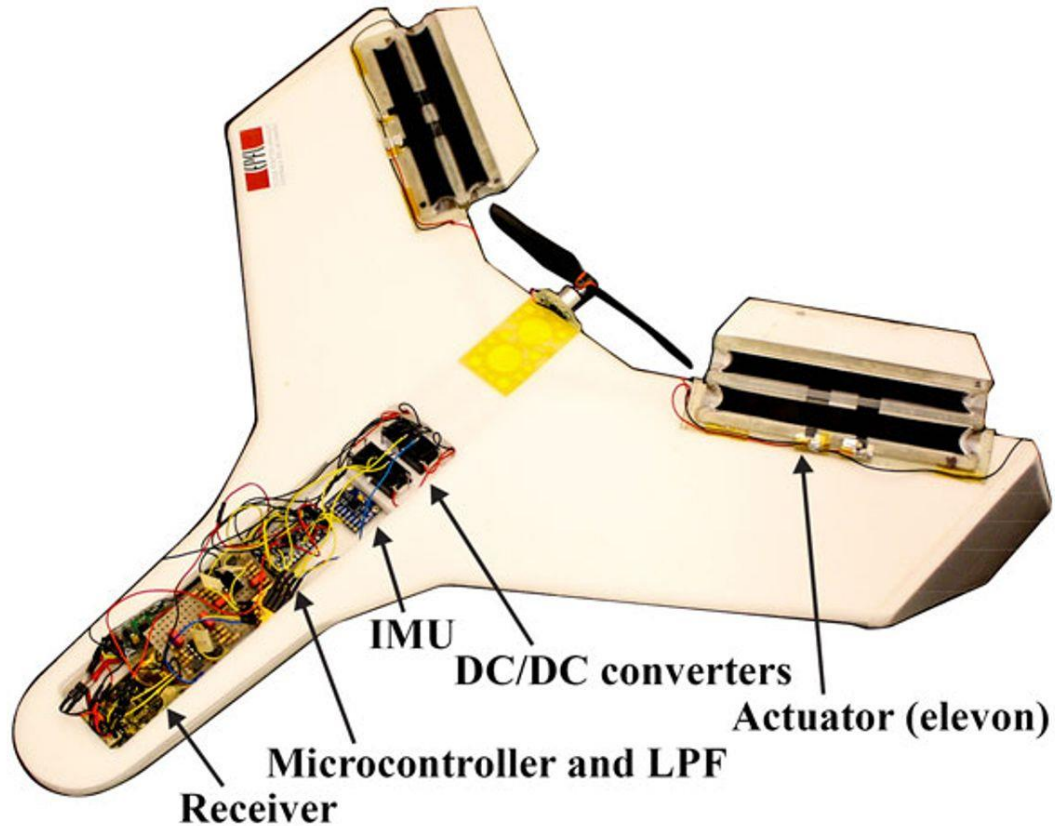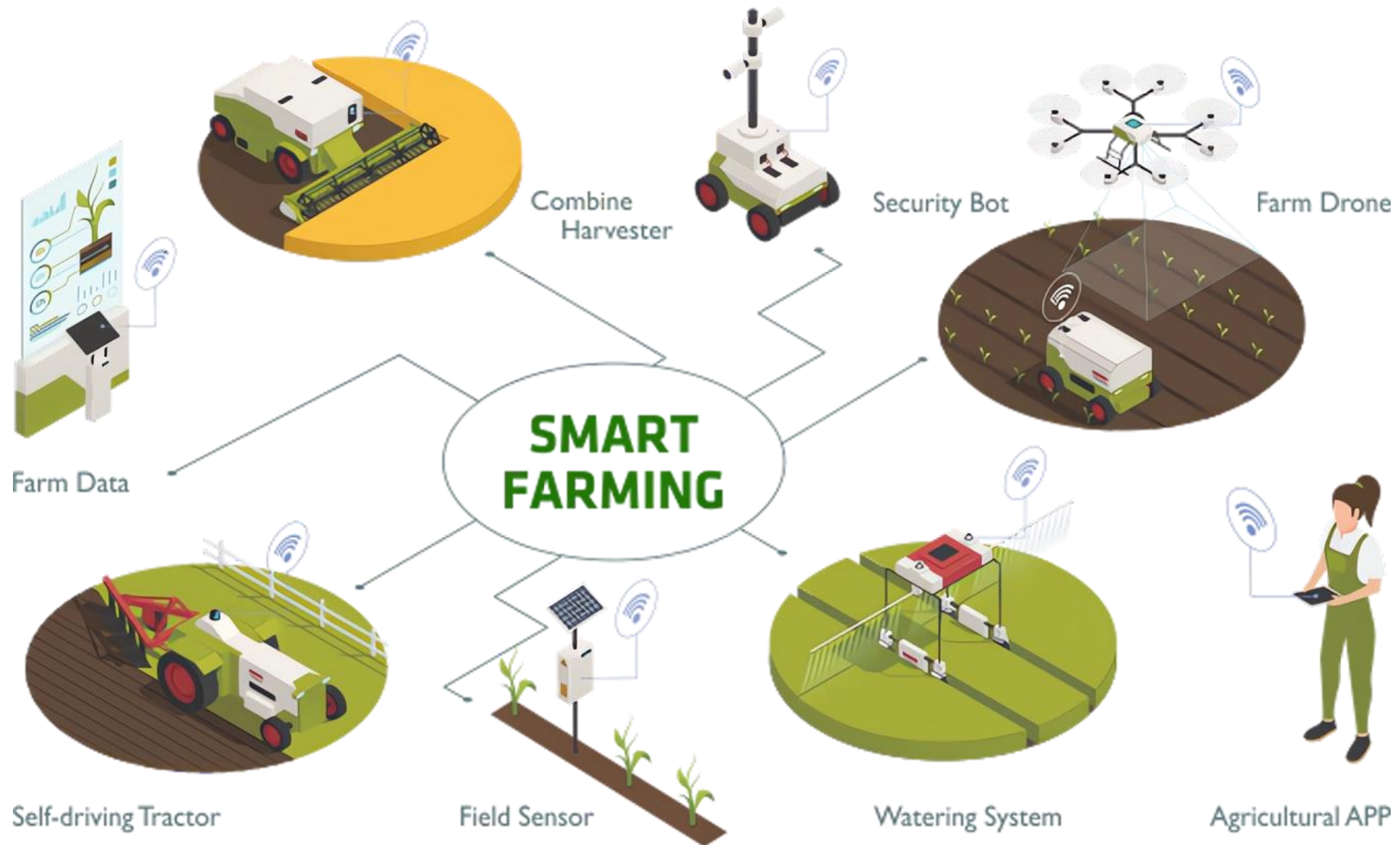
MCU Producers and Markets

Global Participants of MCU Manufacture

MCU Market Size

MICROCONTROLLER (MCU) MARKET SIZE, 2021 TO 2030 (USD BILLION)

PRECEDENCE RESEARCH

Year	Value
2021	$ 25.76
2022	$ 28.2
2023	$ 30.87
2024	$ 33.8
2025	$ 37.0
2026	$ 40.51
2027	$ 44.35
2028	$ 48.56
2029	$ 53.16
2030	$ 58.20
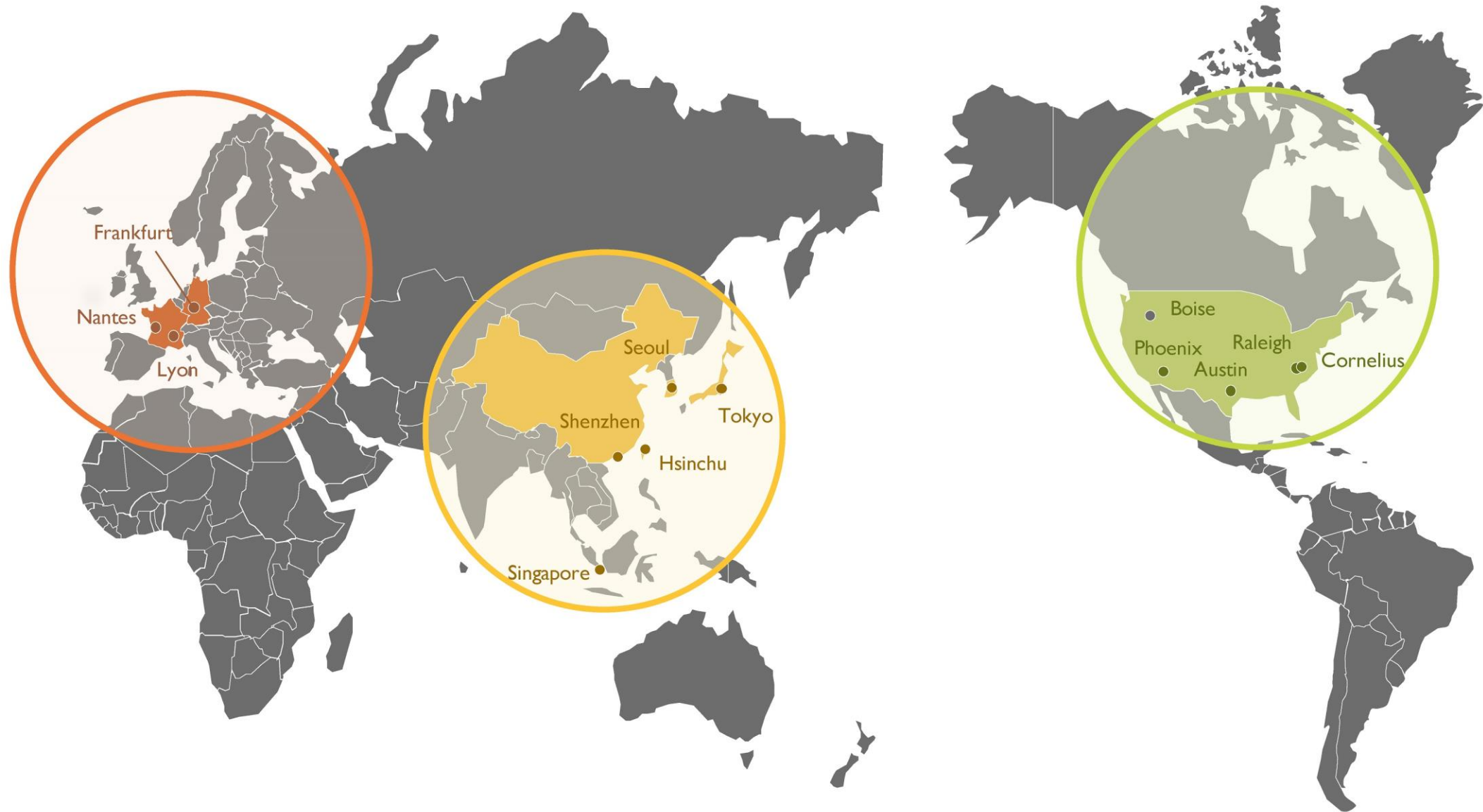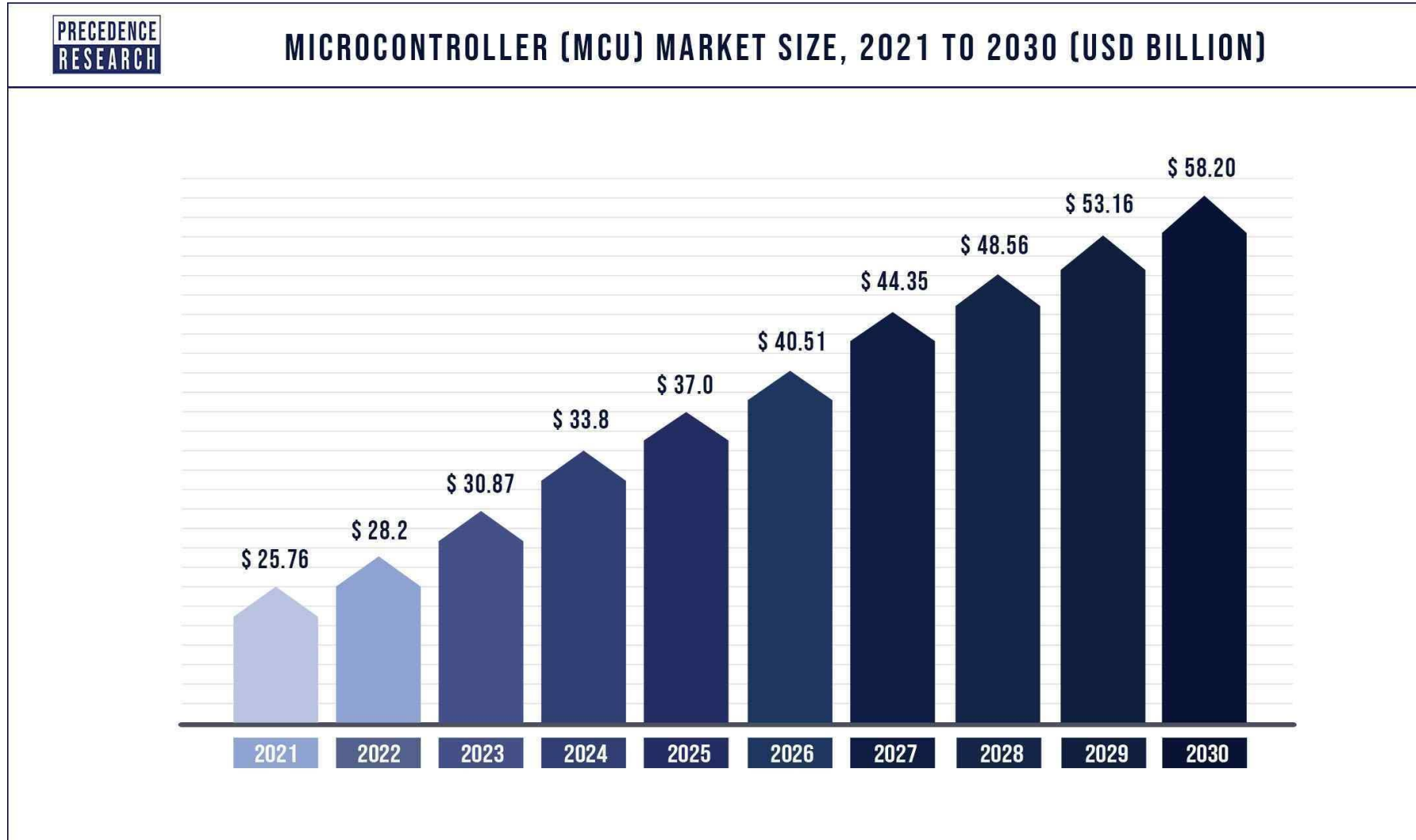
Major MCU Suppliers

