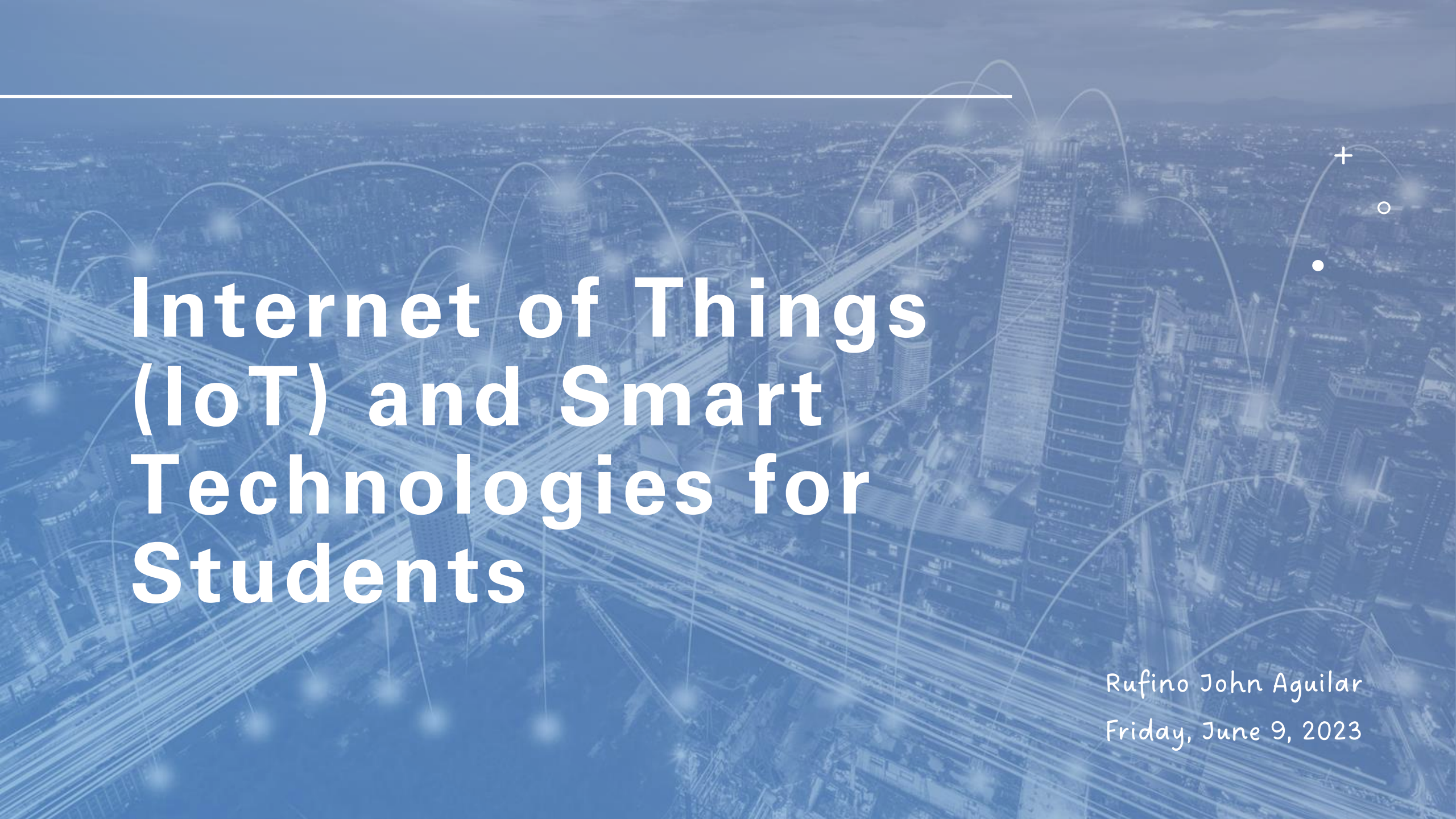


Internet of Things (IoT) and Smart Technologies for Students

Rufino John Aguilar

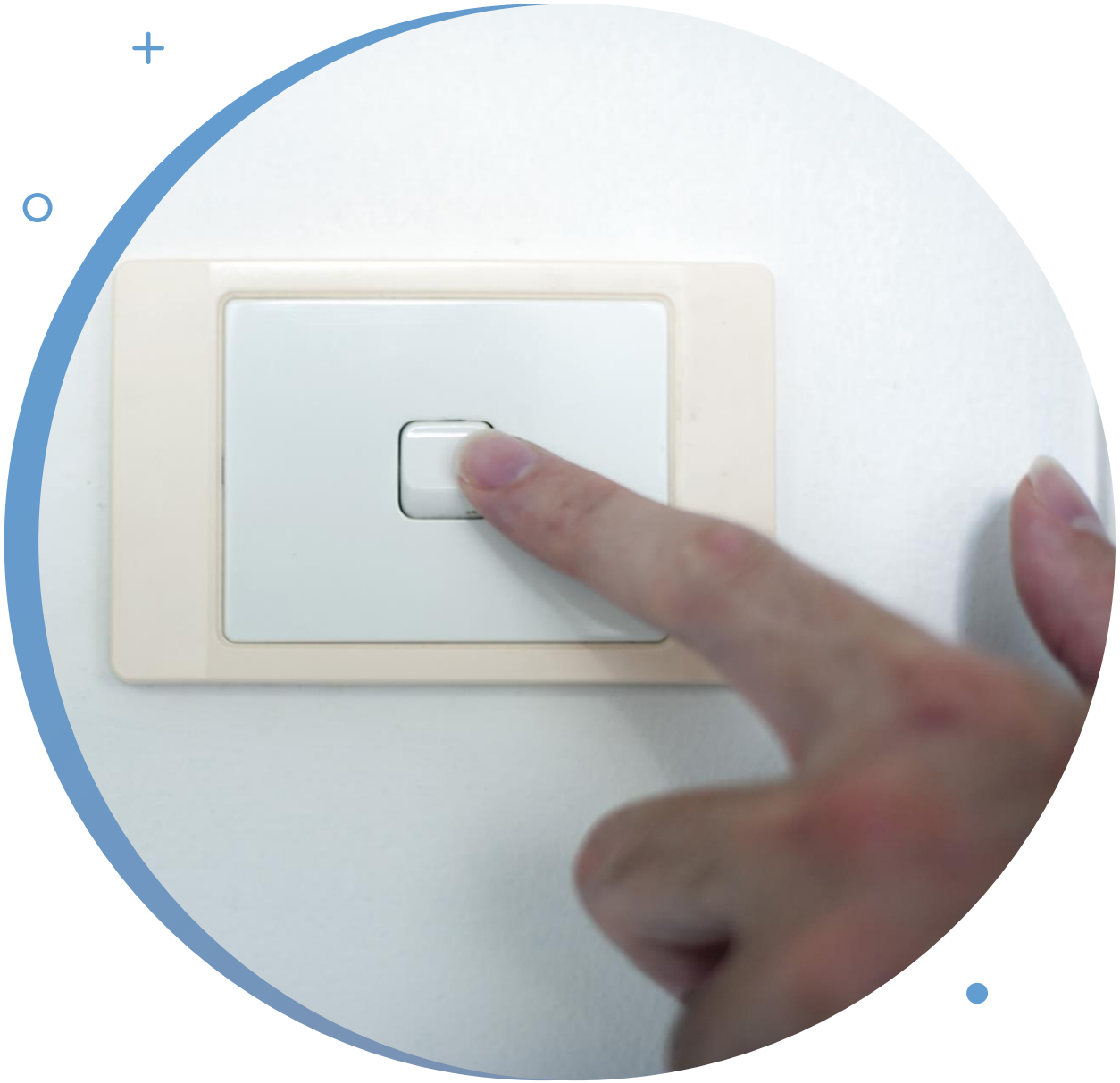
Friday, June 9, 2023

A day in my life

- I wake up at 4:30AM
- Trun on My lights
- Cook Breakfast
- Check my emails
- Wash Dishes
- Go to Office
- Write some code
- Go home
- Play with kids
- And much more …

IT'S A BEAUTIFUL LIFE

But highly inefficient



Turn on Switch

- 500,000 microseconds
- 2 weeks in 1 year

2 WEEKS!!


HOME
ASSISTANT

RUFIN JOHN AGUILAR

Provincial Information and Communications Technology Division (PICTD)

- Software Development Lead
- Database Administrator
- Network Administrator

Freelance Full-stack Developer

Part Time Instructor

- Bukidnon State University - College of Technologies - Information Technology Division

Resource Person

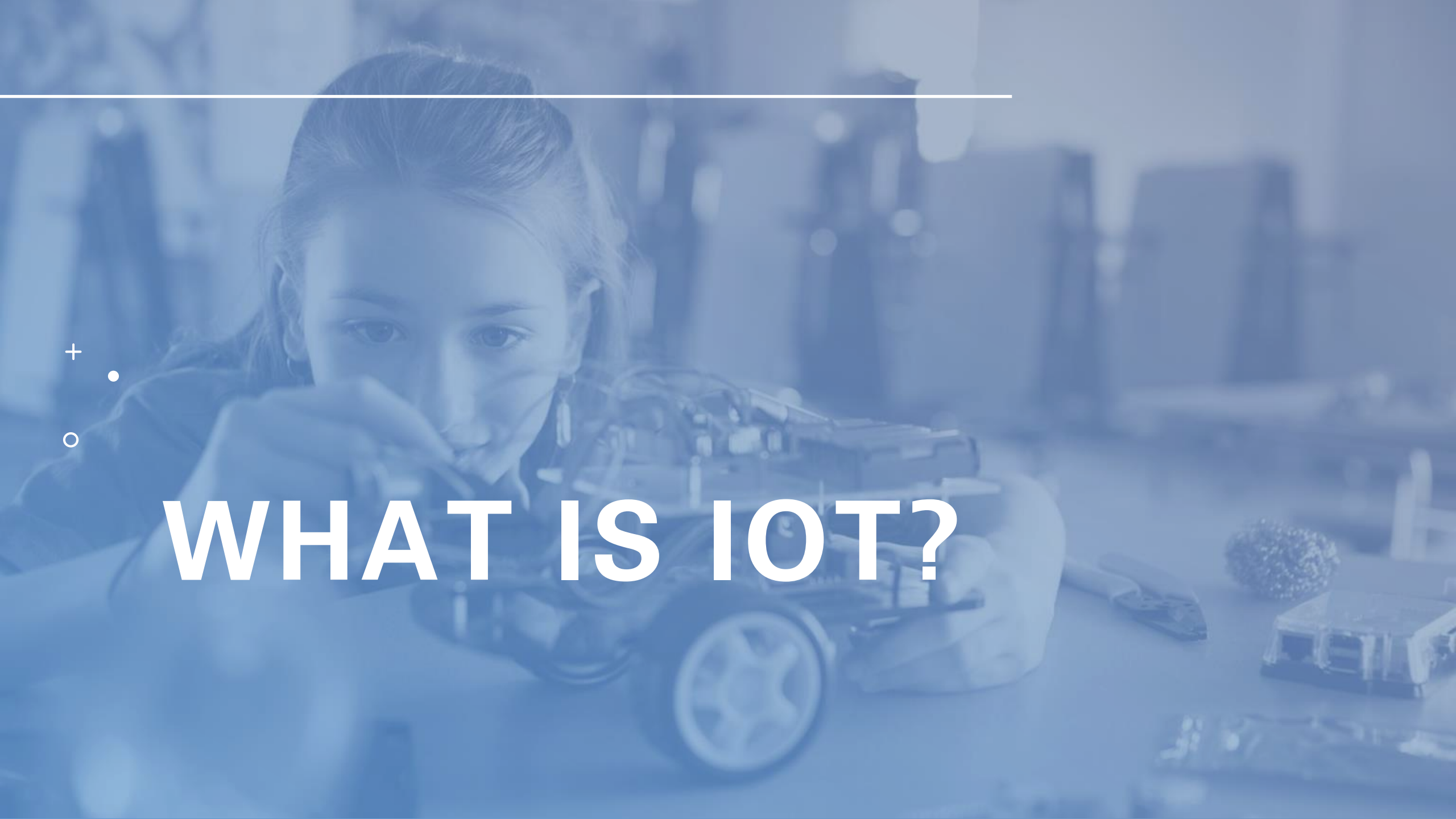
- Rameses Inc.
- EduLearn Technologies
- DICT - ICLDB

BSIT - Bukidnon State University

MIS - University of the Philippines Open University

INTRODUCTION TO IOT

- WHAT IS "IOT"?
- IOT DEVICES AROUND US
- BENEFITS OF IOT
- CHALLENGES OF IOT
- SETUP IOT DEVICE
- SENSORS
- APPLICATIONS OF IOT

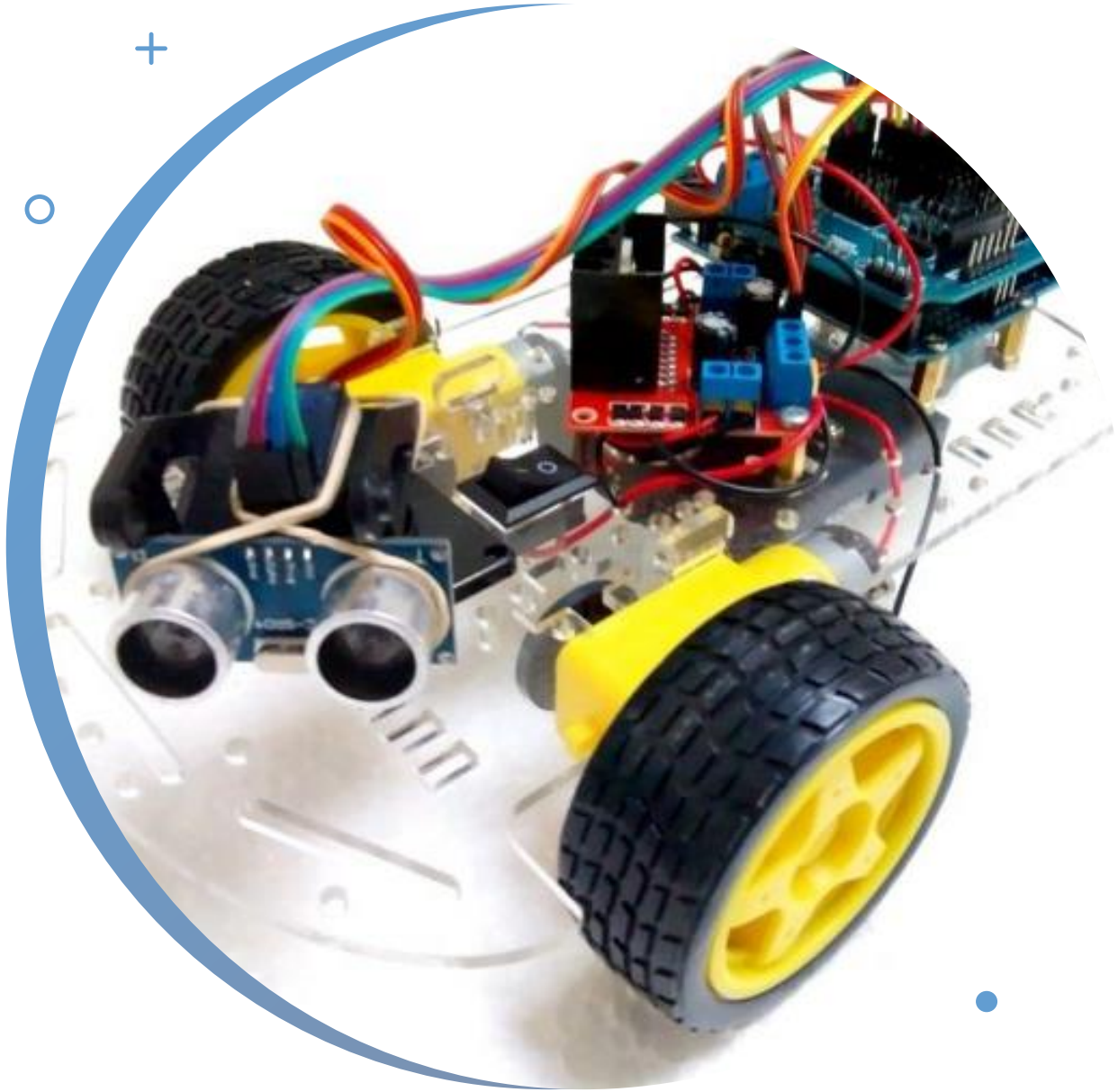


WHAT IS IOT?