Where Can We Find MCUs?
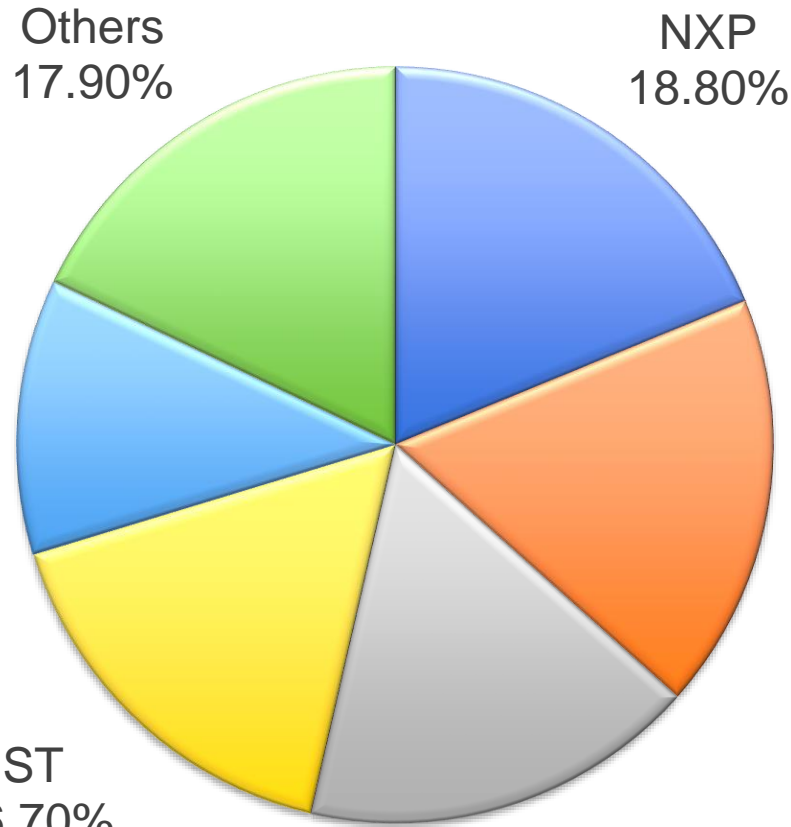
MCU on Cars

MCU Used in Agriculture
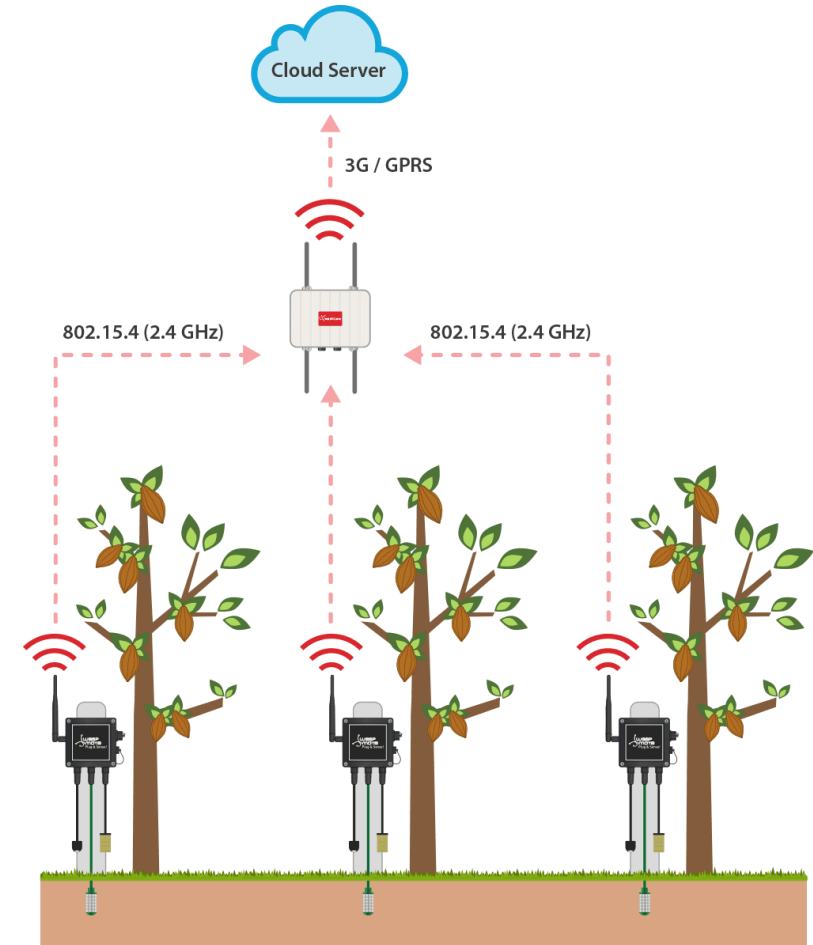
Cloud Server

3G / GPRS

802.15.4 (2.4 GHz)   802.15.4 (2.4 GHz)

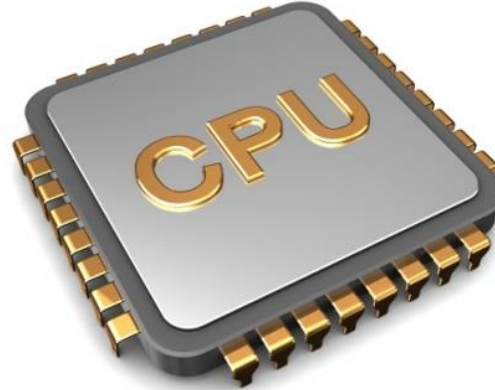# Difference between MCU, MPU, and PLC

Microcontroller
(MCU)
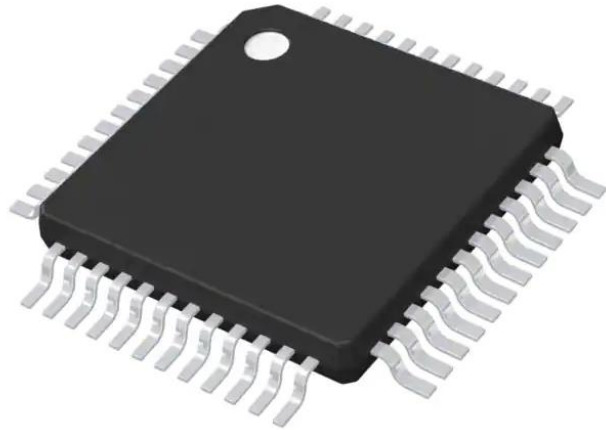
Microprocessor
(MPU)
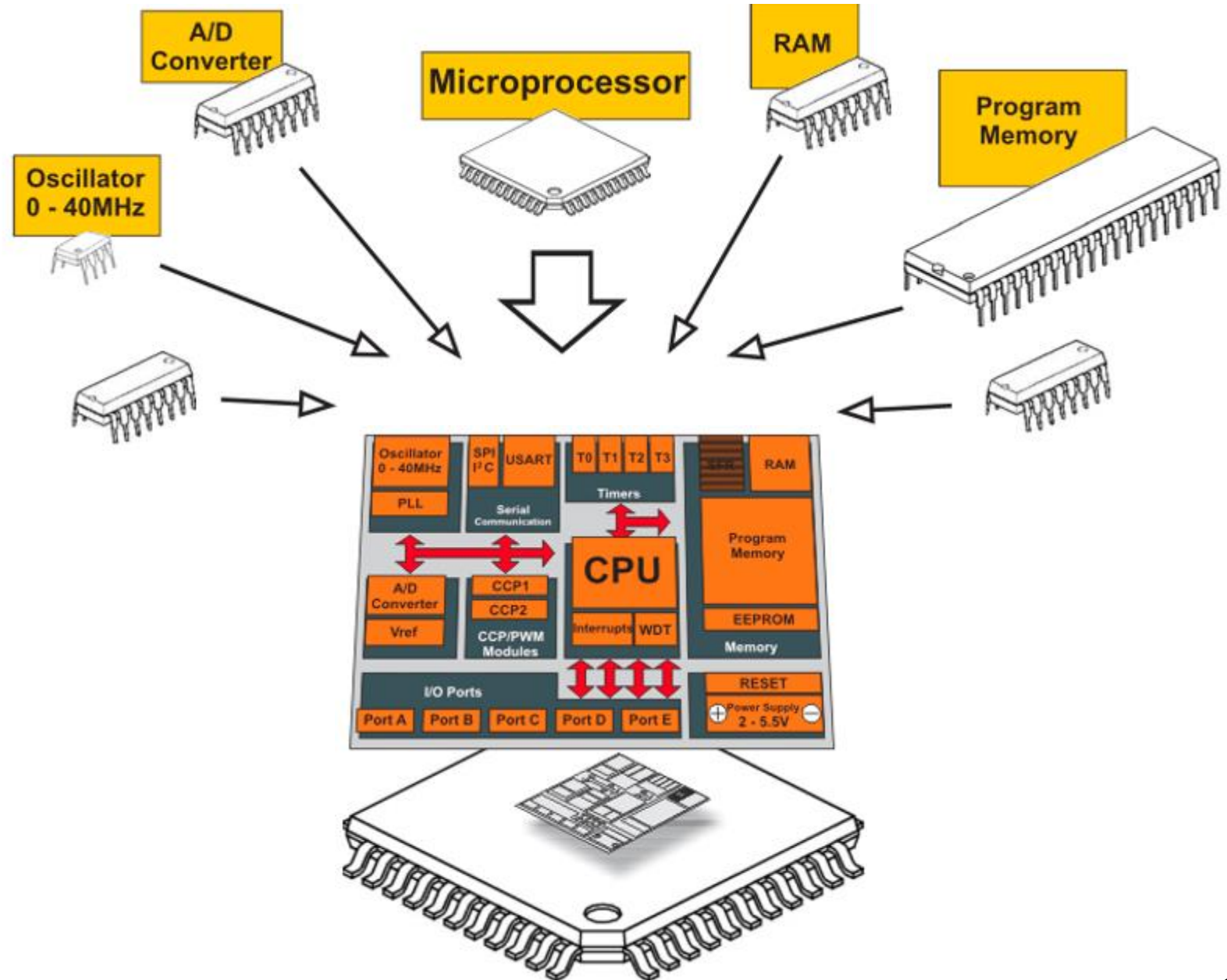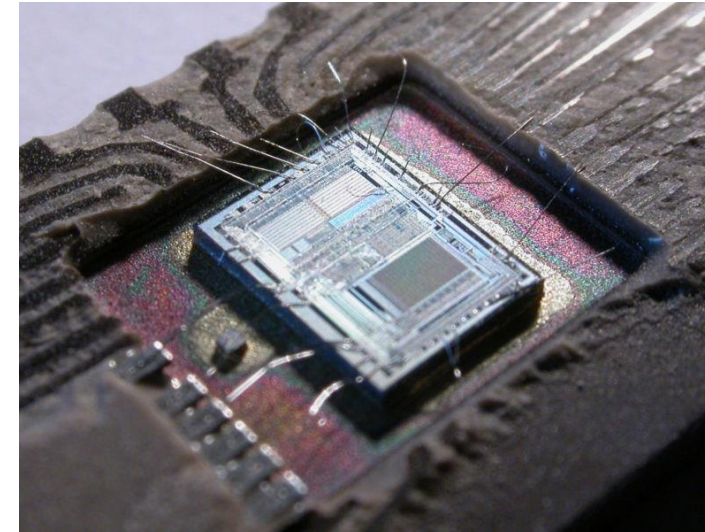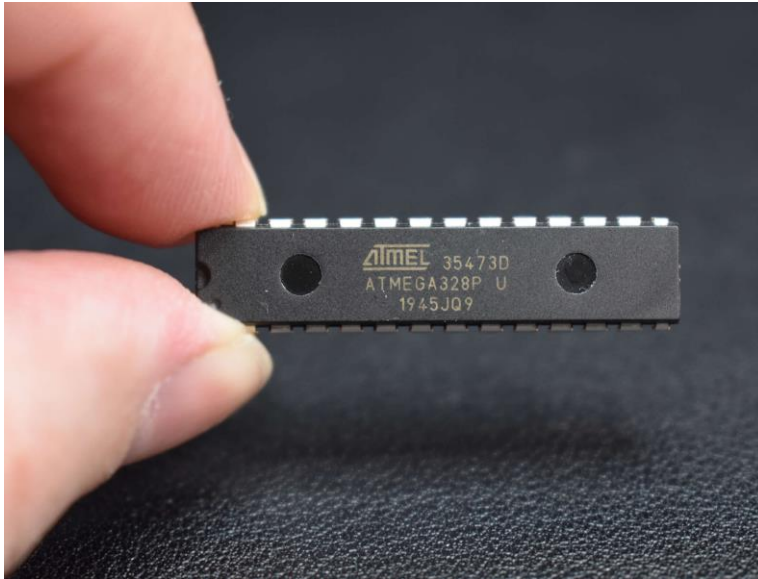
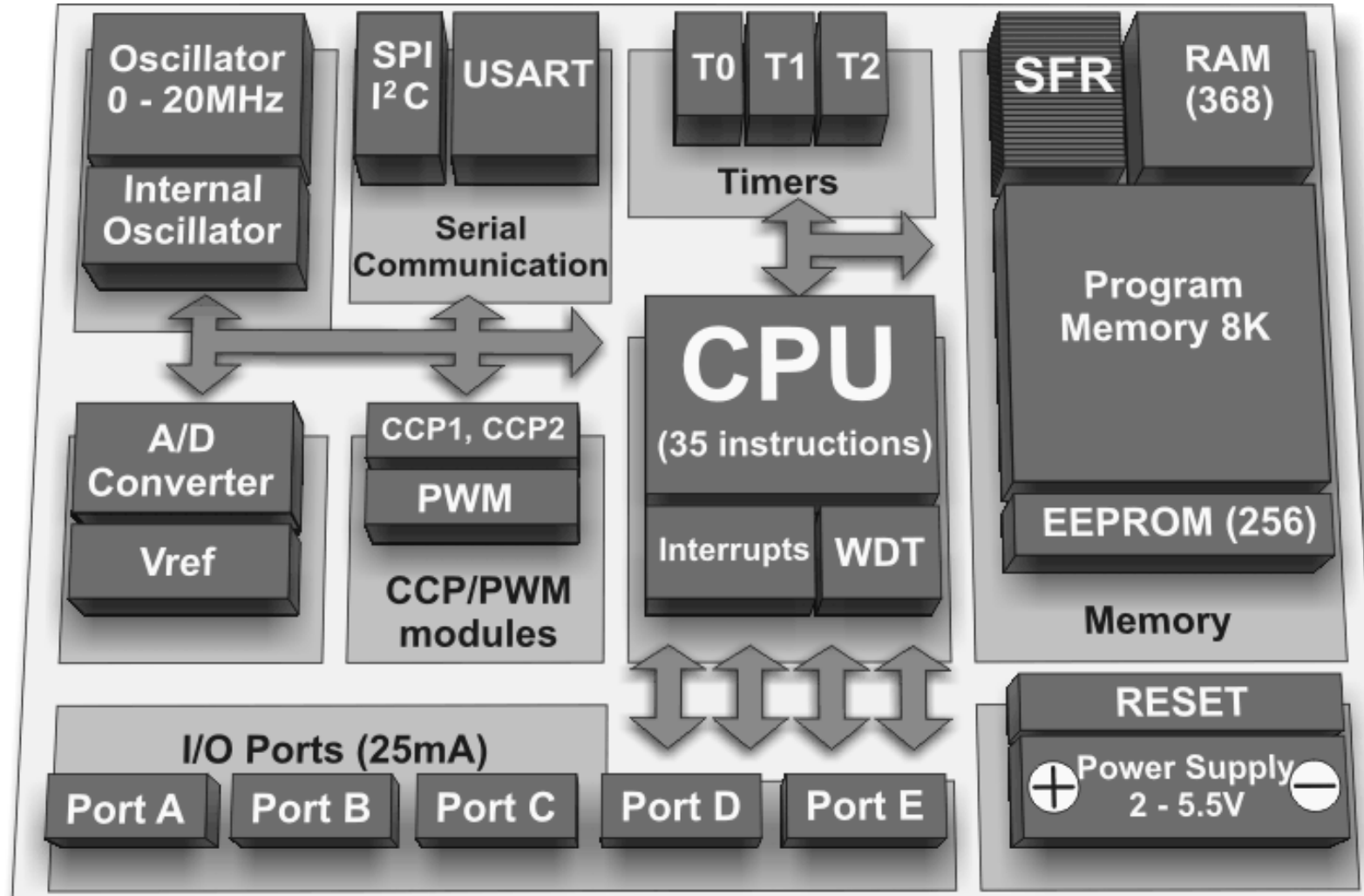Programmable
logic controller
(PLC)
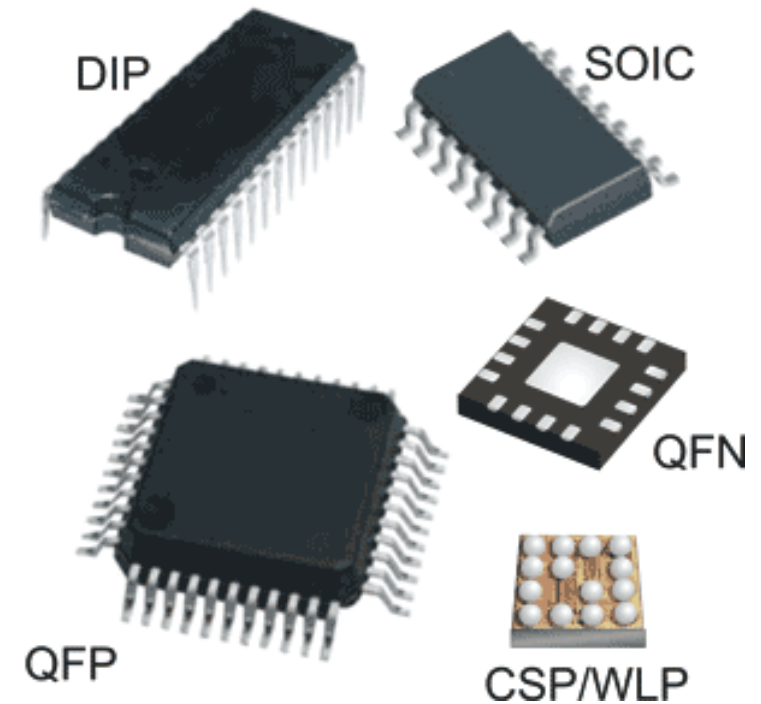
MCU vs. MPU

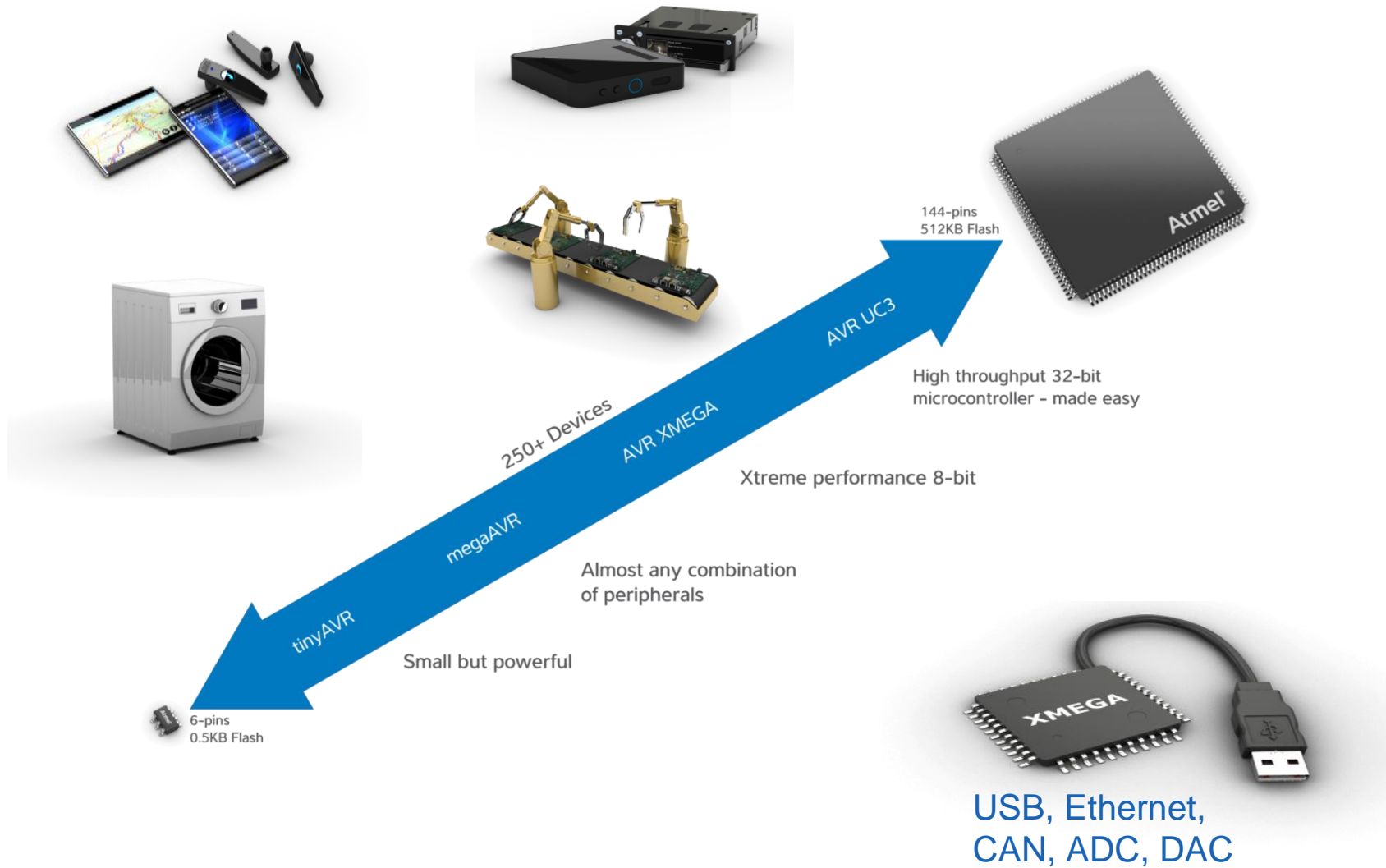# Physical Size of a MCU

In

Inside a MCU

How to Choose a MCU?