KEVIN ASHTON 1999

CONNECTING THE PHYSICAL WORLD TO THE INTERNET

USING SENSORS



Internet of Things

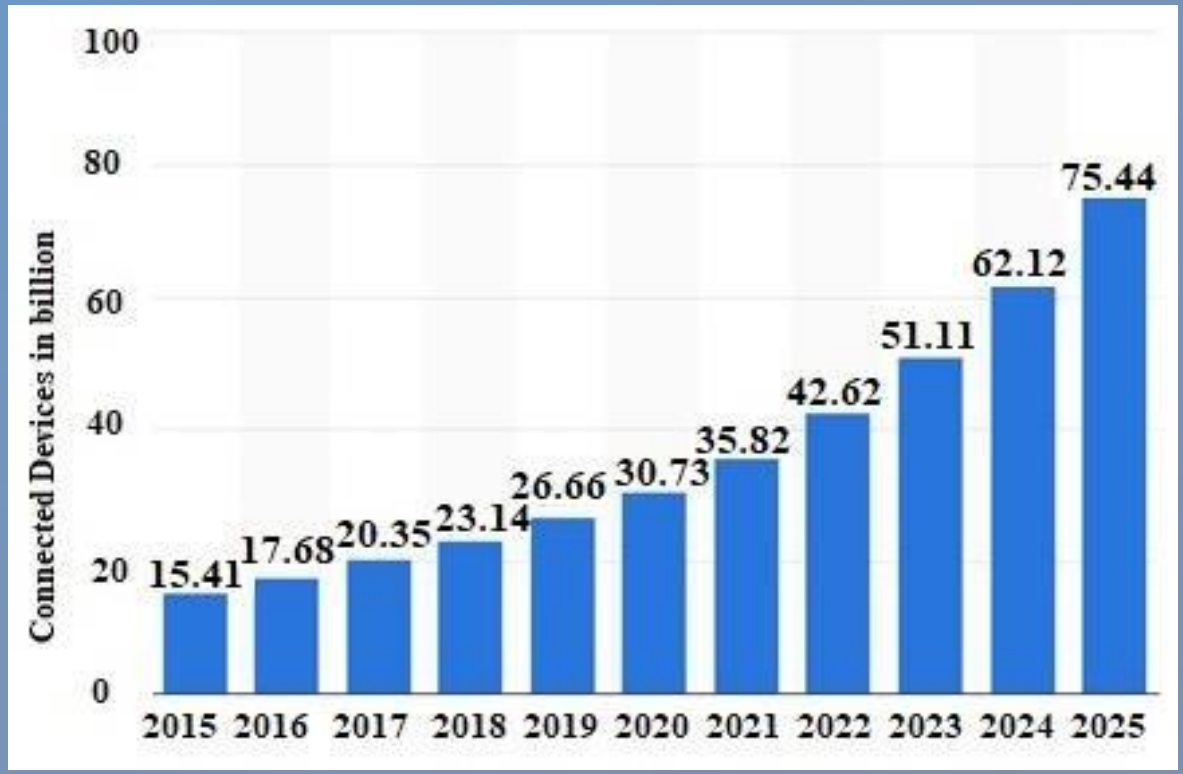
THINK OF IT AS A LARGE ECOSYSTEM WHERE DEVICES

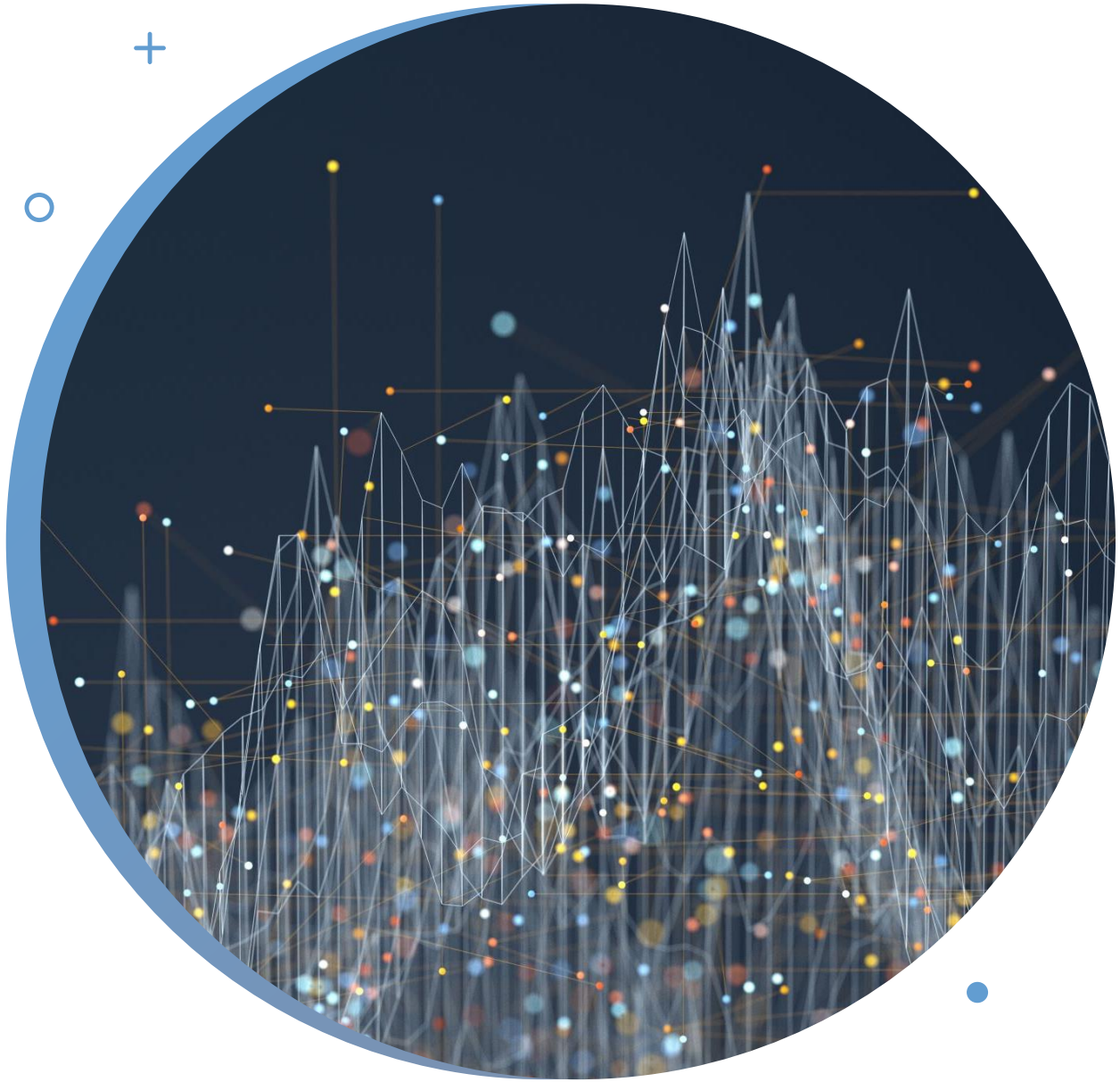
- ✓GATHER DATA (sensors)
- ✓INTERACT (actuators)
- ✓CONNECT (internet)

ACTIVE DEVICES (In billions)

30 B Devices (2020)
80 ZB Data collected (2025)

DATA is the key

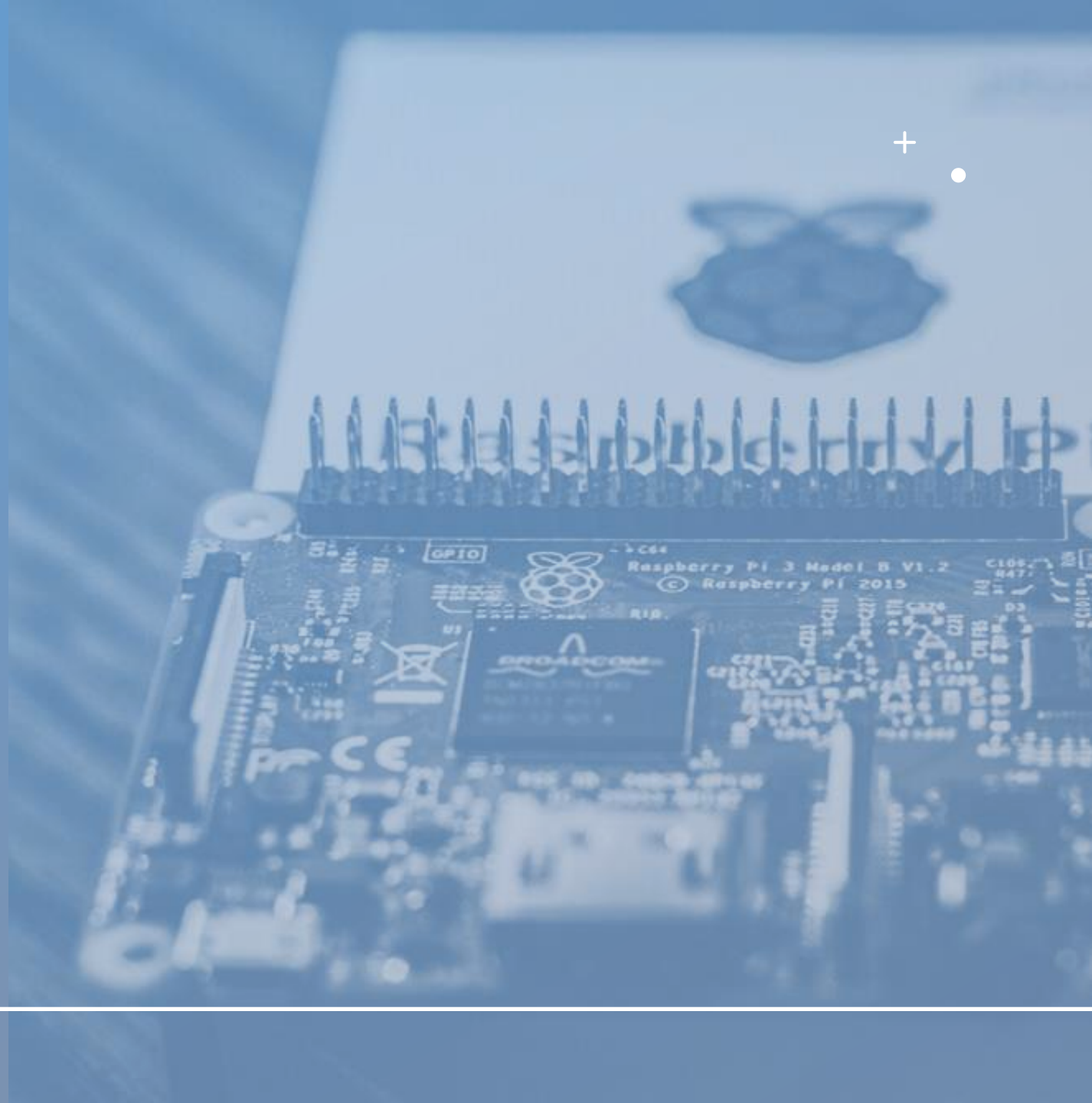




How To Manage Data?

- Useful Data
- Waste Data
- Better Data

IOT DEVICES



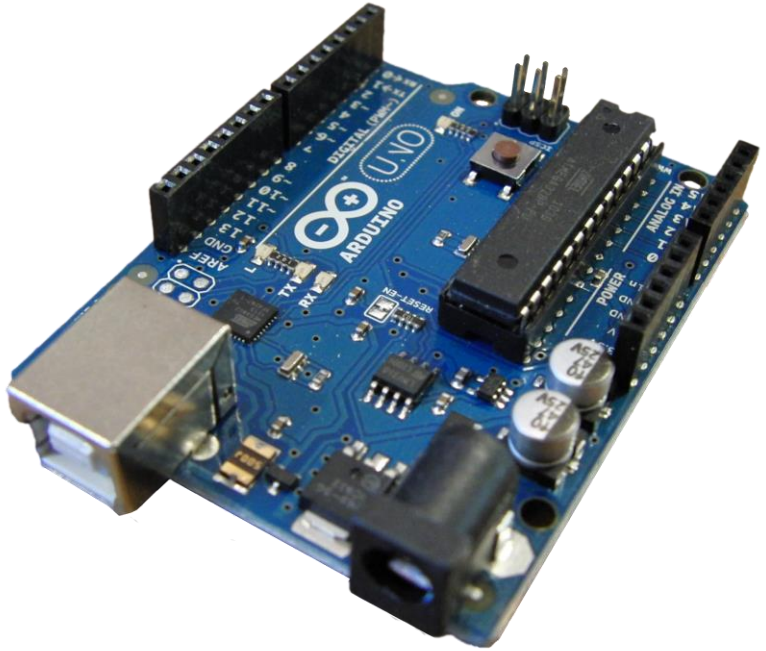
"Things"

- REFERS TO DEVICES THAT INTERACT WITH PHYSICAL WORLD

DEVELOPMENT	PRODUCTION
DEVELOPER KITS TAILORED FOR DEV USE	COMMERCIAL USE DEVICES
EXPOSED PARTS ADDED HARDWARE	CUSTOM MADEE • CPU • CIRCUIT BORAD • ROBUST • REGULAR USE