- Number of I/O pins

- Bits

- Memory (RAM and ROM)

- Clock frequency

- Power consumption

- Internal functions (ADC and PWM)

Number of I/O Pins

144-pins
512KB Flash

AVR UC3

High throughput 32-bit
microcontroller - made easy

250+ Devices

AVR XMEGA

Xtreme performance 8-bit

megaAVR

Almost any combination
of peripherals

tinyAVR

Small but powerful

6-pins
0.5KB Flash
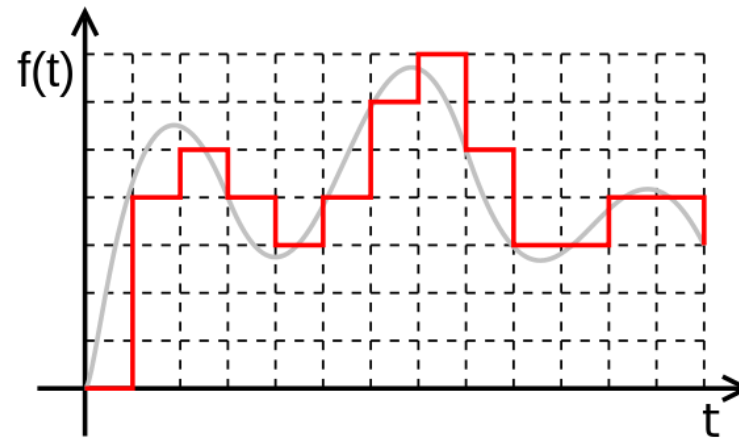
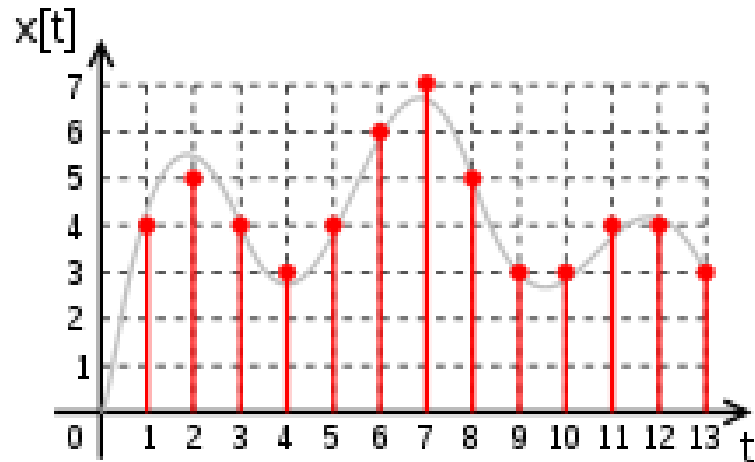USB, Ethernet,
CAN, ADC, DAC

Bits and Memory

1956

5MB大硬碟

Clock Frequency
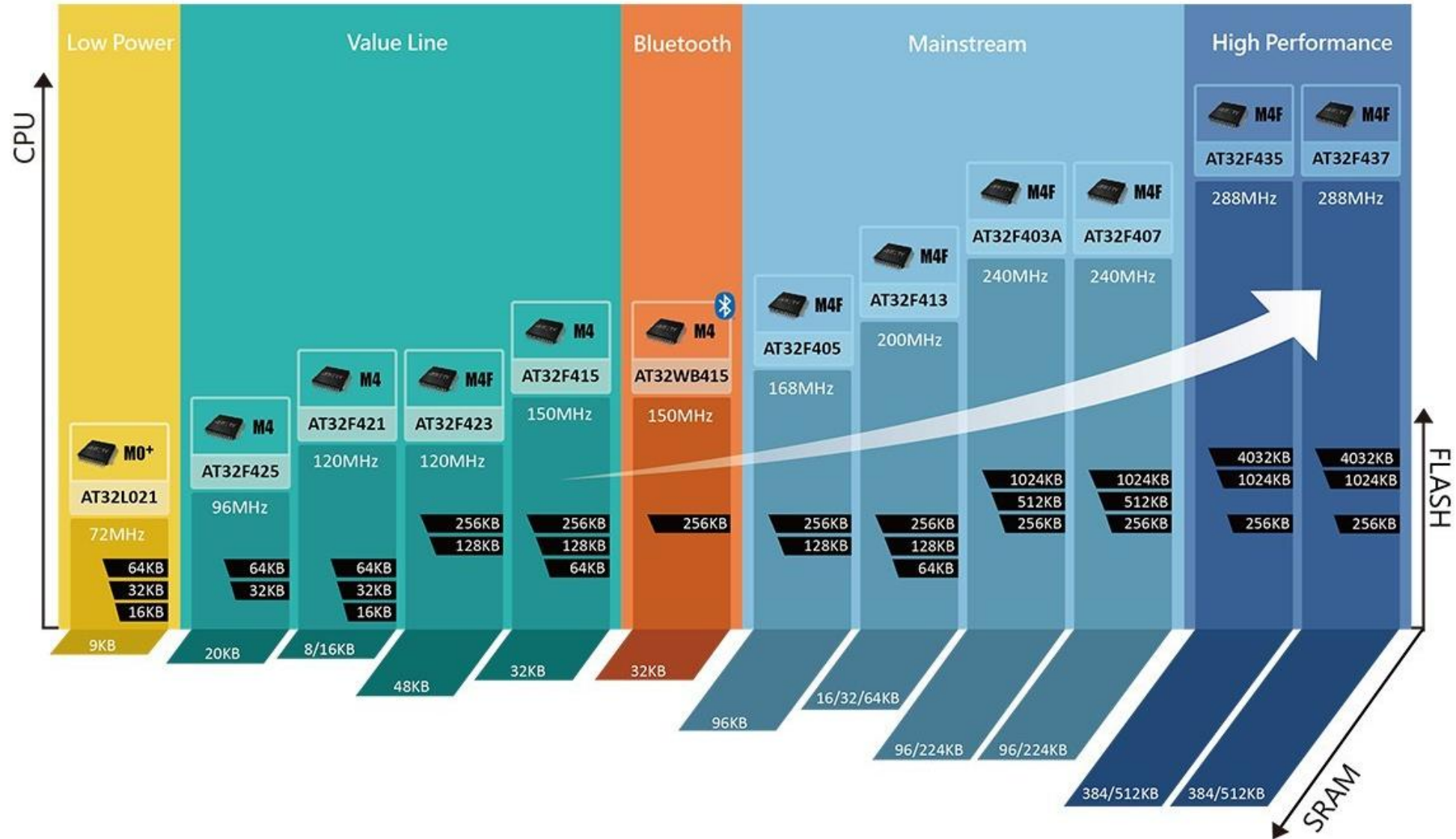
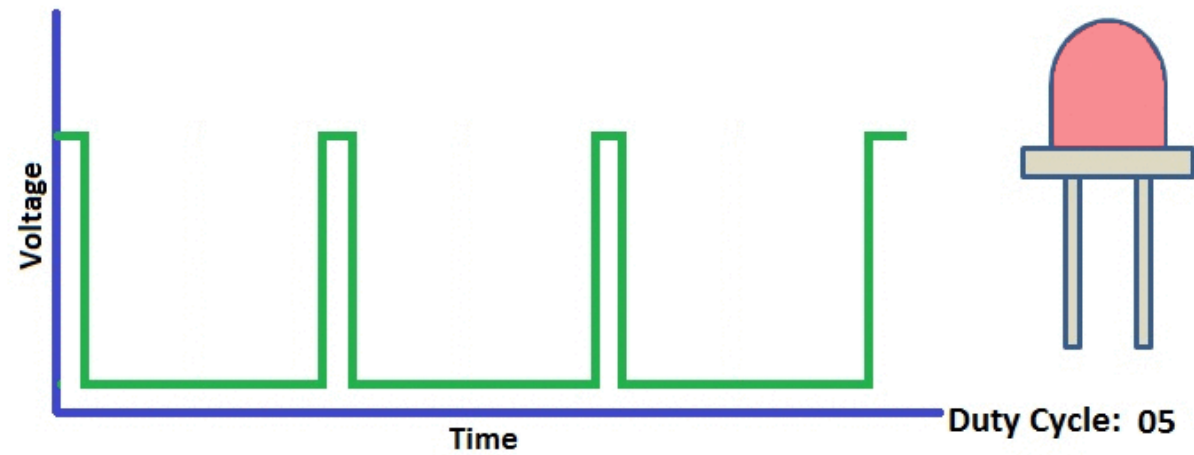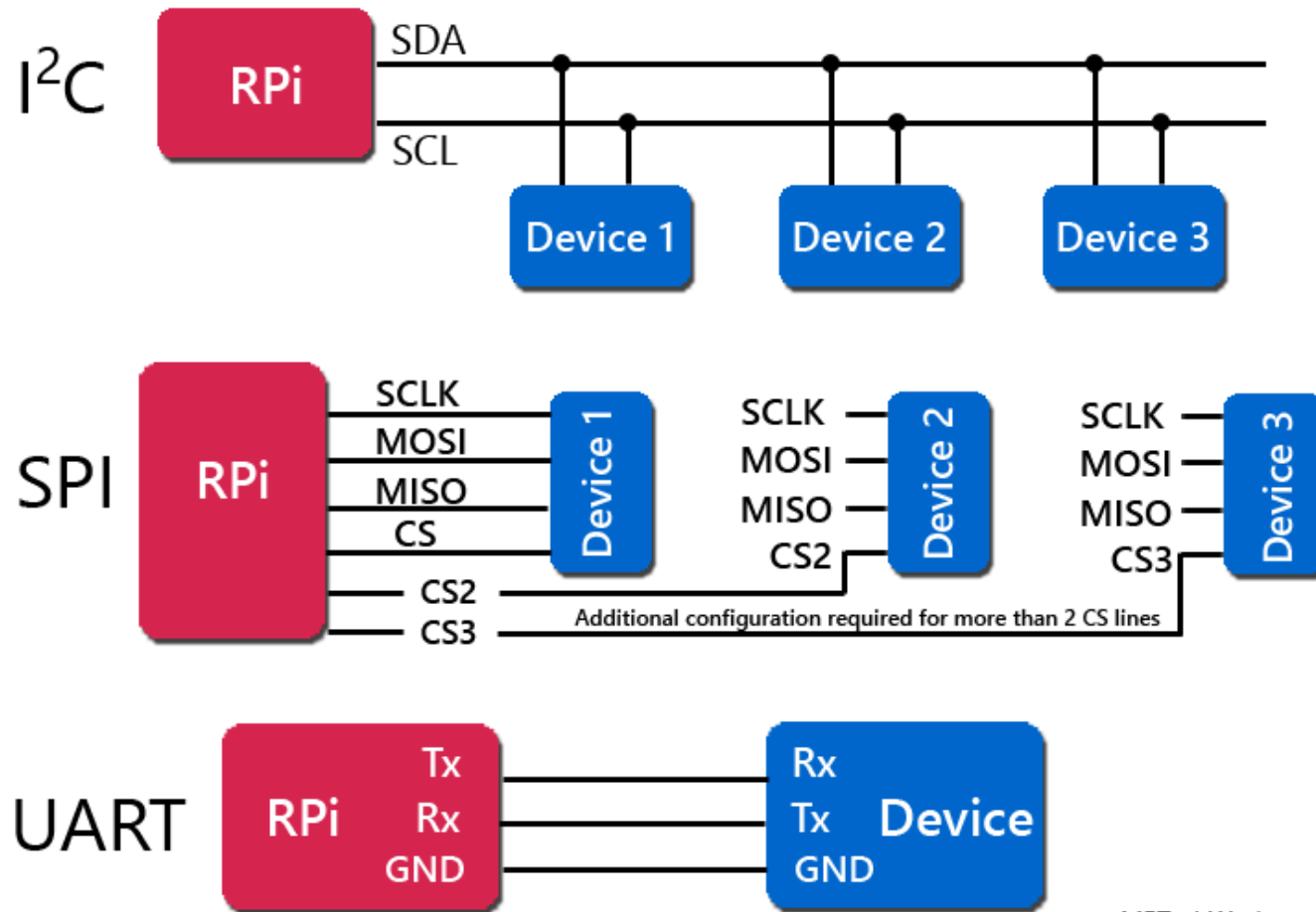# Analog-to-Digital Converter (ADC)

Considerations:

- Resolution

- Sampling freq.

- Input range
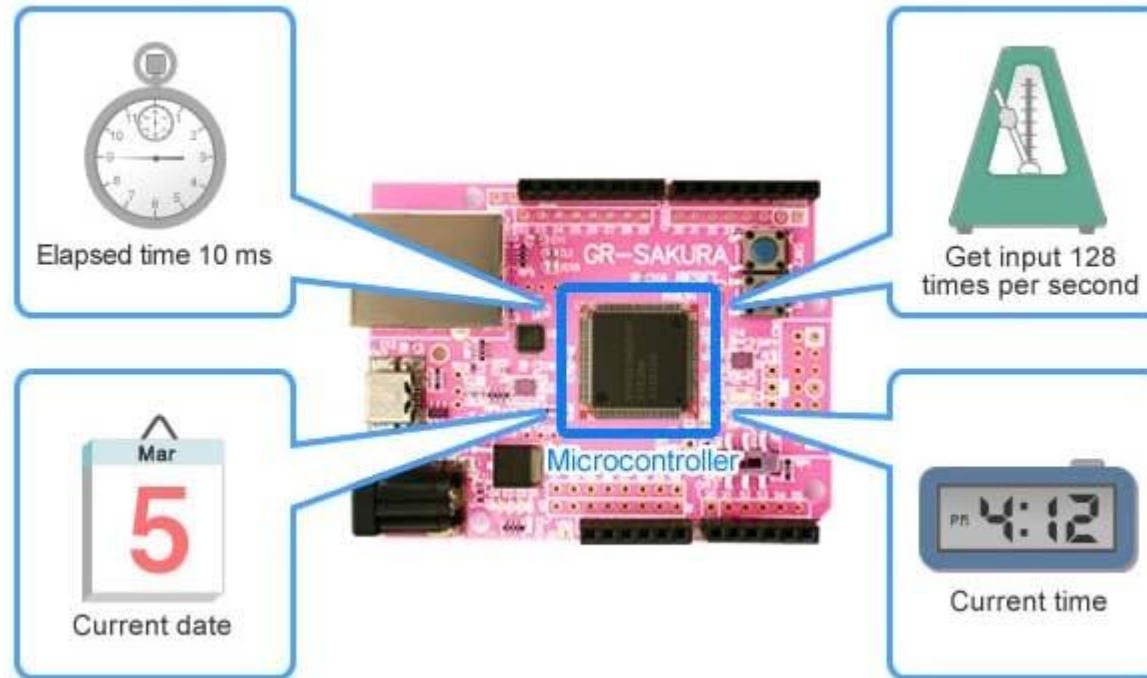
- # of channels

Pulse width modulation (PWM)

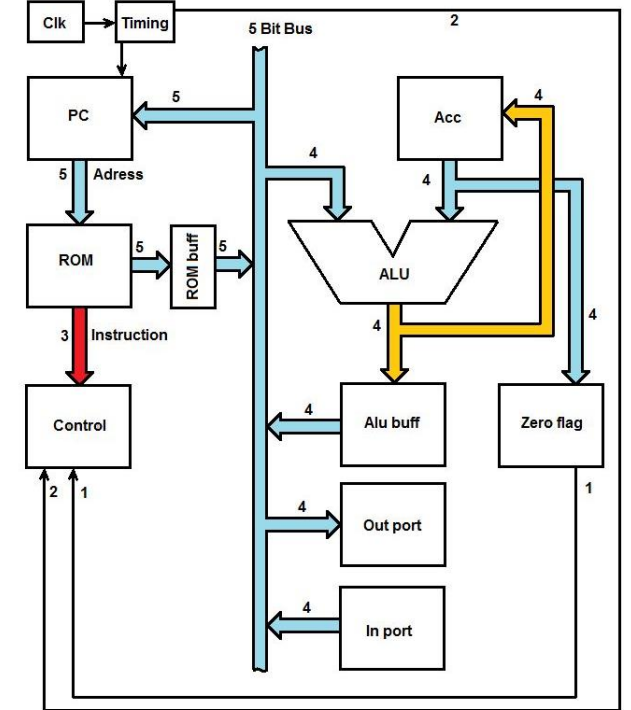Duty Cycle: 05

Wired Communications – I2C, SPI, and UART
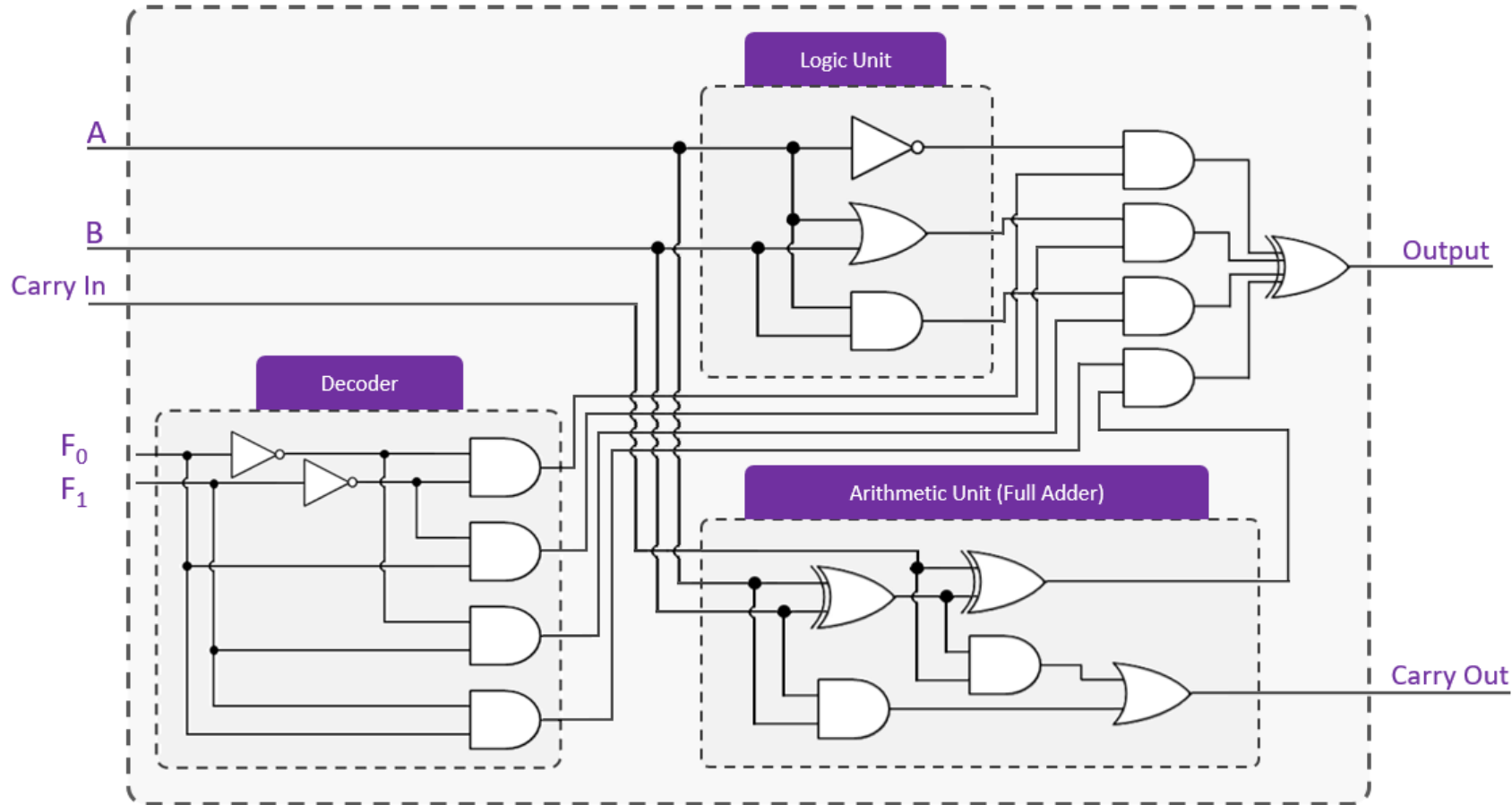
Timer

What We Teach about MCU at NTU?

Computer Architecture

Source: https://www.101computing.net/8-bit-alu-using-logic-gates/
https://en.wikipedia.org/wiki/Computer_architecture