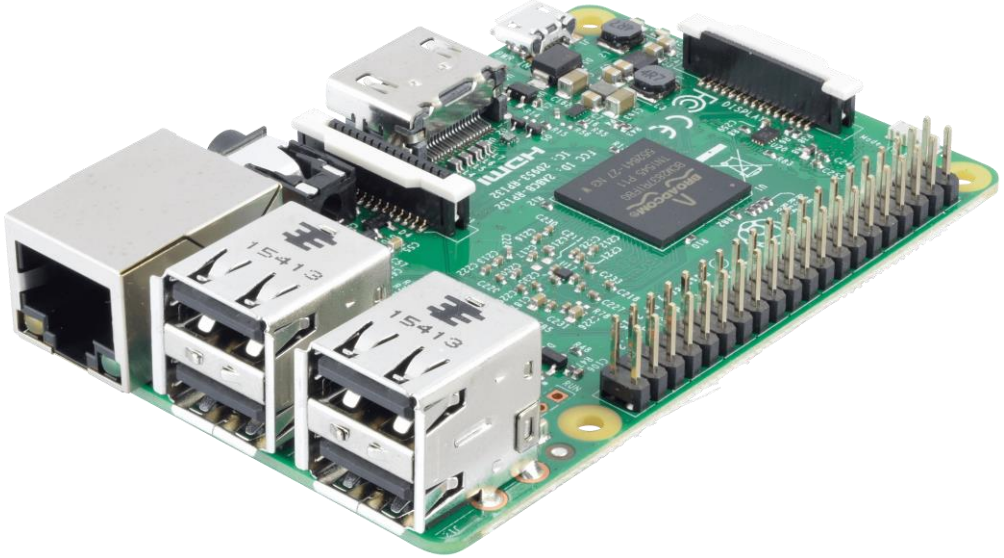
SINGLE BOARD MICRO- CONTROLLERS

Single Focused Task



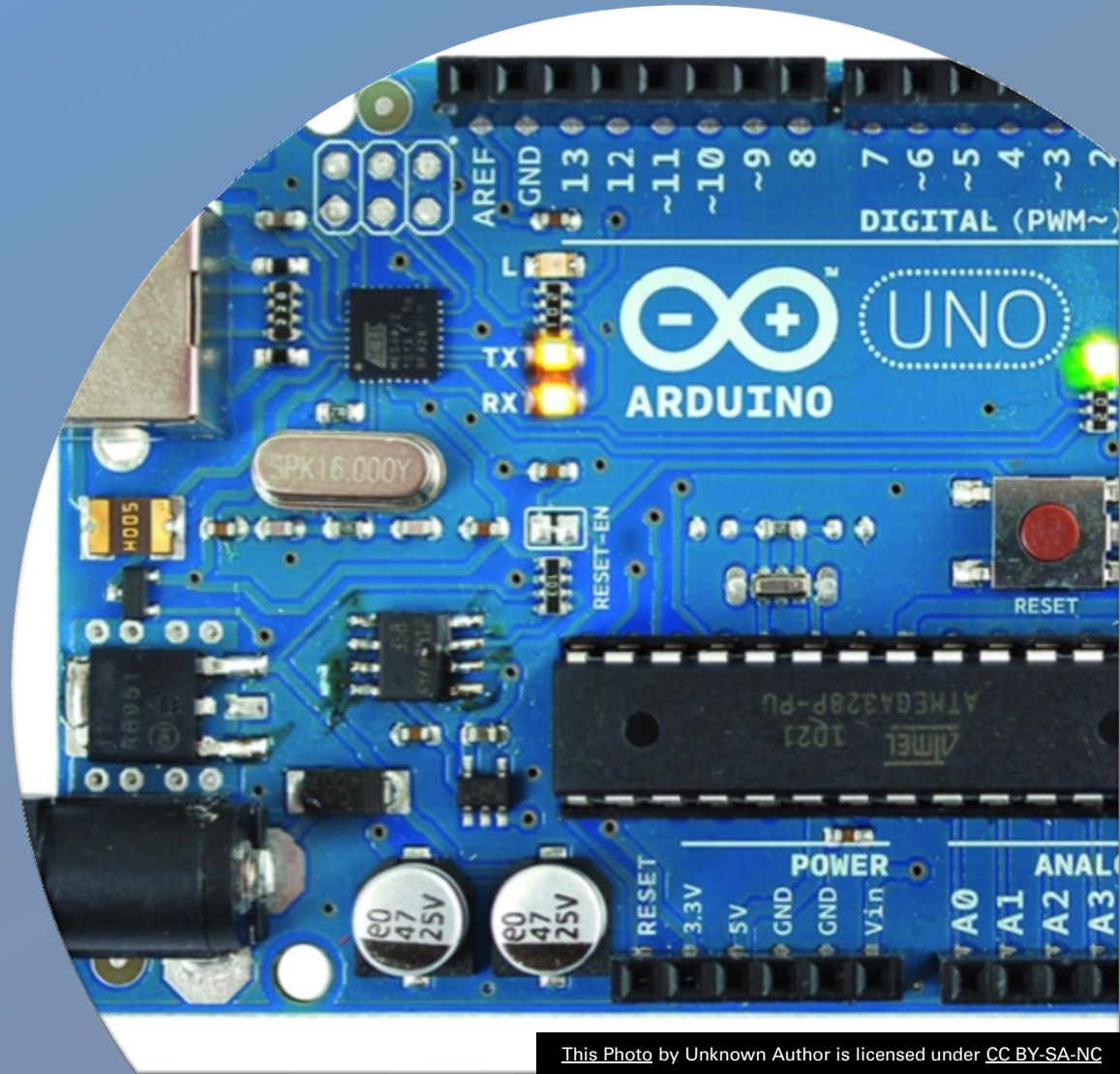
SINGLE BOARD COMPUTERS

Multi- Tasking



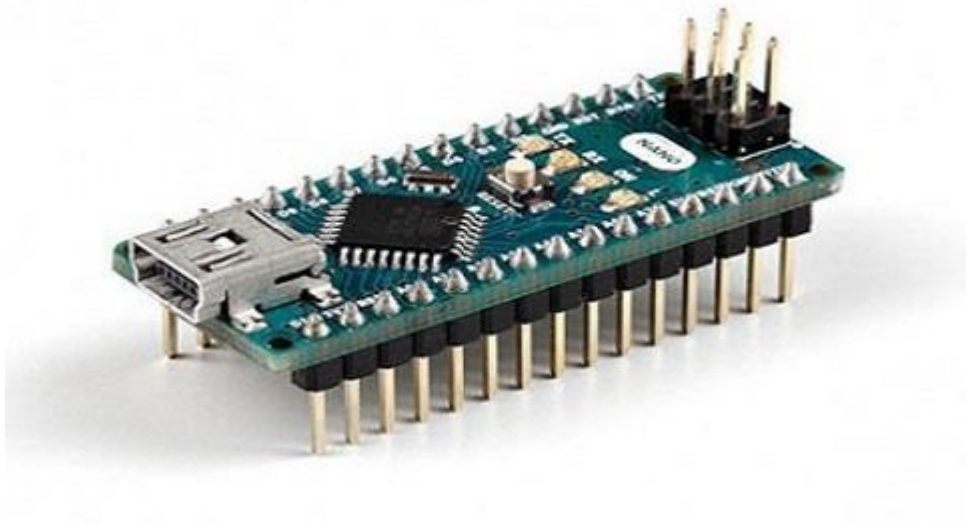
WHAT IS A MICRO CONTROLLER?

- Special Purpose
- Low-Cost Computing Device
- open-source electronics platform
- easy-to-use hardware and software
- Sensors + Actuators
- Display Screen
- Bluetooth + WiFi




100 SECONDS OF

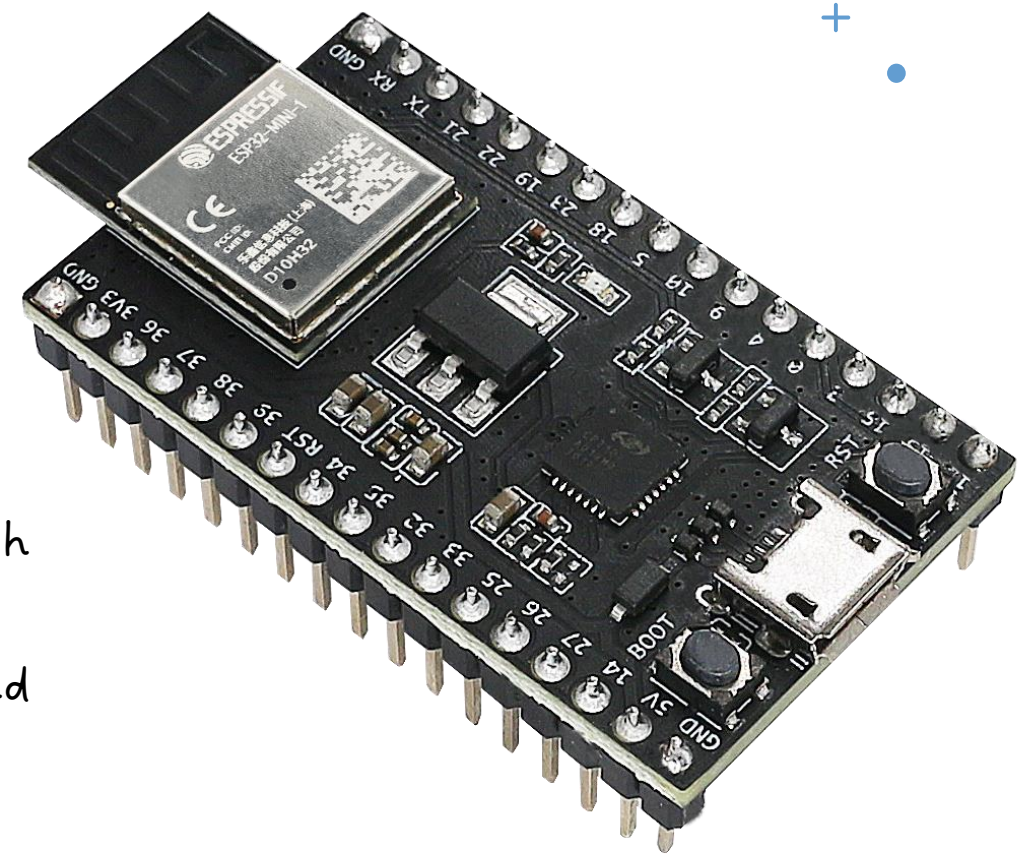
Arduino Nano



- ATmega328P Microcontroller
- Power
  - 5V operating voltage
  - 7-12V (nominal) input
  - 19mA consumption
  - 40mA I/O pins DC Current
- Micro USB
- 22 I/O pins
- 14 Digital I/O Pins
- 6 Analog Pins
- 16Mz Processor
- 2KB SRAM, 32KB Flash, 1KB EEPROM
- 7 g,
- 18 mm W,
- 45 mm L

ESP 32

- ESP32-MINI-1 module (Dual-Core 32-bit LX6 microprocessor)
- Power regulator converts 5 V to 3.3 V.
- Micro-USB Port
- 3.3 V Power On LED
- 18 Analog-to-Digital Converter (ADC) pins
- 3 Serial Peripheral Interface (SPI) pins
- 3 universal asynchronous receiver-transmitter (UART) pins
- 2 12C pins
- 16 PWM output pins
- 2 Digital-to-Analog Converter (DAC) pins
- 10 Capacitive sensing General Purpose I/O (GPIO) pins
- ROM: 448 KB, SRAM: 520 KB, Support up to: 16MB flash
- Wi-Fi: 802.11b/g/n/e/i
- Bluetooth: v4.2 BR/EDR and BLE

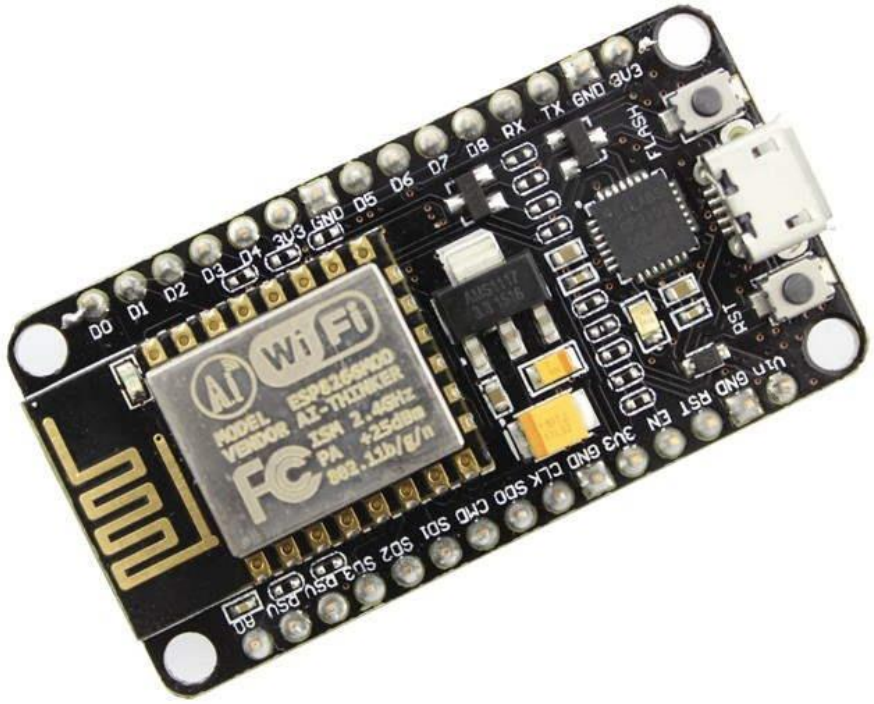


ESP 32 Cam

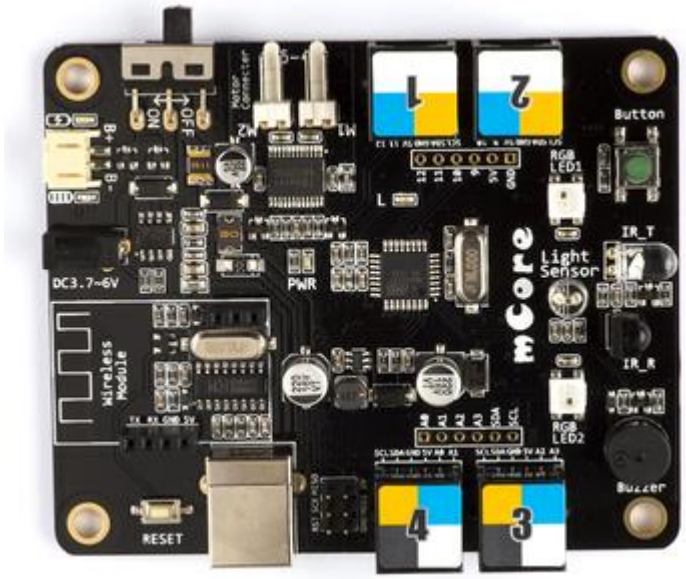
- Same Specs as Esp32
- OV2640 camera 2 MP
- 4MB PSRAM - for buffering
- Built in flash LED
- 4G TF Card for storage

NodeMCU ESP8266

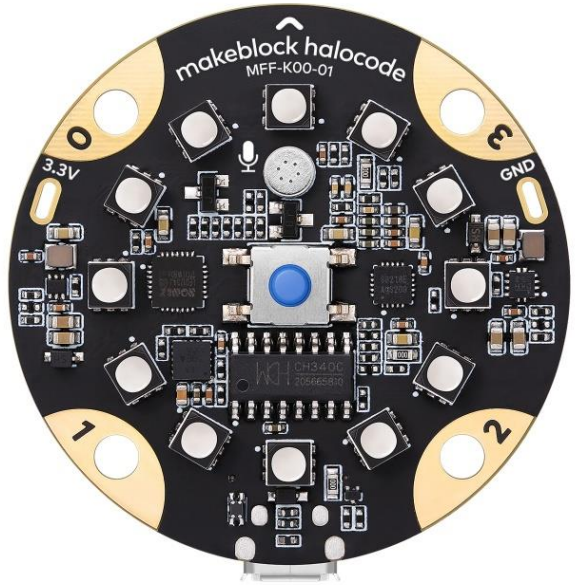
- ESP-8266 32-bit
- 49mm x 26mm
- Clock Speed 80 MHz
- Micro USB
- 3.3 V operating voltage
- 4.5V-10V input voltage
- Flash Memory 4MB, SRAM 64KB
- 11 Digital I/O Pins
- 1 Analog input pin
- Wifi Built In 802.11 b/g/n



Microcontroller for KIDS



mCore



HaloCode

WHAT IS A SINGLE BOARD COMPUTER?