MCU in the Mechatronics Concept Map
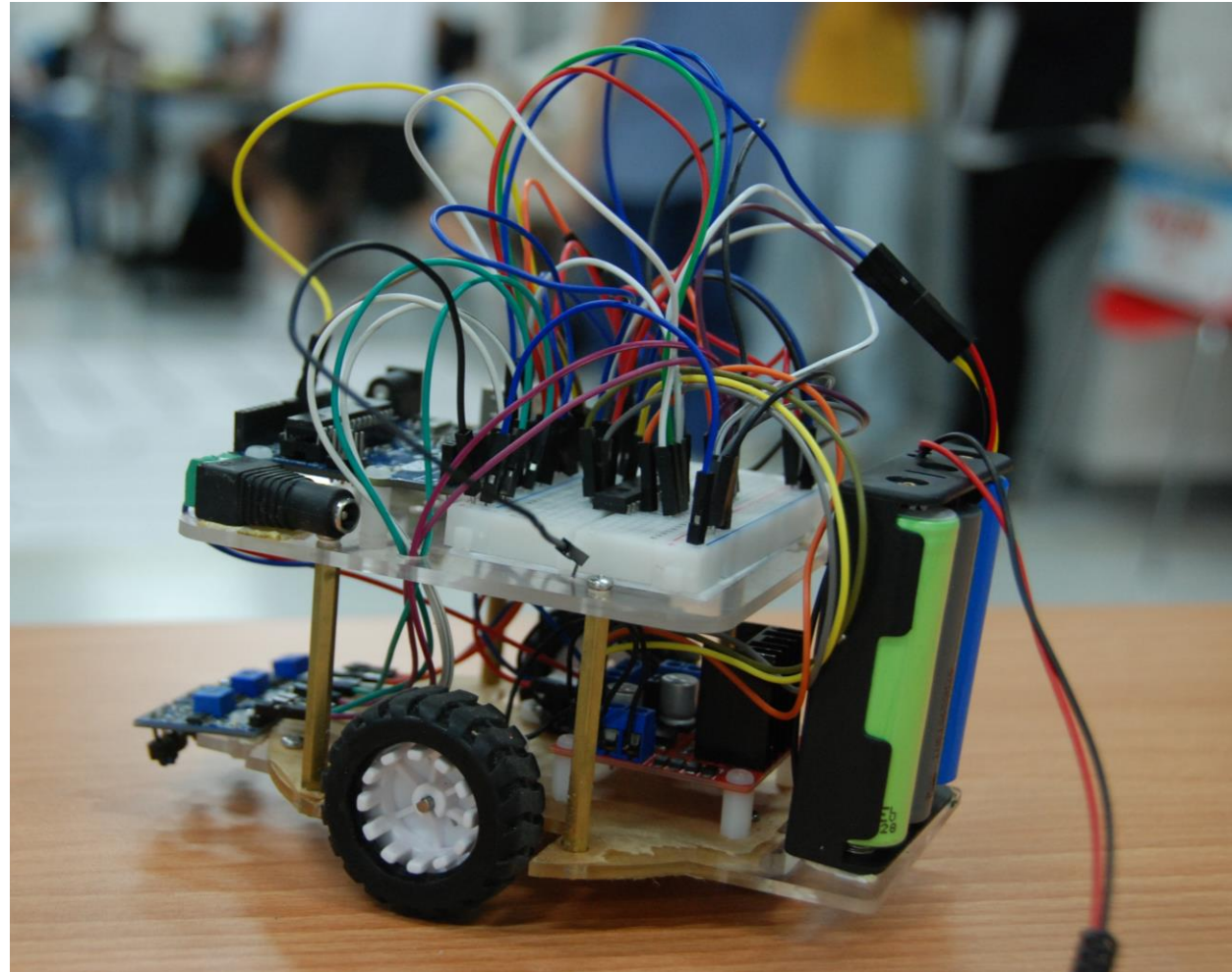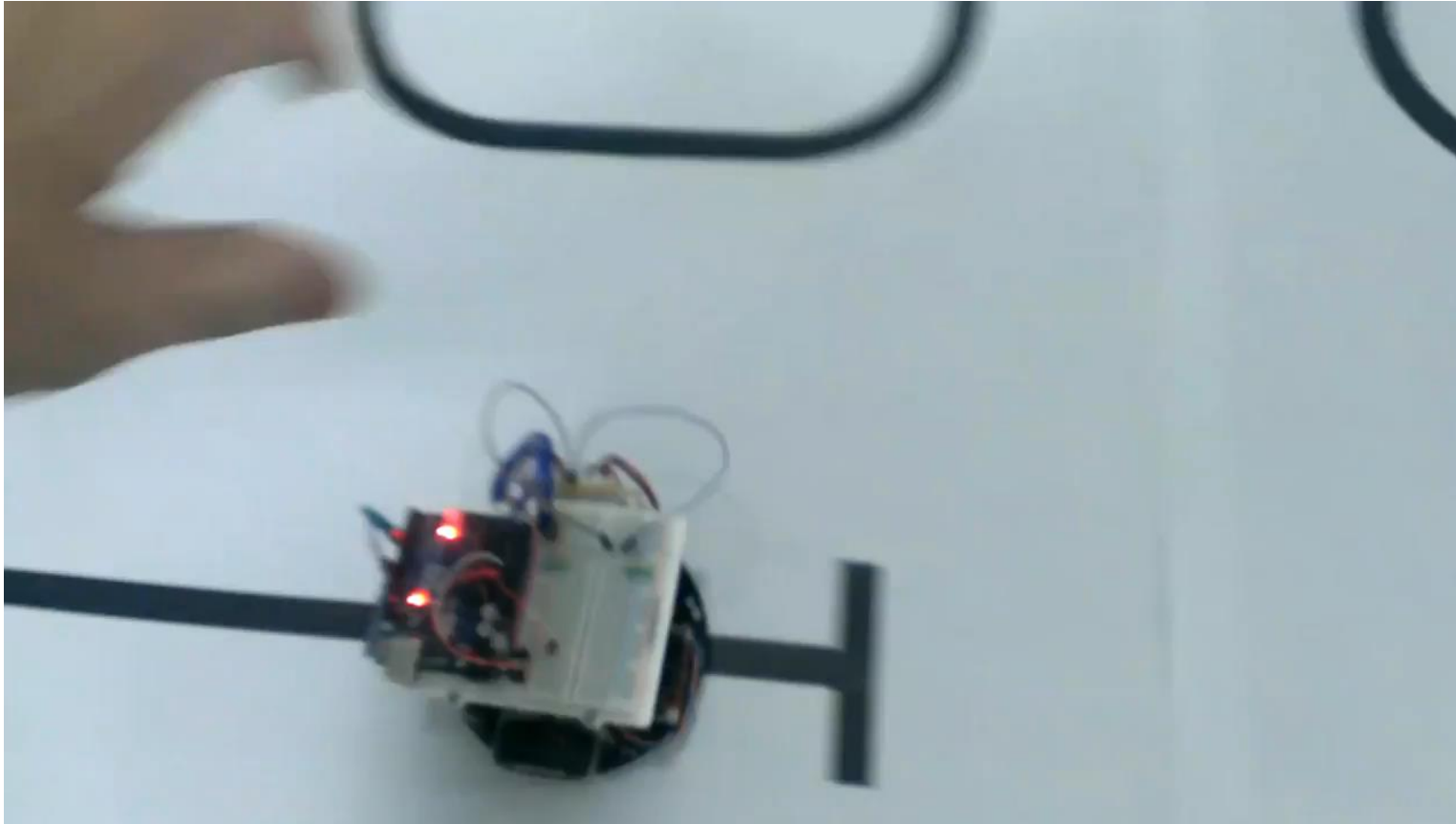
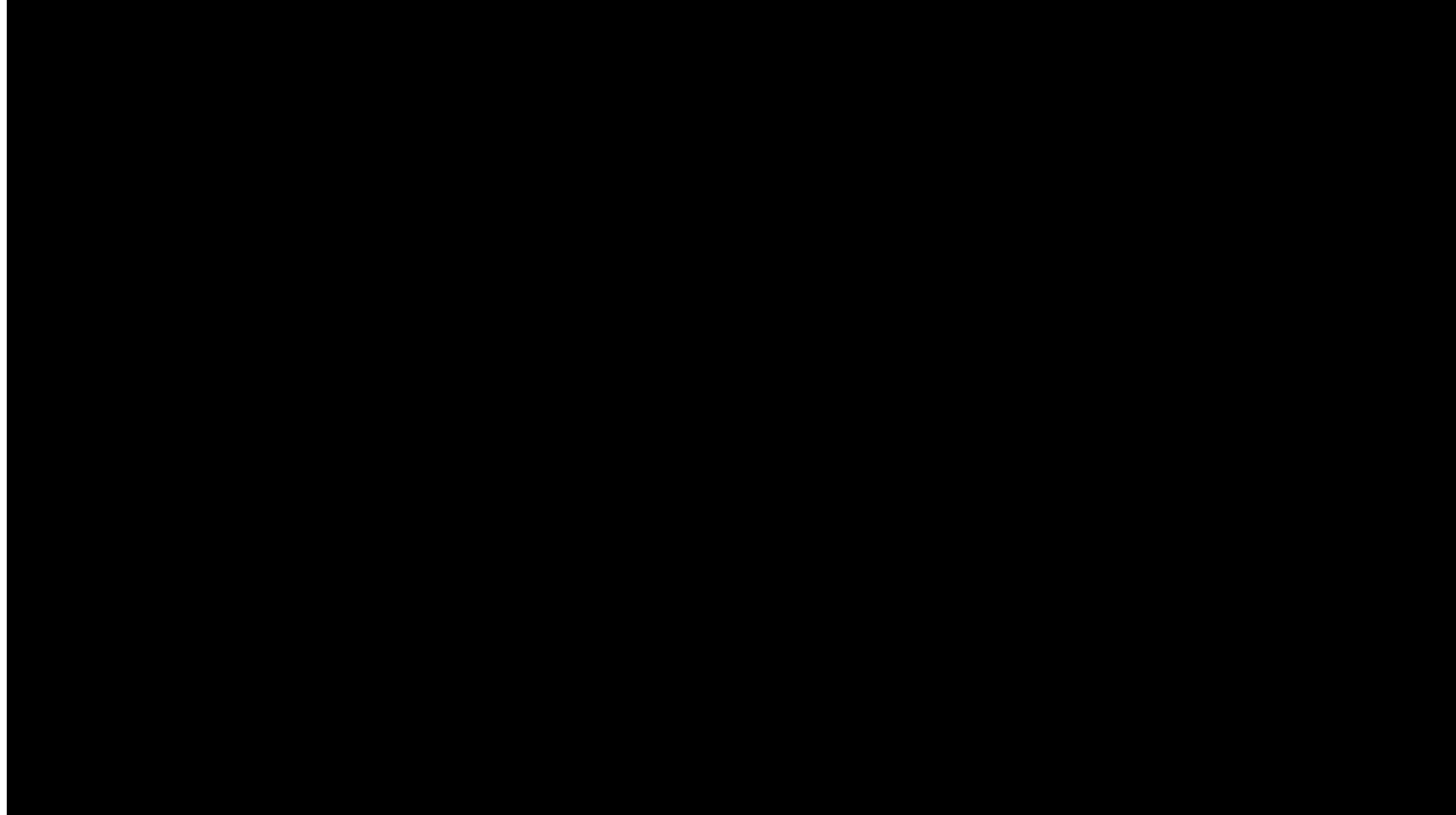# MCU Applications at NTU
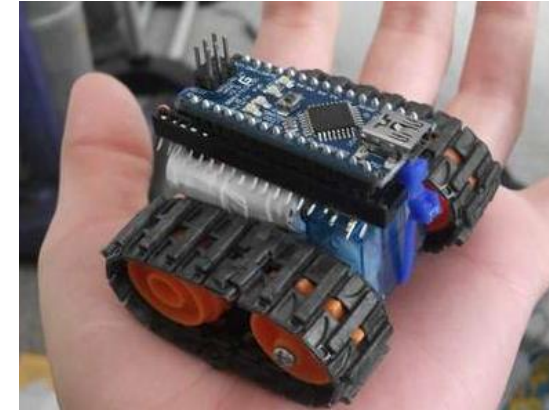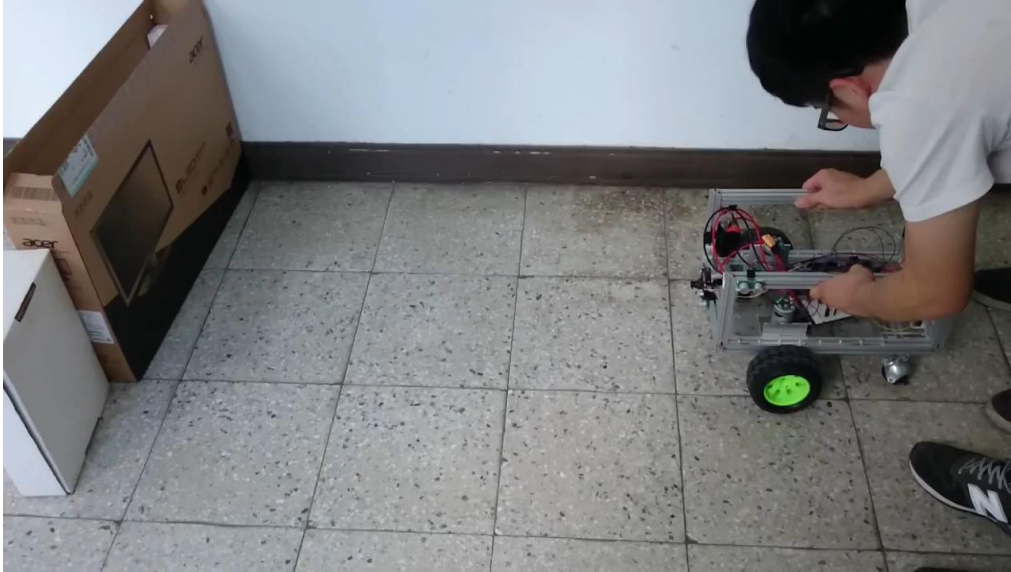
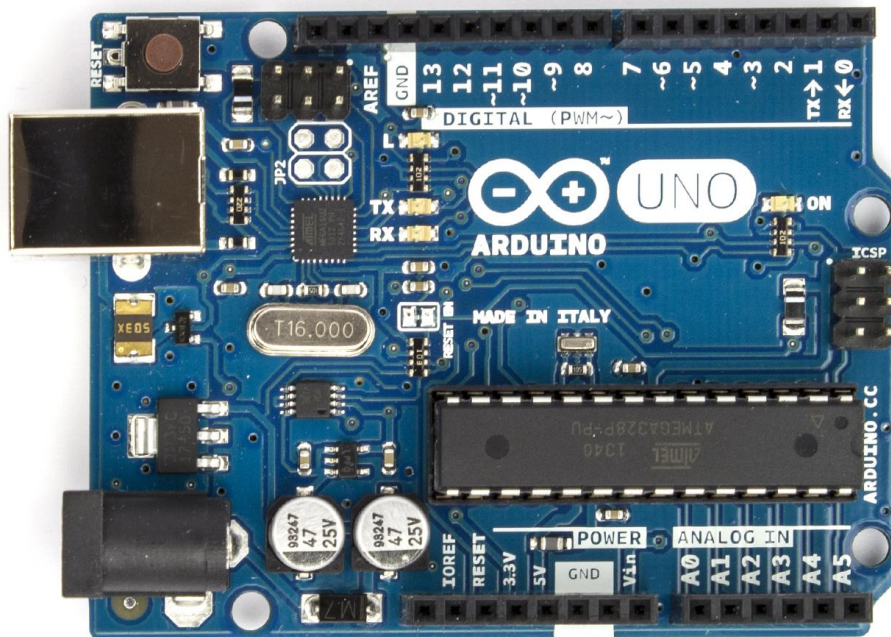# What Do I Teach in the MCU Course at NTU?

Line Tracking and Maze Running

Field Robot Competition

What Will You Learn in the AIoT農業先鋒班?

- Arduino UNO – an integrated microcontroller
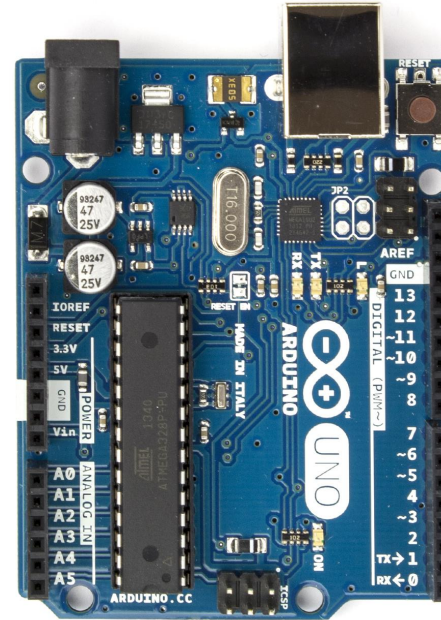
- Using Microchip ATmega328p

Why Arduino?

- Open source

- Low-cost – less than $30 USD

- Easy to use – less hardware logic

- Friendly programming environment

- Dominating the market

Yan-Fu Kuo
Dept. of Biomechatronics Engineering
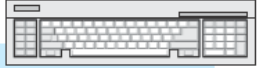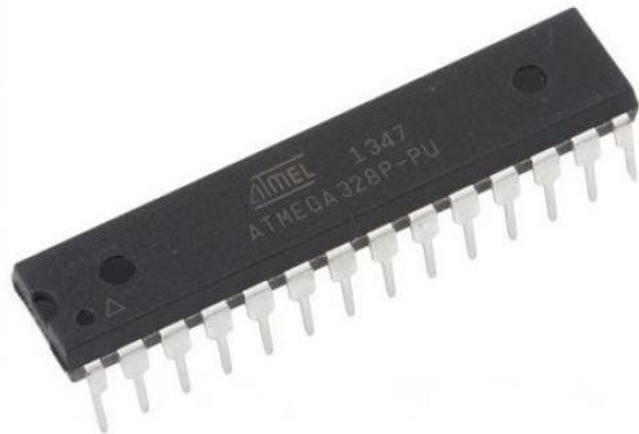
Arduino UNO

Intel 80286 (1982)   =   Arduino Uno (2010)

Programming Arduino

- Using sketch – a language very similar to C language

- The essential functions of MCU are packaged as functions


```
void main() {

  TRISB = 0;              // All port B pins are configured as
                          // outputs
  PORTB = 0b01010101;     // Logic state on port B pins
}
```
Program written in C

```
; ADDRESS      OPCODE        ASM
; ---------------------------------------------
$0000         $2804         GOTO    _main
$0004         $       _main:
;Test.c,1 :: void main() {
;Test.c,3 :: TRISB = 0;            // All port B pins
$0004         $1303         BCF     STATUS, RP1
$0005         $1683         BSF     STATUS, RP0
$0006         $0186         CLRF    TRISB, 1
;Test.c,4 :: PORTB = 0b01010101; // Logic state
$0007         $3055         MOVLW   85
$0008         $1283         BCF     STATUS, RP0
$0009         $0086         MOVWF   PORTB
;Test.c,5 :: }
$000A         $280A         GOTO    $
```
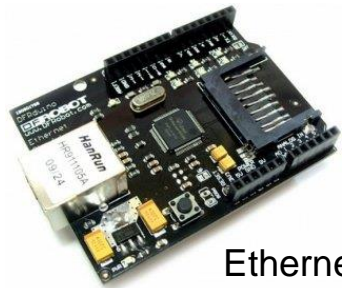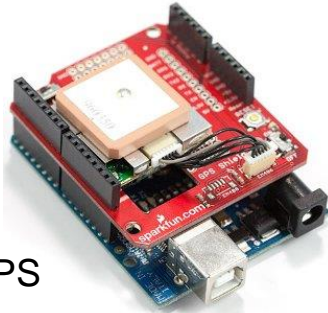Compiled Program

```
:100000000428FF3FFF3FFF3F03138316860155304F
:10001000831286000A28FF3FFF3FFF3FFF3FFF3F5D
:04400E00F22FFFFF8F
:00000001FF
```
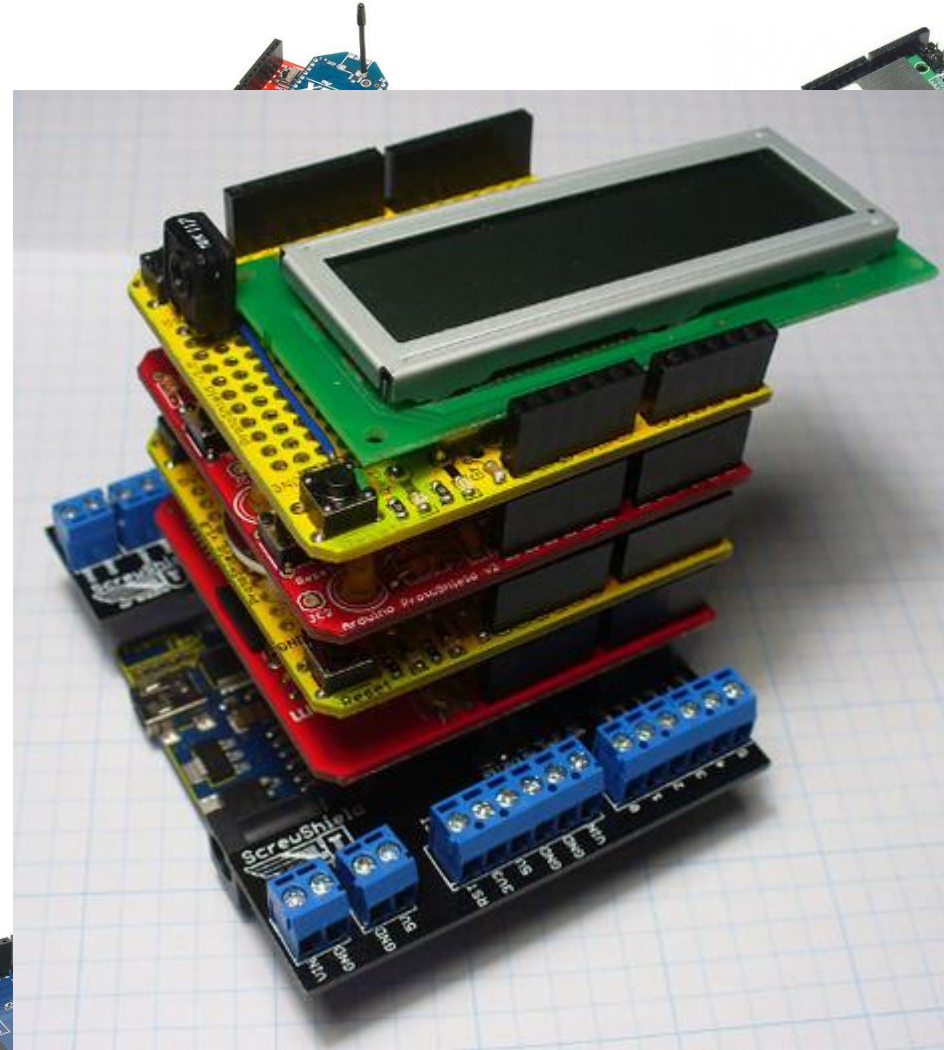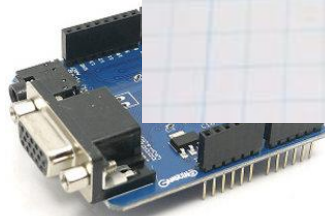Executable Code of the program (HEX code)
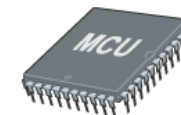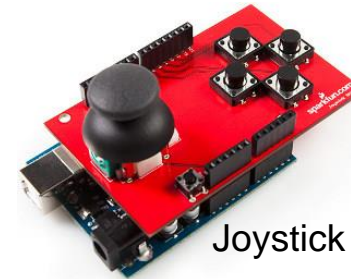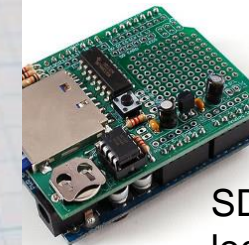
Arduino Shields

GPS

ifi

Ethernet

Joystick

VGA

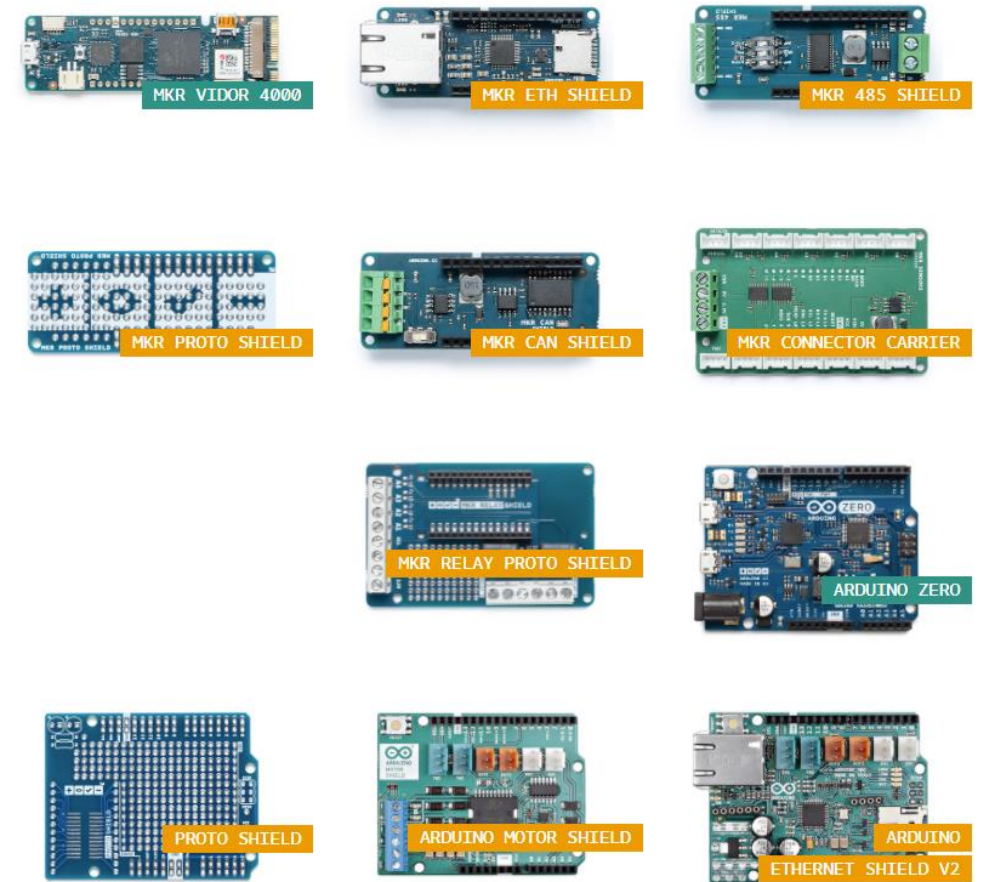Motor controller

SD card logger

Arduino Family
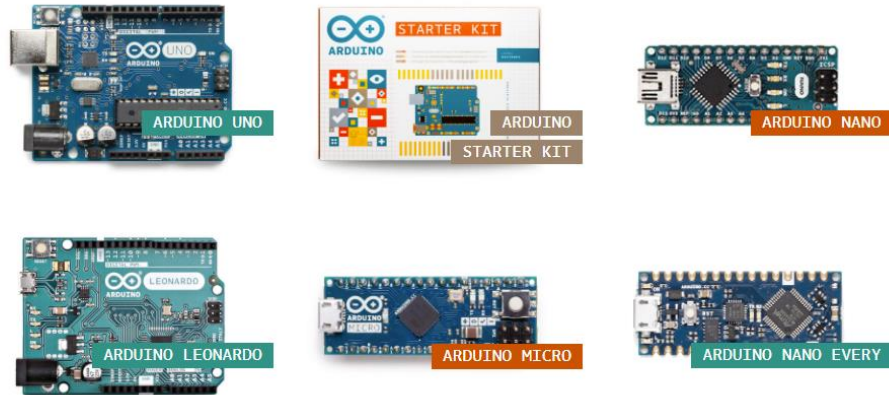
Enhanced Features

Entry
Level

IoT

Arduino Nano 33 IoT

- Embedded WiFi and Bluetooth
- Low power consumption
- Integrated Arduino IoT cloud