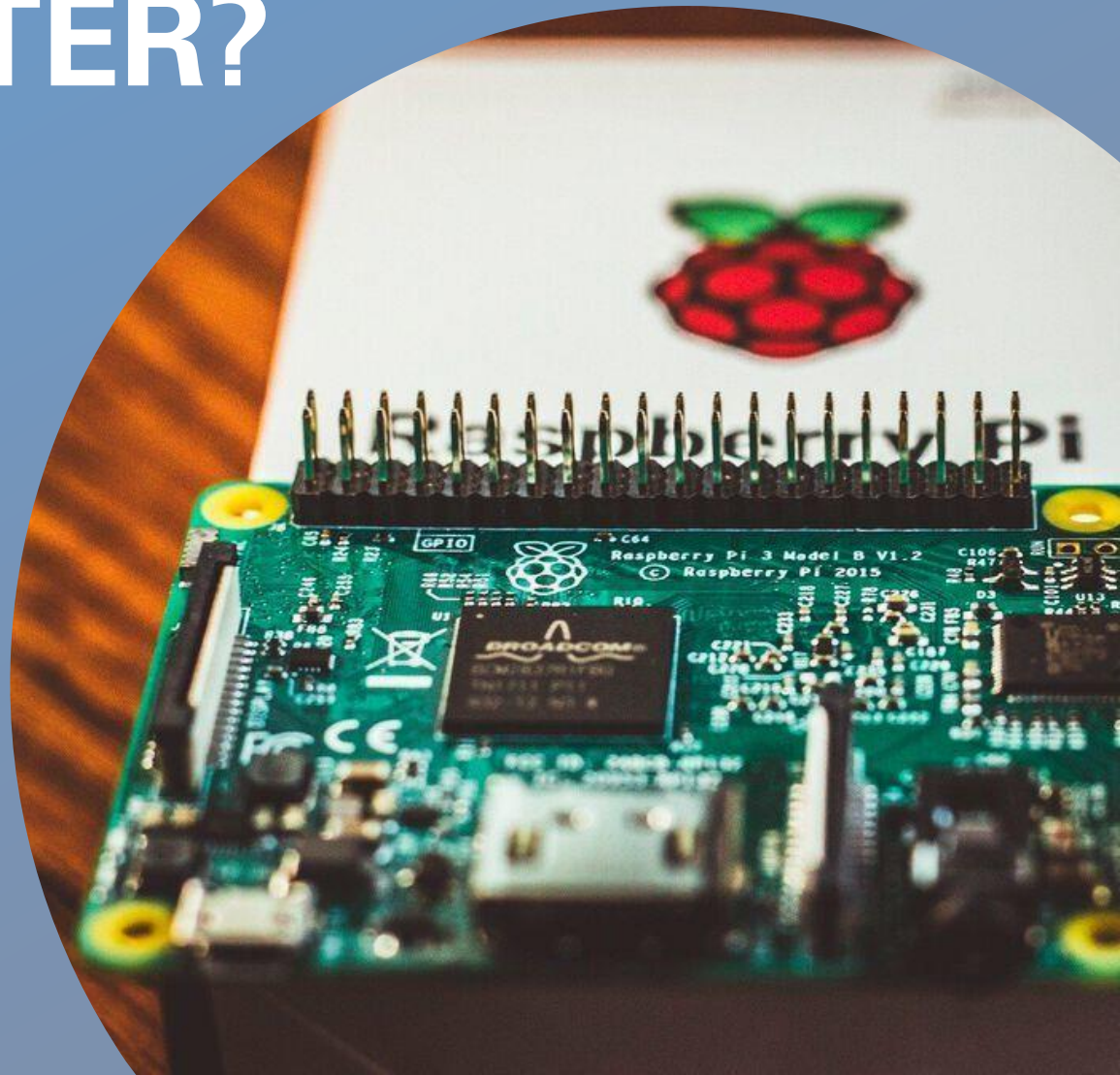
- General Purpose
- Small Computing Device
- Complete Computer
- Close to Desktop
  - Cheaper, Smaller, Less Power

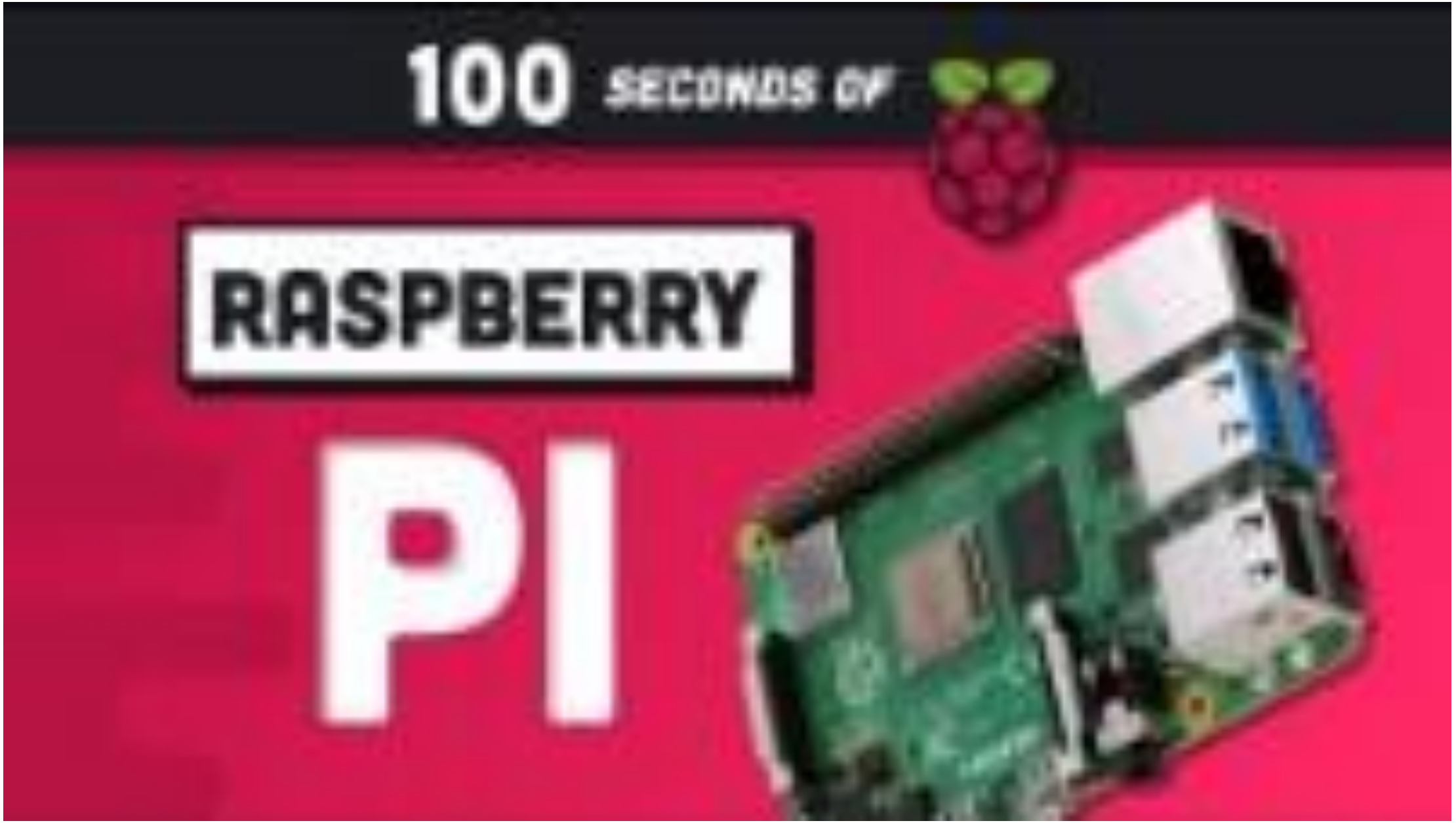
CPU, Memory, I/O (like MCU)

GRAPHICS CHIP (display)

USB PORT (add peripherals)

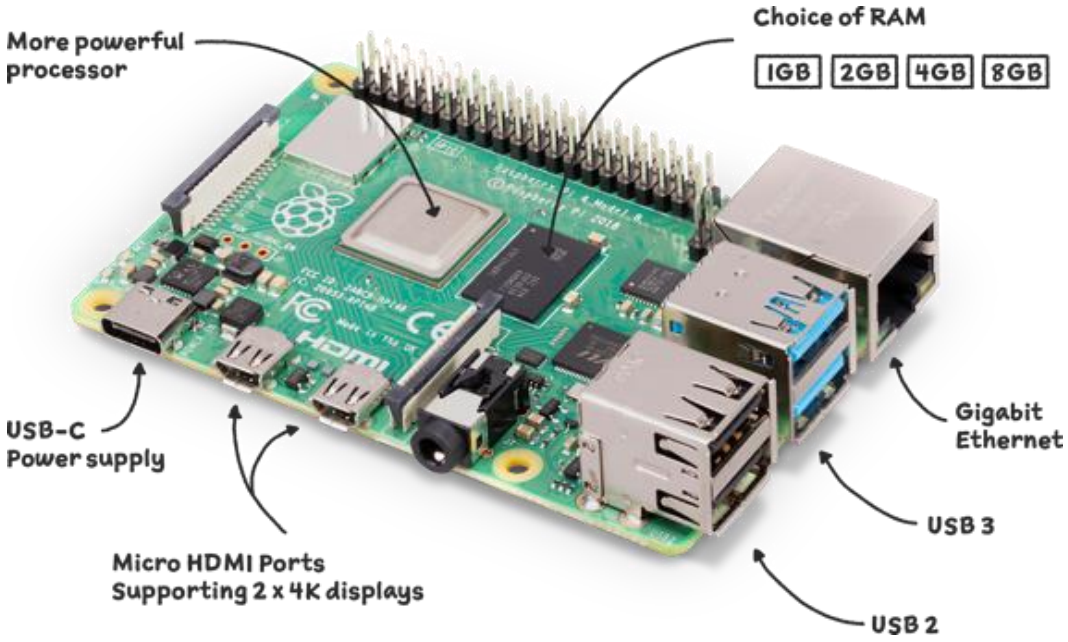
SD CARD (storage)



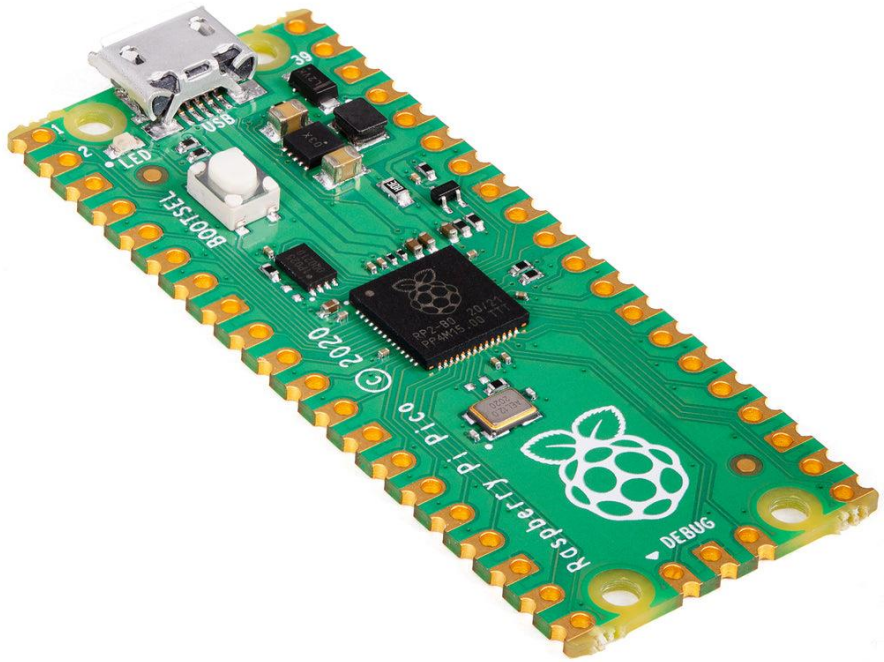

100 SECONDS OF
RASPBERRY
PI

Raspberry Pi 4

- Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.8GHz
- 1GB, 2GB, 4GB or 8GB LPDDR4-3200 SDRAM (depending on model)
- 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE
- Gigabit Ethernet
- 2 USB 3.0 ports; 2 USB 2.0 ports.
- Raspberry Pi standard 40 pin GPIO header (fully backwards compatible with previous boards)
- 2 × micro-HDMI ports (up to 4kp60 supported)
- 2-lane MIPI DSI display port
- 2-lane MIPI CSI camera port
- 4-pole stereo audio and composite video port
- H.265 (4kp60 decode), H264 (1080p60 decode, 1080p30 encode)
- OpenGL ES 3.1, Vulkan 1.0
- Micro-SD card slot for loading operating system and data storage
- 5V DC via USB-C connector (minimum 3A*)
- 5V DC via GPIO header (minimum 3A*)
- Power over Ethernet (PoE) enabled (requires separate PoE HAT)
- Operating temperature: 0 – 50 degrees C ambient



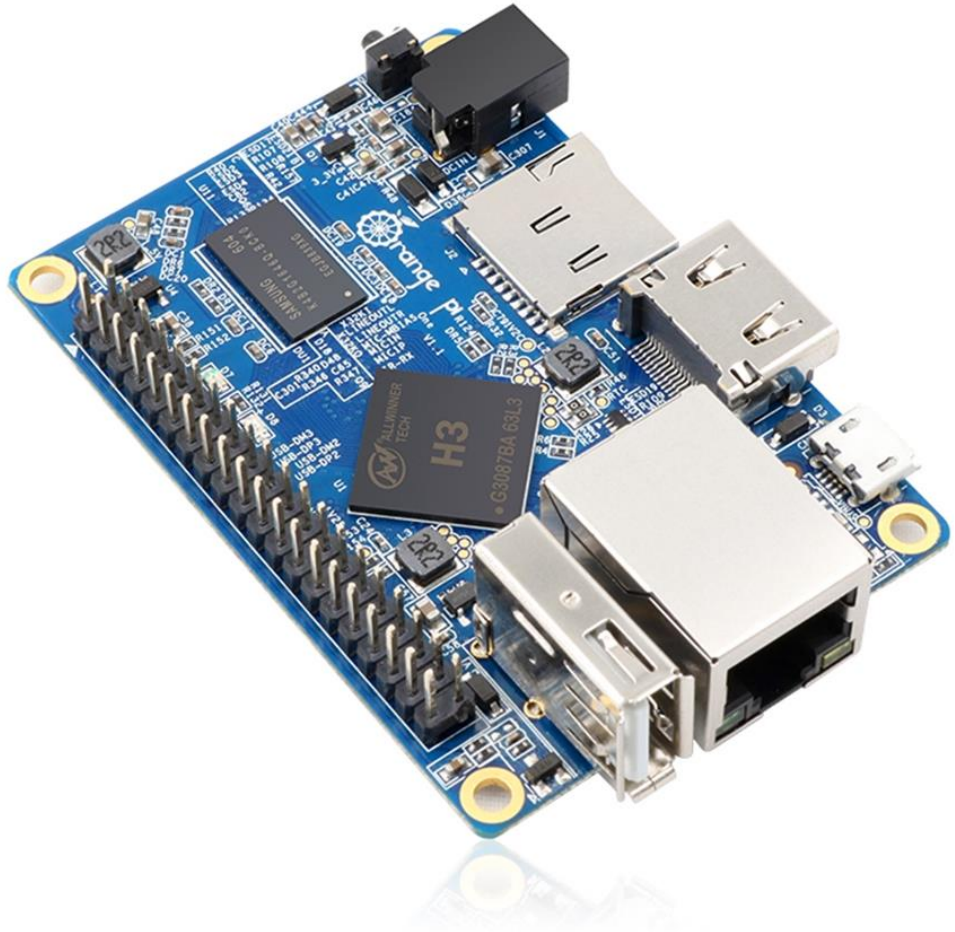
Raspberry Pi Pico



- 21 mm × 51 mm form factor
- RP2040 microcontroller chip designed by Raspberry Pi in the UK
- Dual-core Arm Cortex-M0+ processor, flexible clock running up to 133 MHz
- 264kB on-chip SRAM
- 2MB on-board QSPI flash
- 2.4GHz 802.11n wireless LAN (Raspberry Pi Pico W and WH only)
- 26 multifunction GPIO pins, including 3 analogue inputs
- 2 × UART, 2 × SPI controllers, 2 × I2C controllers, 16 × PWM channels
- 1 × USB 1.1 controller and PHY, with host and device support
- 8 × Programmable I/O (PIO) state machines for custom peripheral support
- Supported input voltage 1.8–5.5V DC
- Operating temperature -20°C to +85°C (Raspberry Pi Pico and Pico H); -20°C to +70°C (Raspberry Pi Pico W and Pico WH)
- Castellated module allows soldering direct to carrier boards (Raspberry Pi Pico and Pico W only)
- Drag-and-drop programming using mass storage over USB
- Low-power sleep and dormant modes
- Accurate on-chip clock
- Temperature sensor
- Accelerated integer and floating-point libraries on-chip

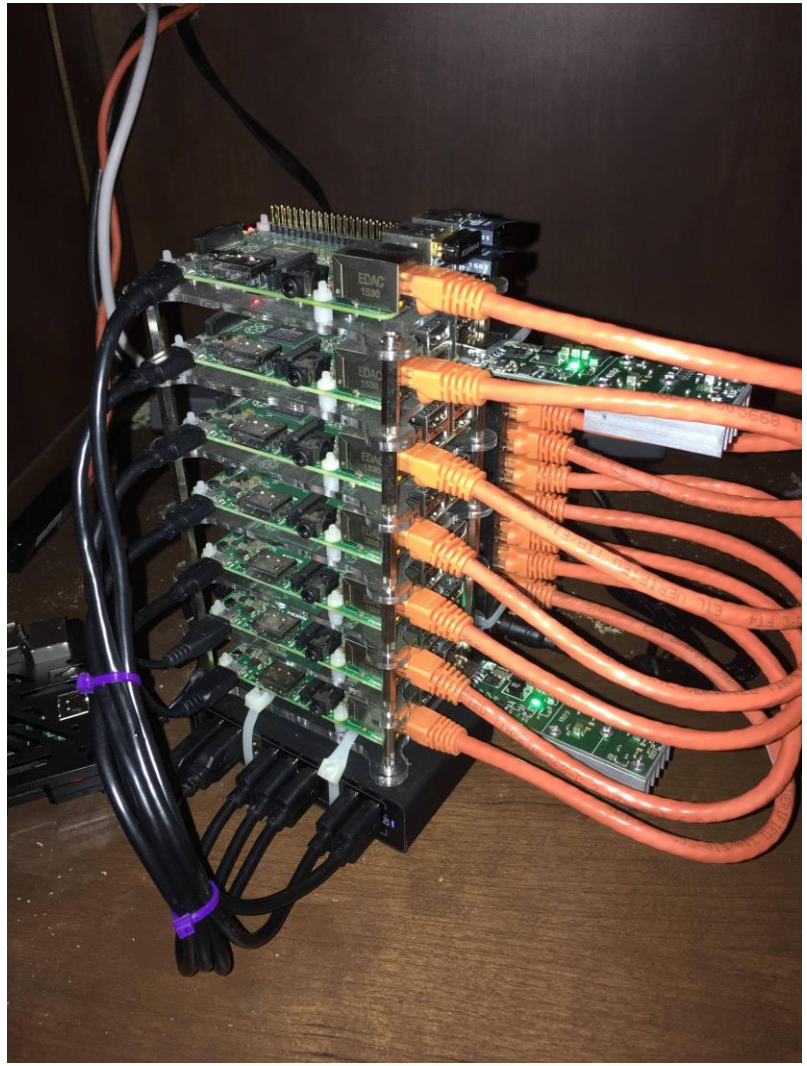
Orange Pi

- CPU H3 Quad-core Cortex-A7 H.265/HEVC 4K
- GPU Mali400MP2 GPU @600MHz
- Memory (SDRAM) 512MB / 1GB DDR3 (shared with GPU)
- Onboard Storage TF card (Max. 32GB) / MMC card slot
- Onboard Network 10/100M Ethernet RJ45
- Video Input
- HDMI output with HDCP Supports
- USB OTG input don't supply power USB 2.0 Ports
- Only One USB 2.0 HOST, one USB 2.0 OTG Buttons
- Power Button(SW4) Low-level peripherals
- 40 Pins Header LED Power led & Stat led Key POWER Supported OS Androic Ubuntu, Debian Image Interface definition
- Product size 69 mm × 48mm

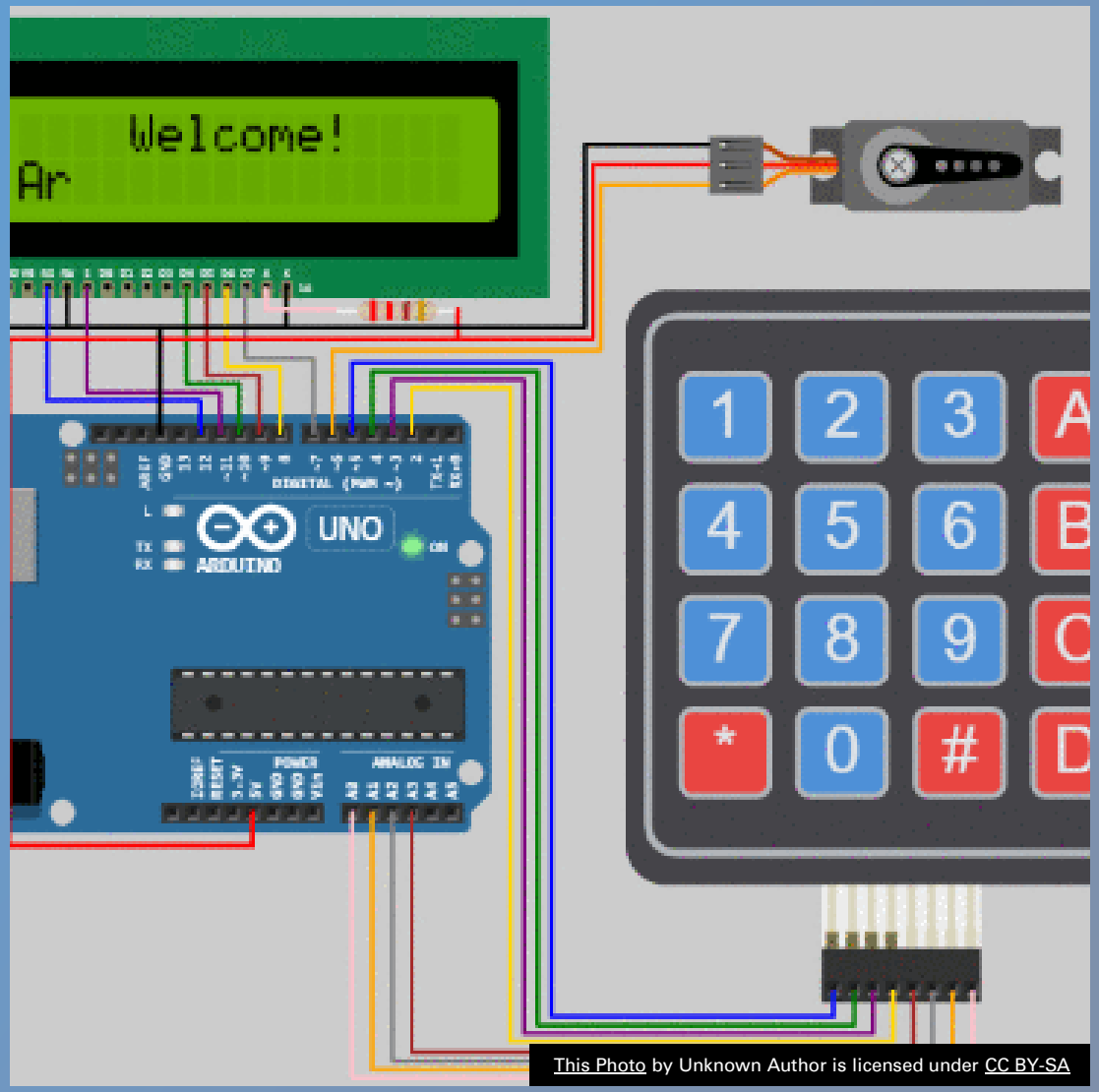


Gaming Console
Retro Pi

Piso WiFi



Crypto Mining Farm



VIRTUAL DEVICE

- Proteus
- Tinkercad
- Wokwi
- Shortcuits (Steam)

ARDUINO DEVELOPMENT KIT

- IDE Options
  - Arduino IDE
  - Visual Studio Code IDE
    - Platform IO

1. Code on Desktop/Laptop
2. Compile Code
3. Upload Code to Target Device

- Programming Language
  - C/C++, MicroPython

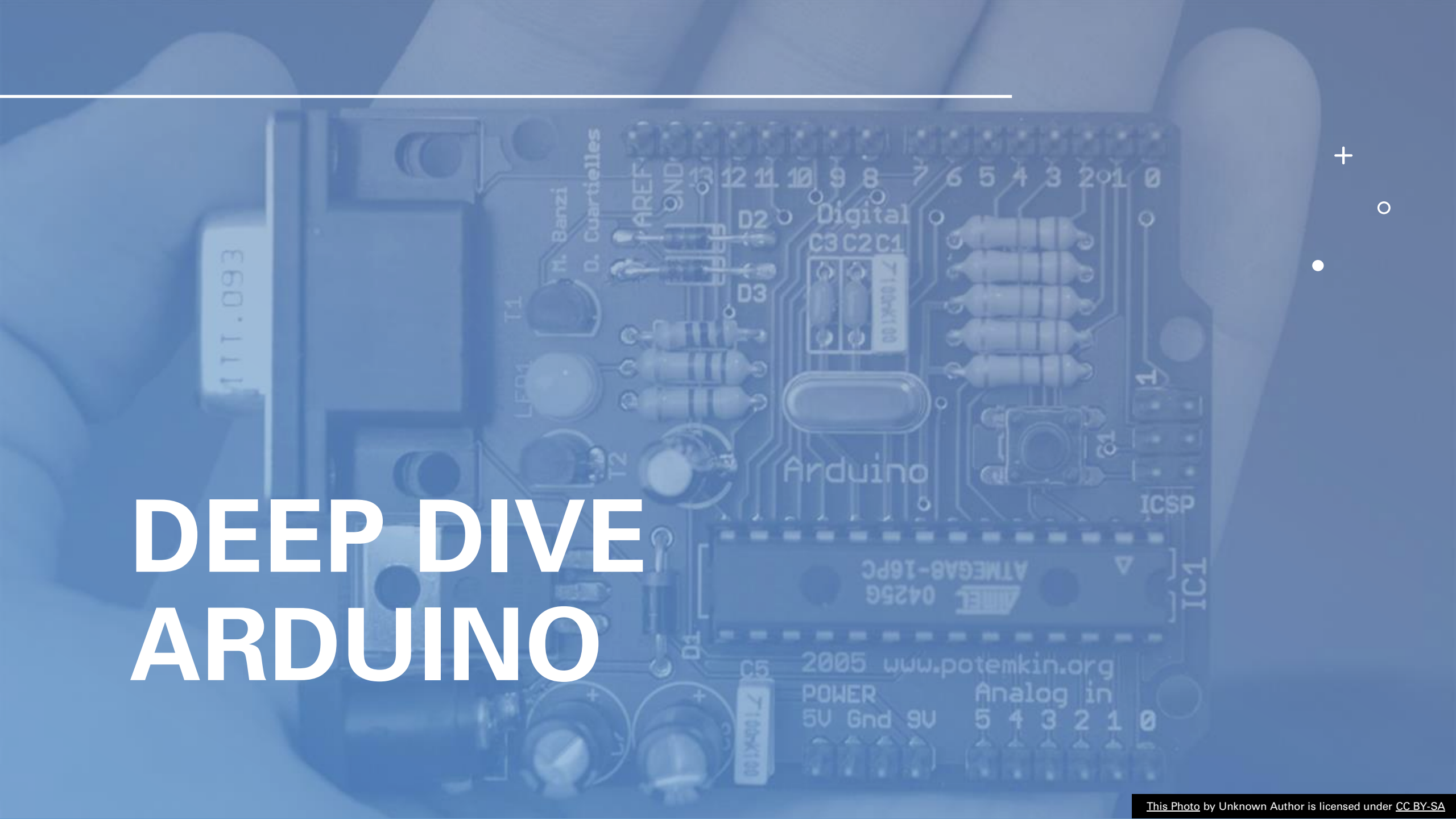
SINGLE BOARD COMPUTER DEV KIT

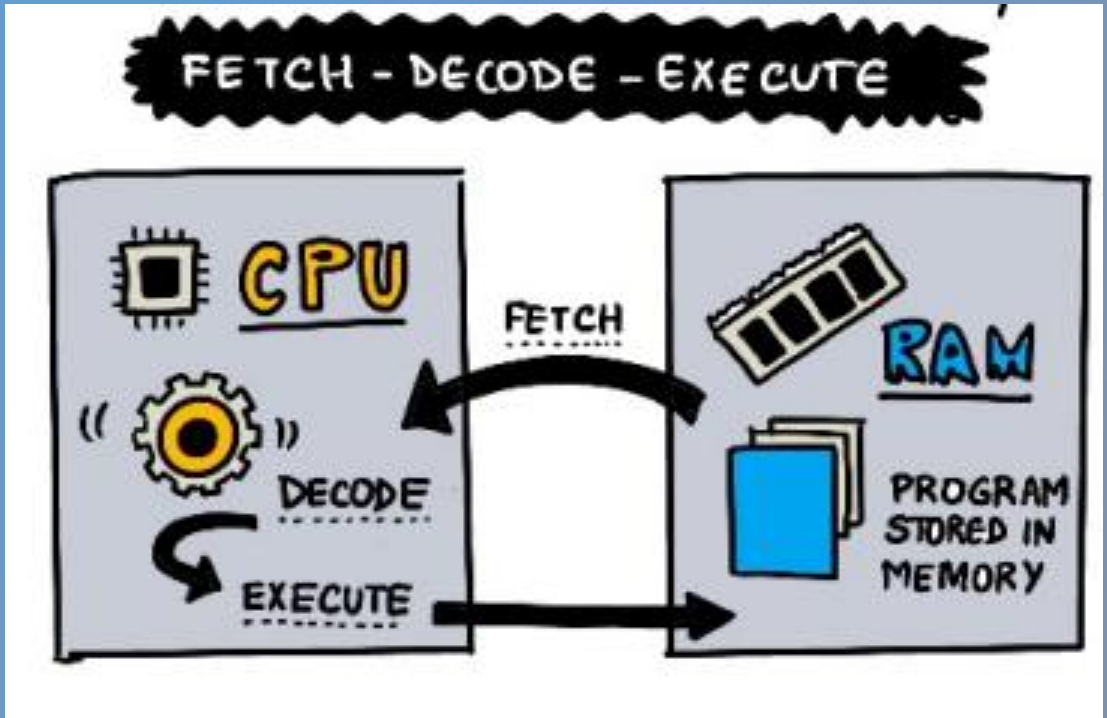
- Code on Physical Device or Virtual Device (Virtual Machine)
- IDE Options
  - Visual Studio Code