SAMD21 Cortex®-M0+ 32bit low power ARM MCU

Power LED(Green)

Nina W102 uBlox module (WiFi + Bluetooth)

Micro USB Port

Arduino Nano 33 IoT

www.eTechnophiles.com

ATECC608A Crypto IC

Programmable LED(Orange)

LSM6DS3 - IMU (Accelerometer, Gyro, Magnetometer)

Yan-Fu Kuo
Dept. of Biomechatronics Engineering

An Arduino IoT Project

My Teaching Videos

Source: https://www.youtube.com/c/yanfukuo

AIoT?

- Embeding AI on chips

Graph   C++

Tensorflow   Mbed

Source: https://www.youtube.com/watch?v=IGHi4Vjg9SY
https://os.mbed.com/blog/entry/Mbed-and-Machine-Learning/
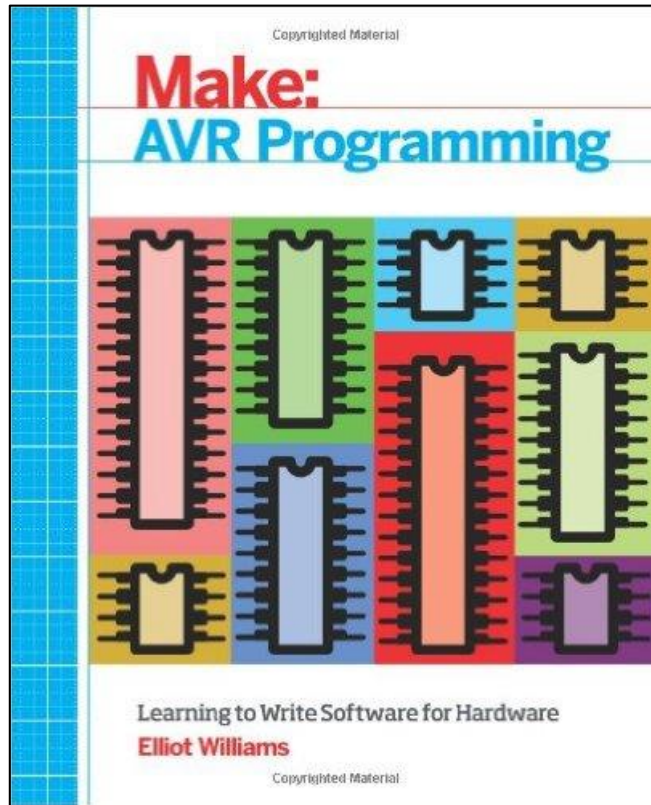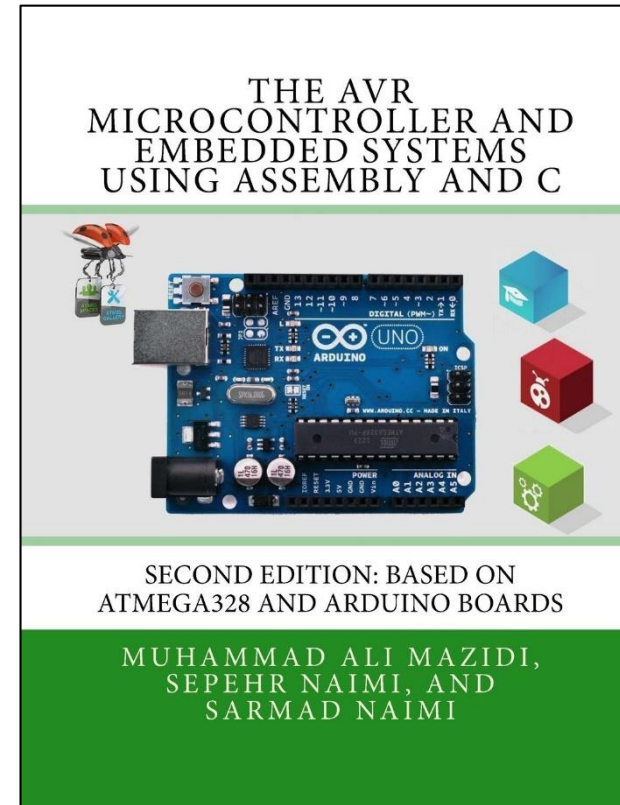
Reference Books

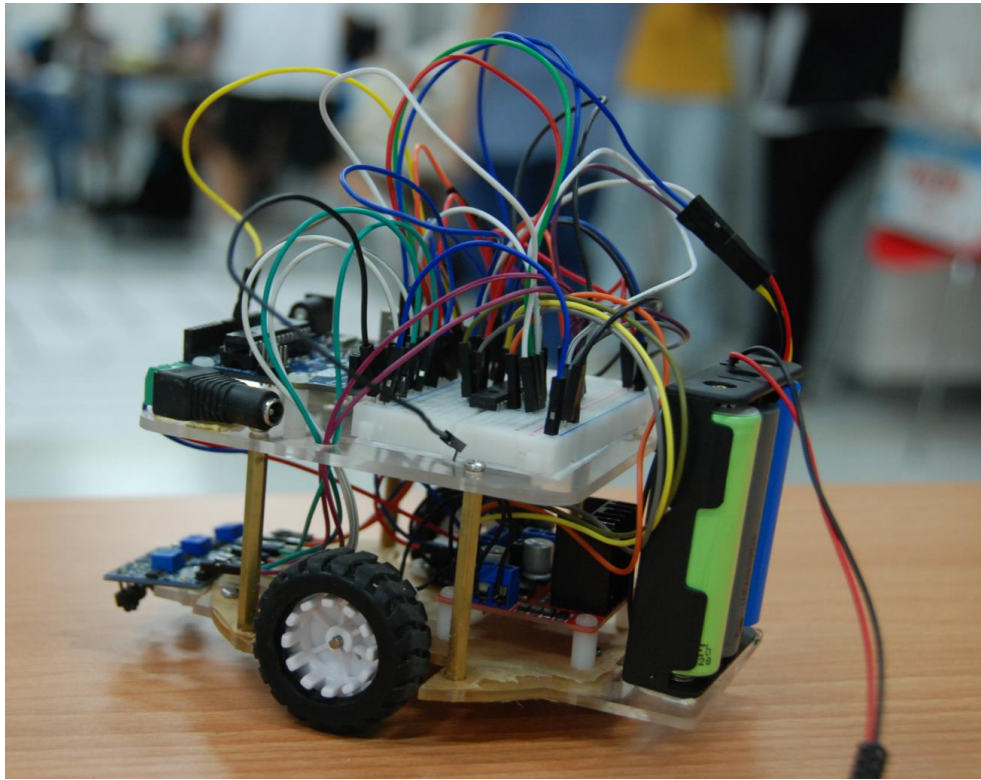"Make: AVR Programming - Learning to Write Software for Hardware" by E. Williams

"The AVR Microcontroller and Embedded Systems Using Assembly and C" by M. A. Mazidi, S. Naimi, and S. Naimi
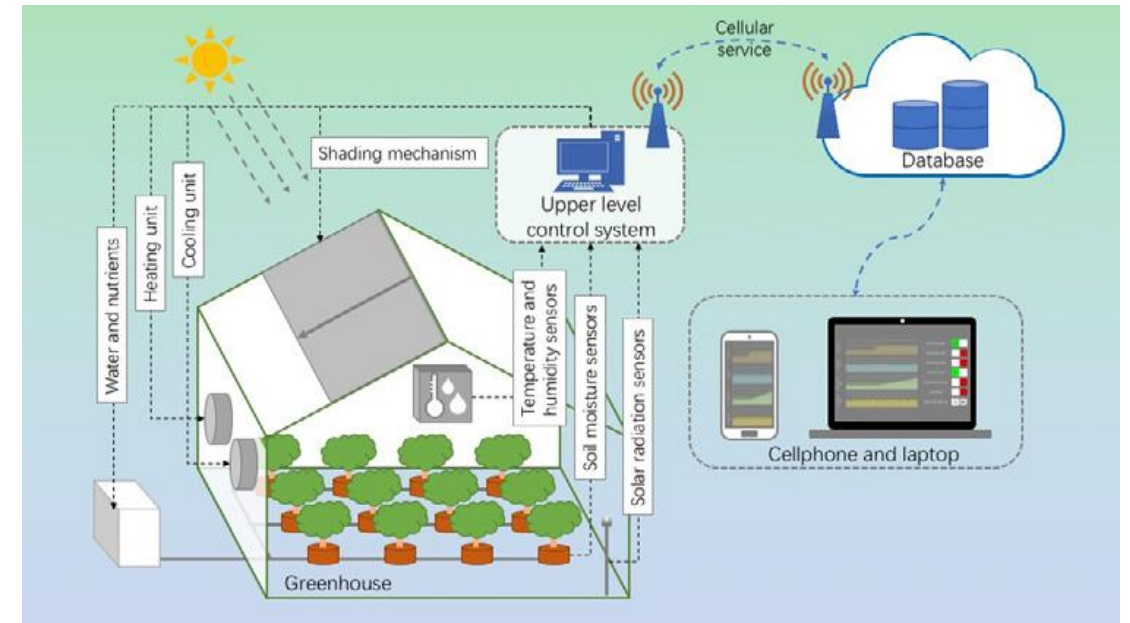
What Project You Would Like to Do in the AIoT Course?

1. Car?

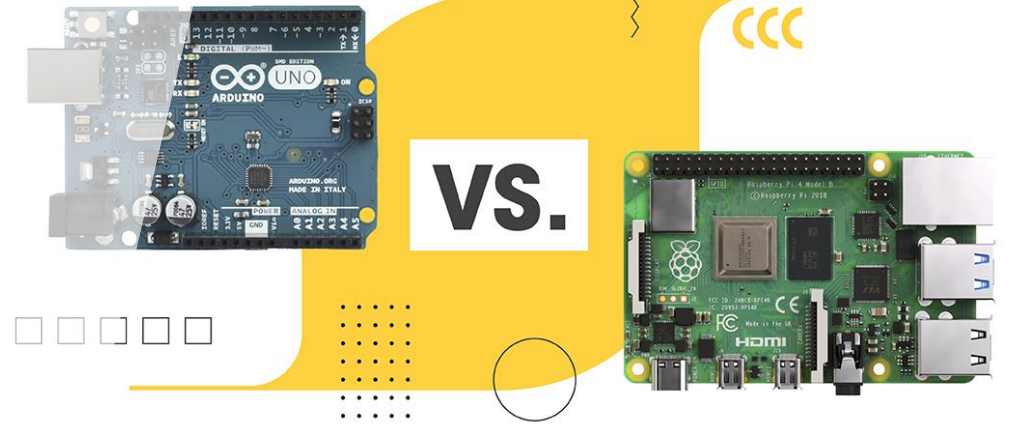## 2. Greenhouse?

National Taiwan University
Biomechatronics Engineering

NTU X COA

Thanks for listening

Yan-Fu Kuo | 19, June 2023