1. Code Directly on R-Pi
2. VS Code for R-Pi
3. VS Code + Remote SSH (extension)

- Programming Language
  - Python

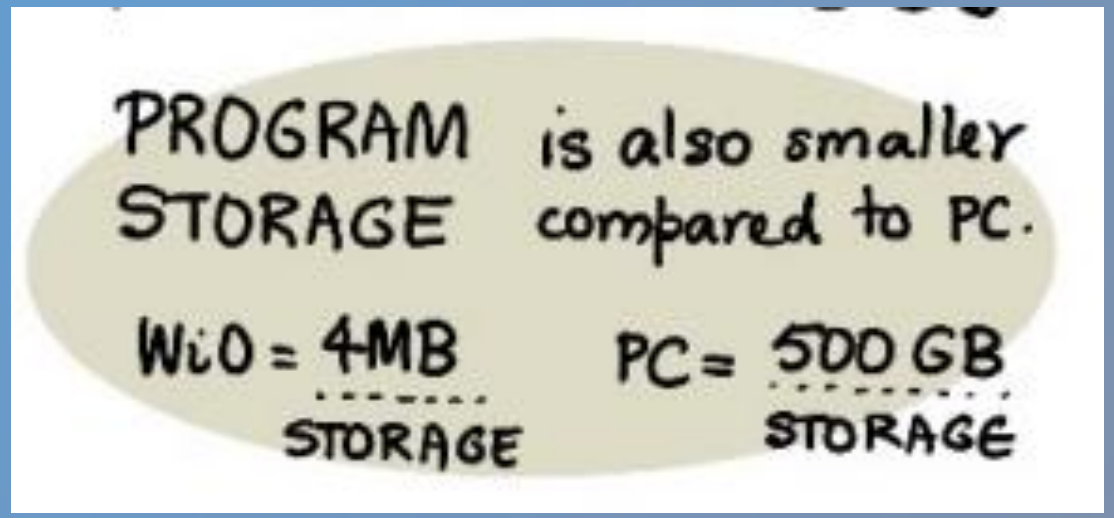
DEEP DIVE ARDUINO





MICROCONTROLLER: CPU

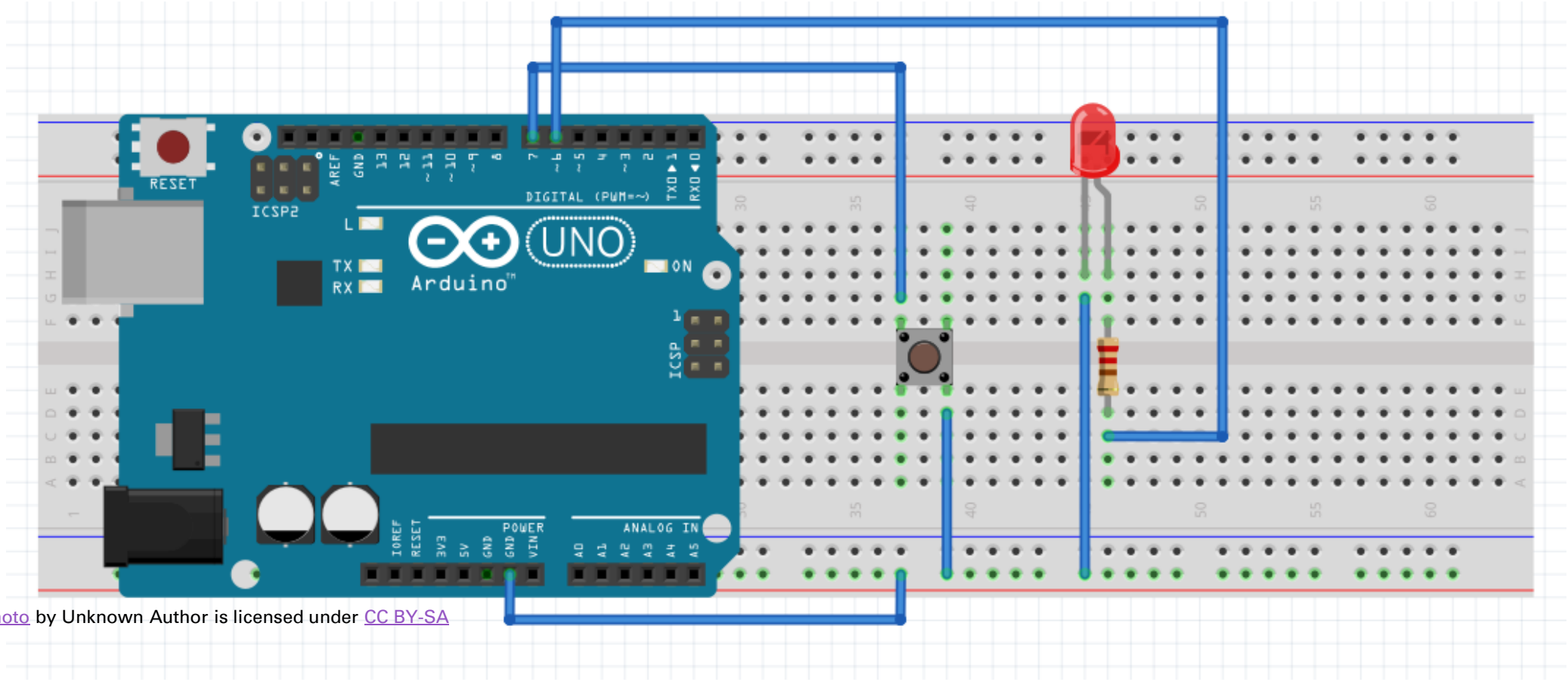
- CENTRAL PROCESSING UNIT (BRAIN)
- SEND/ RECEIVES MESSAGE
- EXECUTES ONE INSTRUCTION PER CLOCK TICK
  - MILLIONS/ BILLIONS OF TICKS PER SEC
  - HIGHER SPEED MEANS MORE INSTRUCTIONS
- One Clock tick means CPU Fetch, Decode and Execute



MICROCONTROLLER: MEMORY

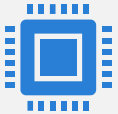
- 2 TYPES
  - PROGRAM MEMORY
    - STORE CODE
    - PERSIST DATA WHEN THERE IS NO POWER
  - RAM
    - USE TO RUN CODE WHEN POWERED
    - RESETS WHEN THERE IS NO POWER

INPUT/OUTPUT



FRAMEWORK & OPERATING SYSTEM

MICROCONTROLLER DON'T RUN A TRADITIONAL OPERATING SYSTEM



MCU HAVE LOW SPEED, MEMORY

PERFORM FOCUS TASKS

MCU USE FRAMEWORKS (ARDUINO)

- USE API TO TALK TO PERIPHERALS
- STANDARD FRAMEWORK ACROSS MULTIPLE MICROCONTROLLER

ARDUINO: CORE SETUP

2 CORE FUNCTIONS

- setup()
- loop()

WHEN BOARD POWERS UP

- RUNS setup() ONCE
- THEN RUNS loop() CONTINUOUSLY (till power off)

ARCHITECTURE: EVENT LOOP

SETUP

- IS FOR ONE TIME INITIALIZATION CODE
  - Connect to WiFi, Cloud Service, Settings etc.

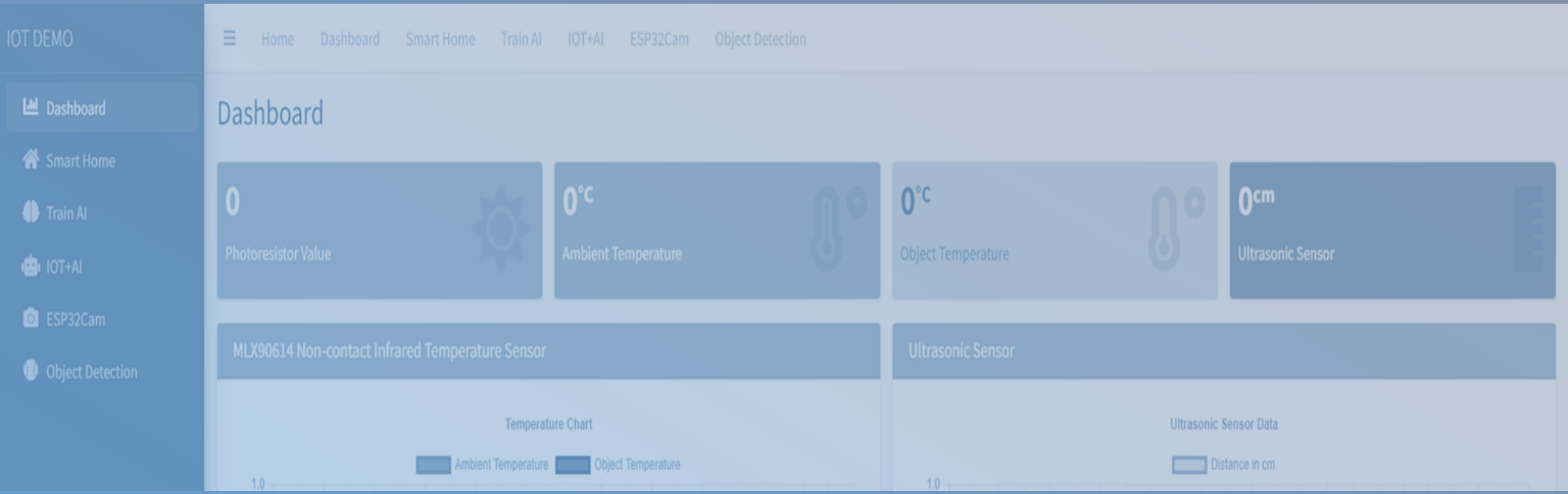
LOOP

- IS FOR PRECESSING CODE (sleep/wake cycle)
  - Sensor read
  - Send/receive message
- LISTENS FOR:
  - MESSAGE FROM UI (button click, keyboard..)
  - MESSAGE FROM NETWORK (actuator request)

ARDINO: STANDARD LIBRARIES

- STANDARD LIBRARIES FOR INTERACTING WITH I/O PINS AND MICROCONTROLLER
- EXPOSES CONSISTENT API ACROSS DRIVERS

- delay() - PAUSE PROGRAM FOR GIVEN PERIOD OF TIME
- digitalRead() - READ VALUE OF I/O PIN (HIGH OR LOW)


IOT DEMO
Home
Dashboard
Smart Home
Train AI
IOT+AI
ESP32Cam
Object Detection
Dashboard
Smart Home
Train AI
IOT+AI
ESP32Cam
Object Detection
Dashboard
0
Photoresistor Value
0°C
Ambient Temperature
0°C
Object Temperature
0cm
Ultrasonic Sensor
MLX90614 Non-contact Infrared Temperature Sensor
Temperature Chart
Ambient Temperature
Object Temperature
1.0
Ultrasonic Sensor
Ultrasonic Sensor Data
Distance in cm
1.0

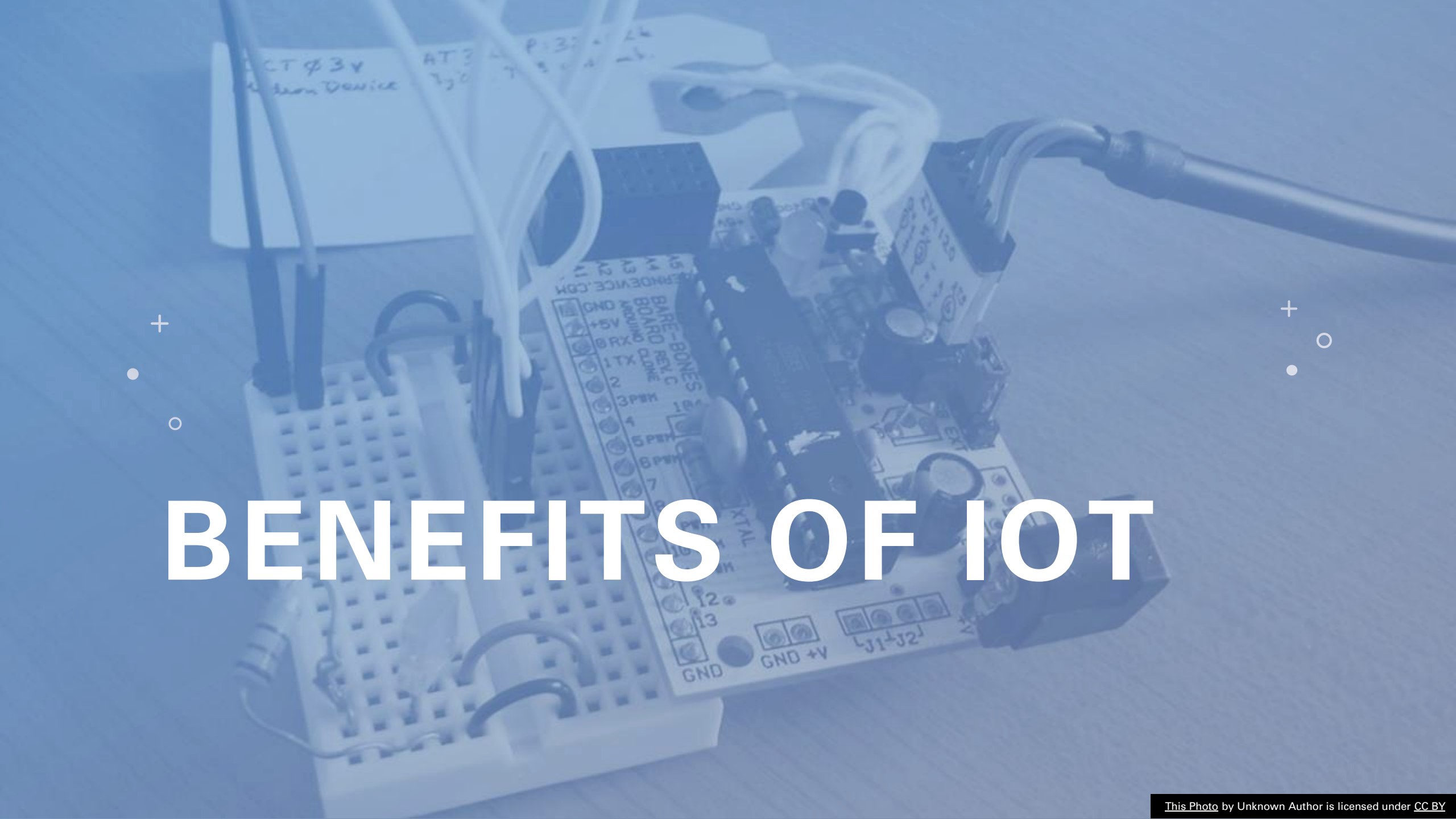
LET'S TRY!

ARDINO IDE

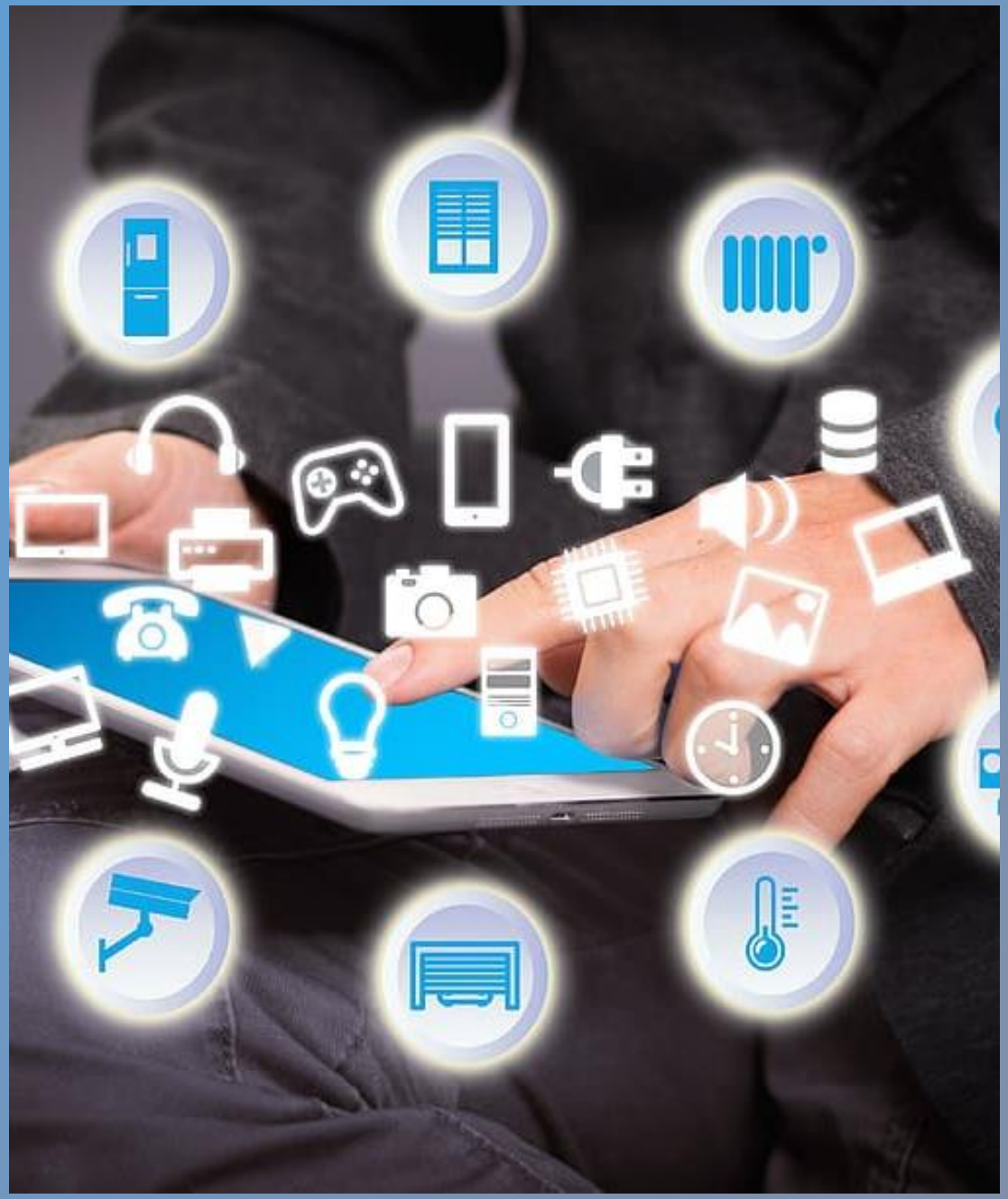
- ARDUINO IDE
- Visual Studio Code (platrofm.io extension)
  - Copilot & Copilot X
- https://wokwi.com/
  - Devices/Sensors

IOT DEMO APP

- ESP32 & ESP32-Cam
- Node JS, expressjs, ejs, socketio
- AdminLTE, Bootstrap



BENEFITS OF IOT

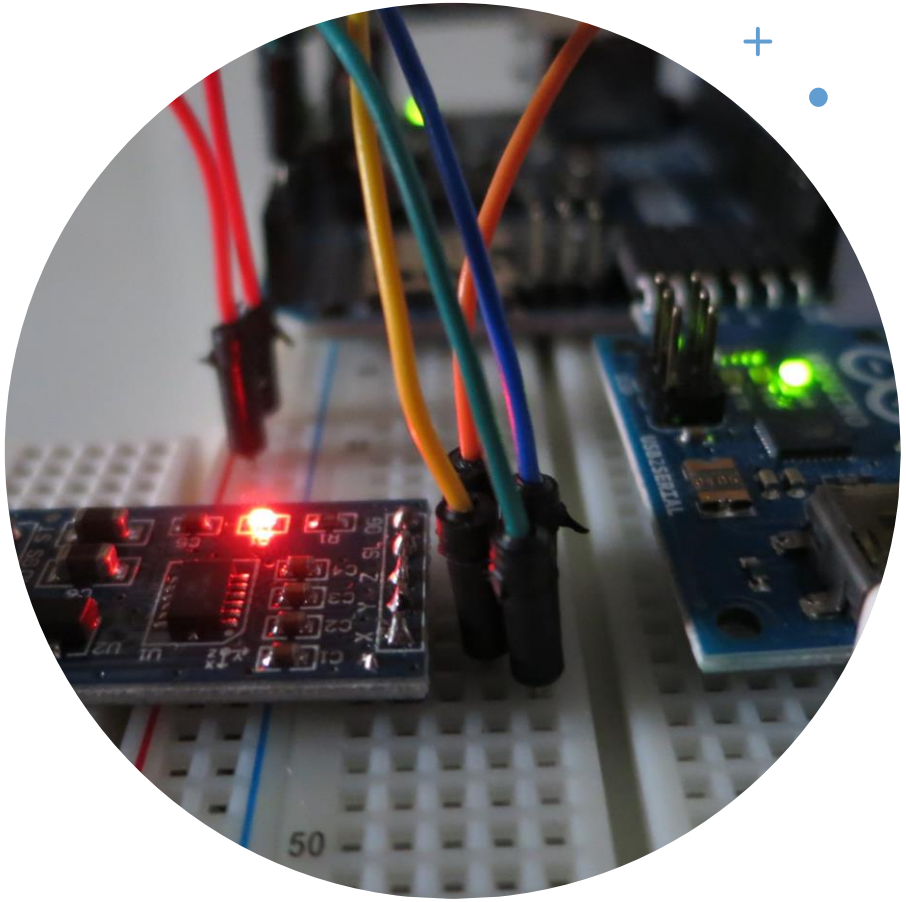


Benefits of IoT

- Increased Efficiency
- Improved Safety
- Enhanced Customer Experience
- Cost Saving

Increased Efficiency

- automate routine tasks and provide real-time data
- allowing businesses to make better decisions
- optimize their operations

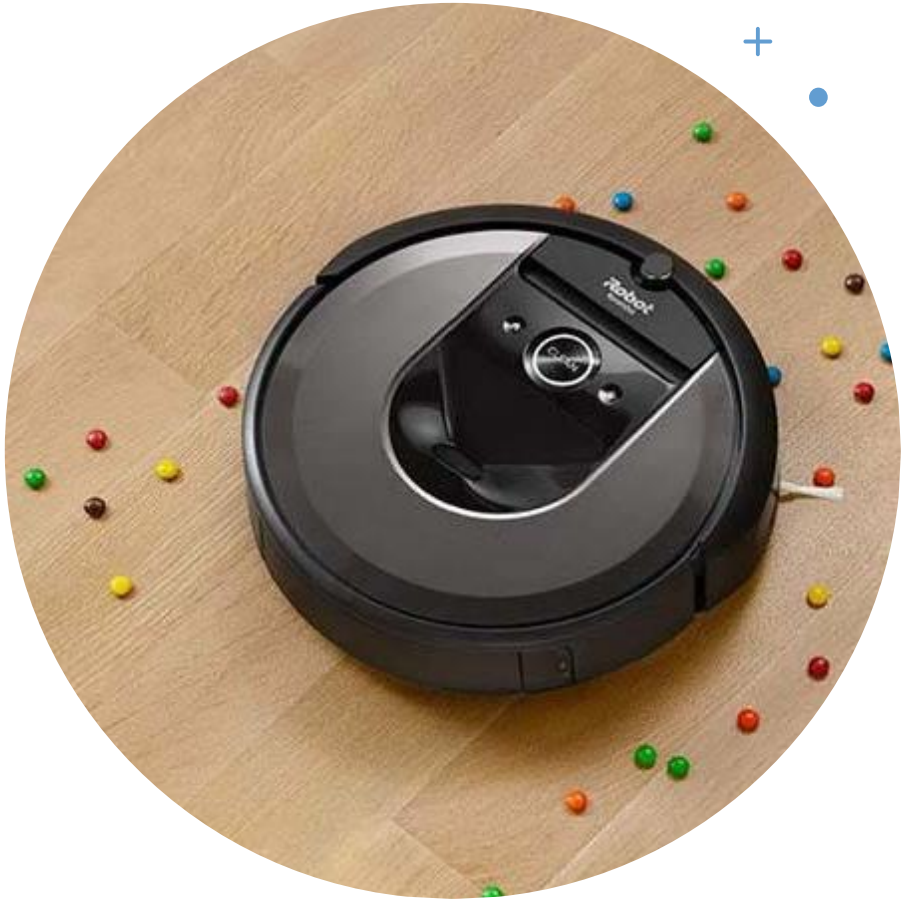


Improved Safety

- monitor and control safety systems in factories, homes, and public spaces
- Sensors for gas Leaks, Air Quality, Fire Hazards
- IoT can also respond to the hazard. Extinguish fire

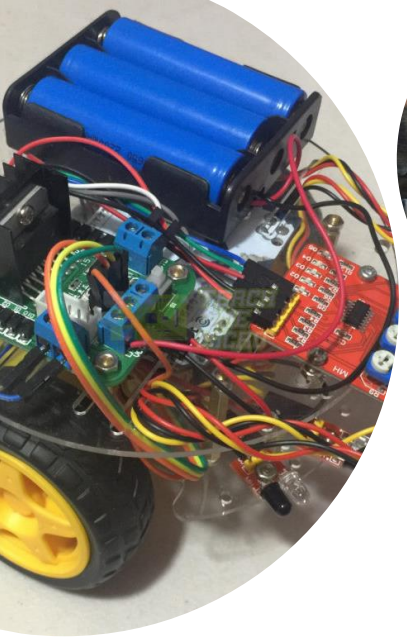
Enhanced Customer Experience

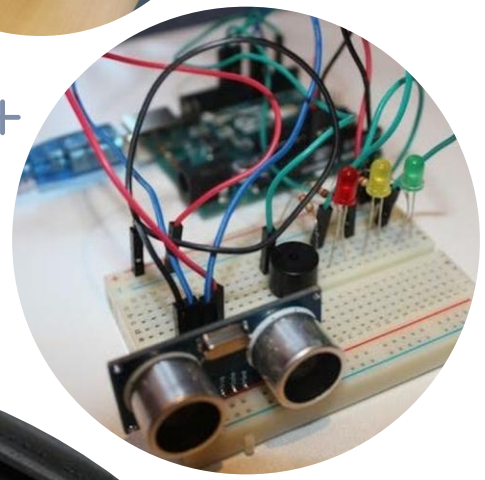
- provide personalized services and support
- virtual assistants
- smart homes
- connected cars (waze/google app for traffic/navigation or routing)

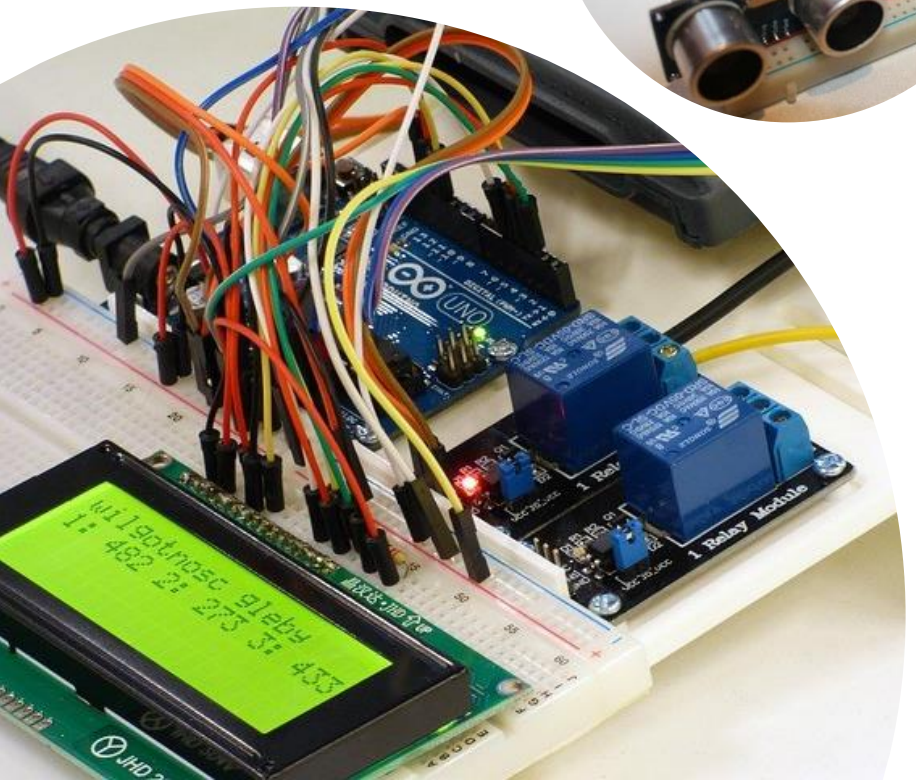


Cost Saving

- reduce costs by optimizing energy consumption
- reducing waste
- streamlining processes
- smart lighting systems can automatically adjust brightness and turn off when not in use







IoT Applications

- Consumer IoT
- Commercial IoT
- Industrial IoT
- Healthcare IoT

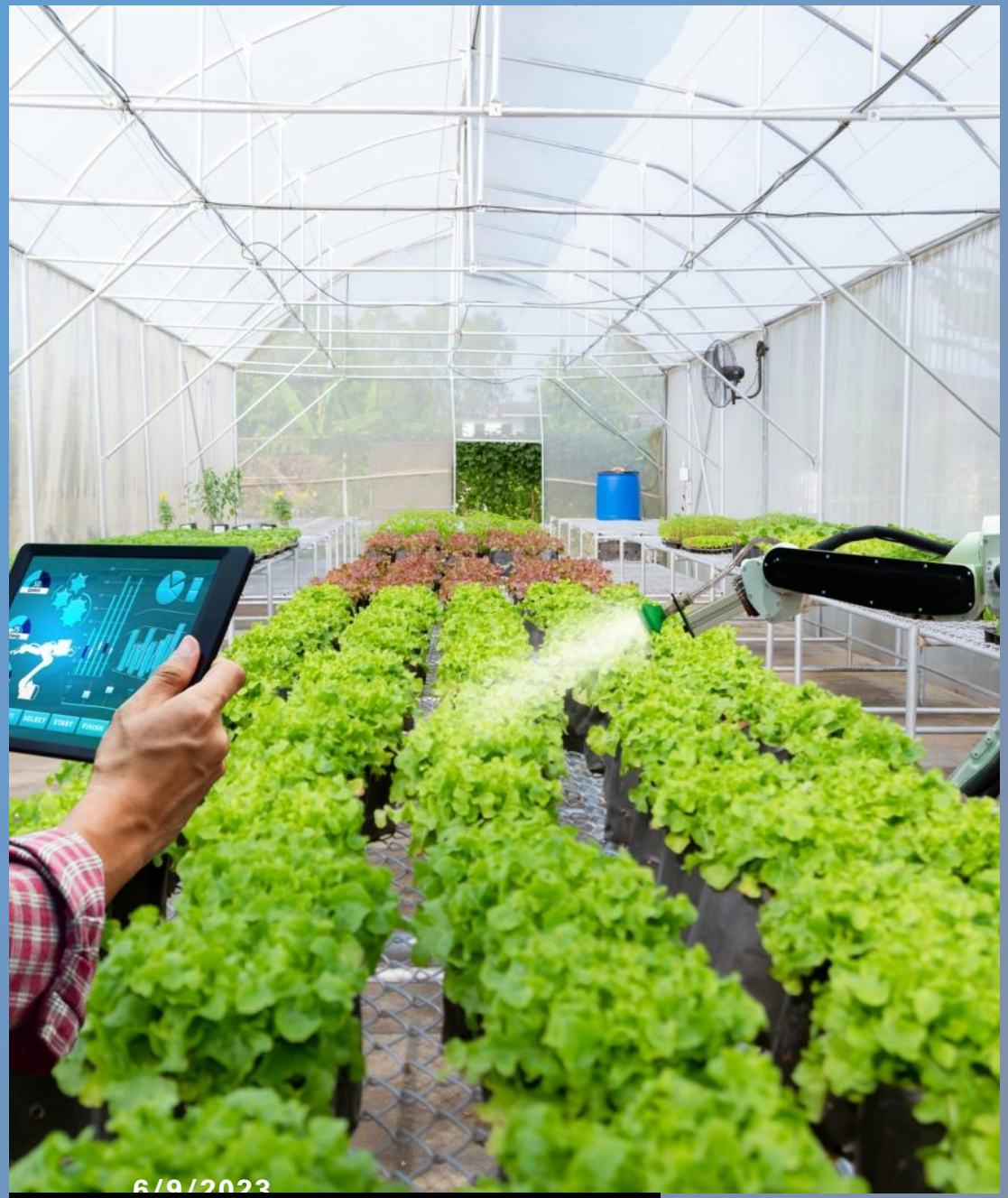
CONSUMER IOT

- DEVICES THAT CONSUMERS USE AROUND THEIR HOME
- USERS WITH DISABILITY (PWD)
- SMART SPEAKERS, ROBOT CLEANERS, VOICE CONTROLLED DEVICES, HEALTH MONITORS, TIME TRACKERS..ETC.

COMMERCIAL IOT

- IOT IN WORKPLACE

- OCCUPANCY SENSOR, MOTION TRACKER, SAFETY/SECURITY MONITORING, TEMPERATURE TRACKING, VEHICLE TRACKING



INDUSTRIAL IOT

- IOT IN FACTORIES WITH LARGE SCALE MACHINERY
- DIGITAL AGRICULTURE
- PREDICTIVE MAINTAINANCE, PREDICTIVE HARVEST READINESS, SOIL MOISTURE MONITORING, CROP MONITORING (HEALTH), SAFTY MONITORING

HEALTH CARE IOT

- DEVICES THAT MONITOR HEALTH
- SMART WATCH (WEARABLE DEVICES)
- REMOTE PATIENT MONITORING, MEDICAL MANAGEMENT, HOSPITAL ASSET TRACKING, TELEMEDICINE, FALL DETECTION AND ELDERLY CARE, ENVIROMENTAL MONITORING

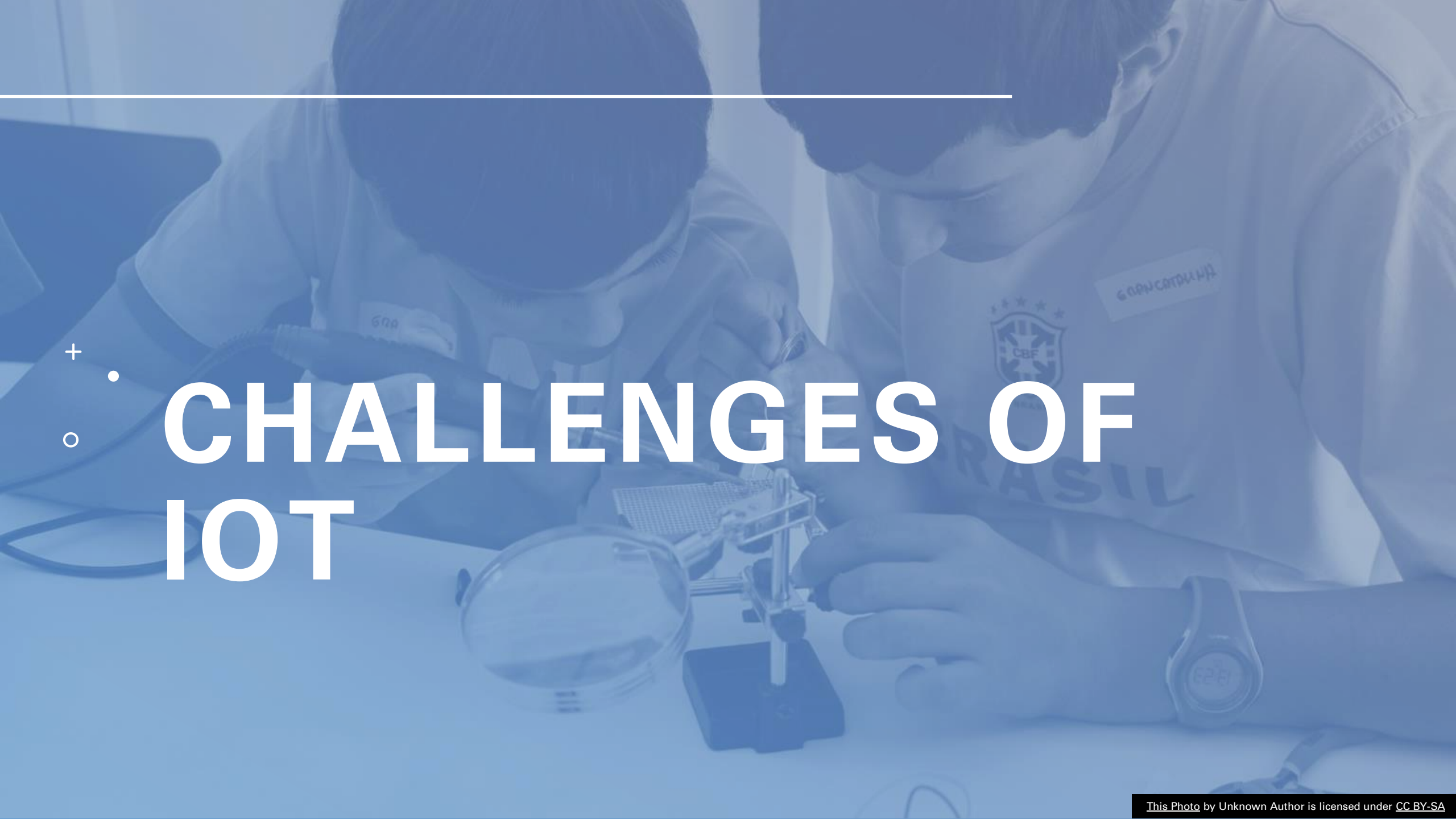
Arduino/ ESP32 Applications

- Home Automation (Lights, Blinds, Appliance, Gate)
- Home Security (Motion Sensors, Window Sensors, Alarm, Camera)
- Robotics (Autonomous Vehicles, Robotic Arms)
- Wearable Technology
- Environmental Monitoring (Humidity, Air Quality, Pollution)
- Smart Agriculture (Soil Moisture, Temperature, Humidity Levels, Optimize Crop Growth and Production)
- Education and Learning (Teach Electronics, Programming and Prototyping, Robotics)

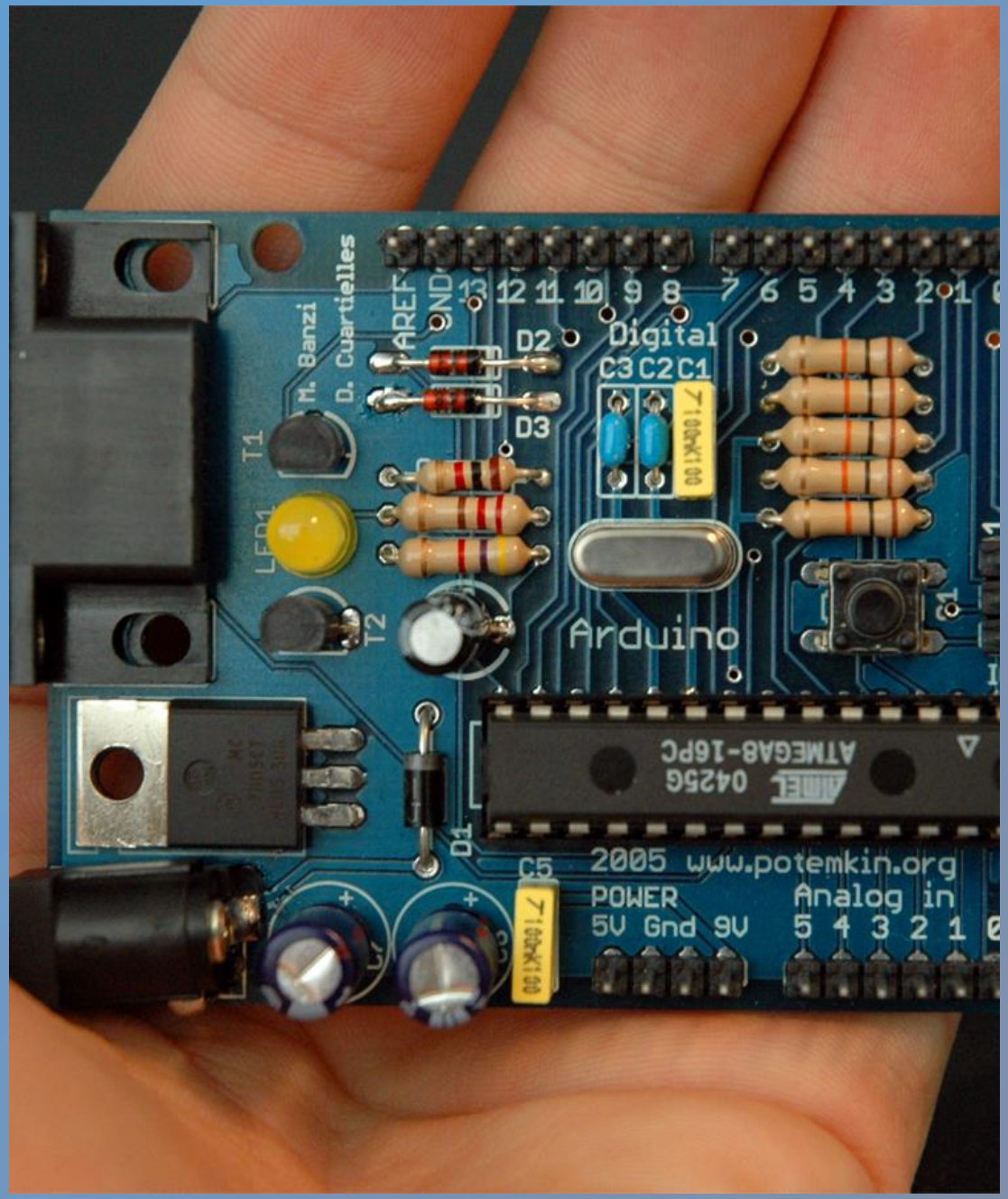
Raspberry Pi Industrial Application

- Desktop Computer
- Print Server
- Web Server/ Game Servers
- Retro Gaming Machine
- Robot Controller
- Network Video Recorder (NVR)
- Network Access Storage (NAS)
- Smart Home/Building Solutions
- IoT Gateway
- Network – Router, DHCP Server, DNS, VPN, Firewall.. etc.


SMART CITY



CHALLENGES OF IOT



Challenges

- Security
- Privacy
- Interoperability

SECUIRTY

- IOT DEVICES CONNECTED TO THE CLOUD ARE ONLY AS SECURED AS THE CLOUD / THE NETWORK

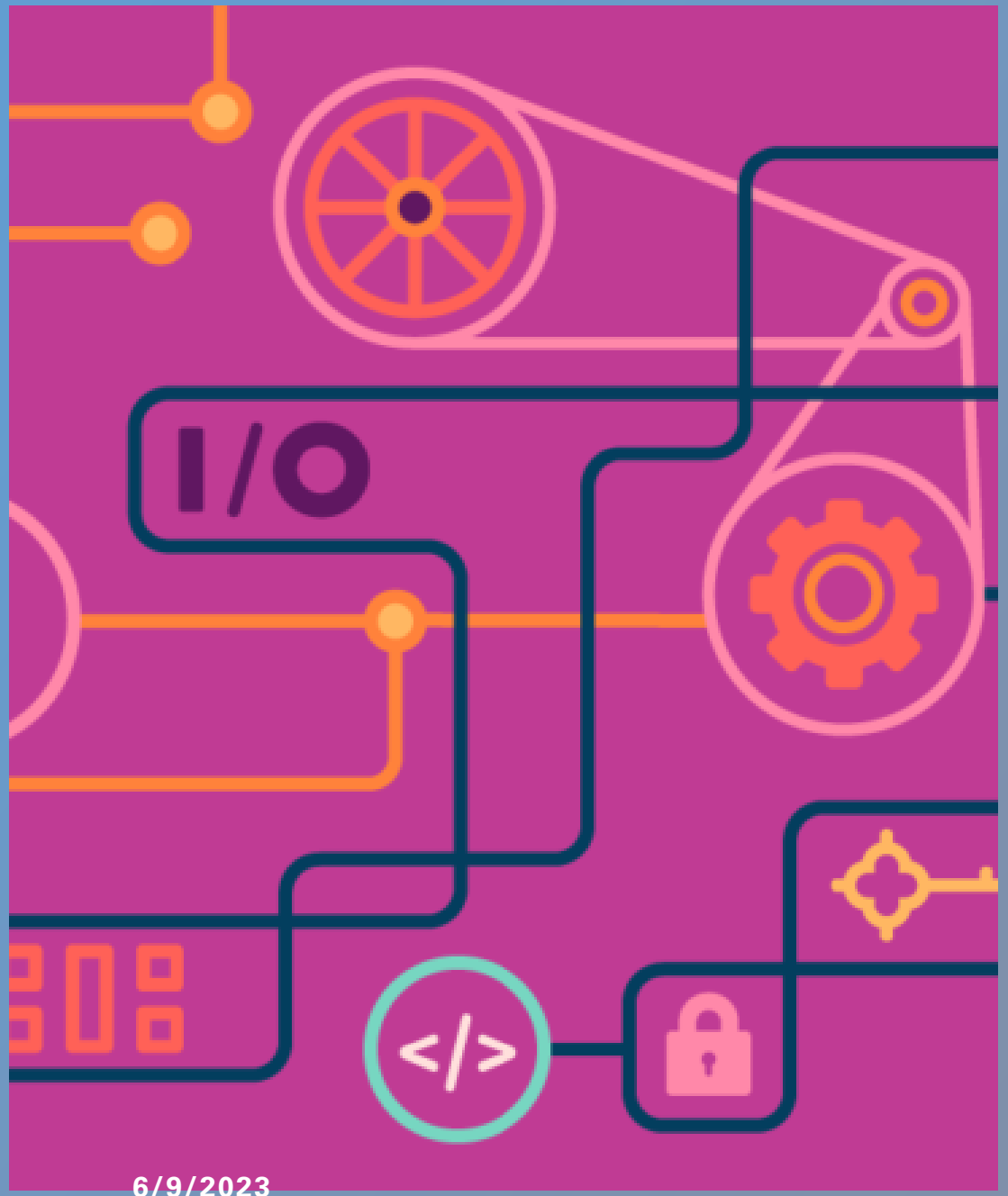
- MALICIOUS DEVICES
- VIRUS ATTACKS

- MALICIOUS DATA/ DEVICES

PRIVACY

- IOT DEVICES COLLECT AND TRANSMIT LARGE AMOUNT OF PERSONAL DATA

- TARGETED ADVERTISING
- ONLINE TRACKING
- PROFILING AND DISCRIMINATION
- LOCATION TRACKING
- DATA SHAREING AND SELLING
- GOVERNMENT SURVEILLANCE



INTEROPERABILITY

- IOT DEVICES AND SYSTEMS MAY USE DIFFERENT PROTOCOLS AND STANDARDS

- DIFFICULT TO CONNECT
- DIFFICULT TO EXCHANGE DATA

- COMMUNICATION STANDARDS

WHAT V.S. HOW

THANK YOU

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