EDGE IMPULSE

Making things smarter

GLOBAL AGENDA

Embedded Programming

Lectures (1 & 2):	01/10/2021
Lab 1:	01/10/2021

IoT communication protocols

Lecture 1:	06/10/2021
Lab 1:	15/10/2021

Introduction to Embedded Machine Learning

Lecture 3:	12/11/2021
Lab 2:	12/11/2021

AGENDA

Embedded Programming 2/3

Introduction to Real Time Operating Systems (RTOS)

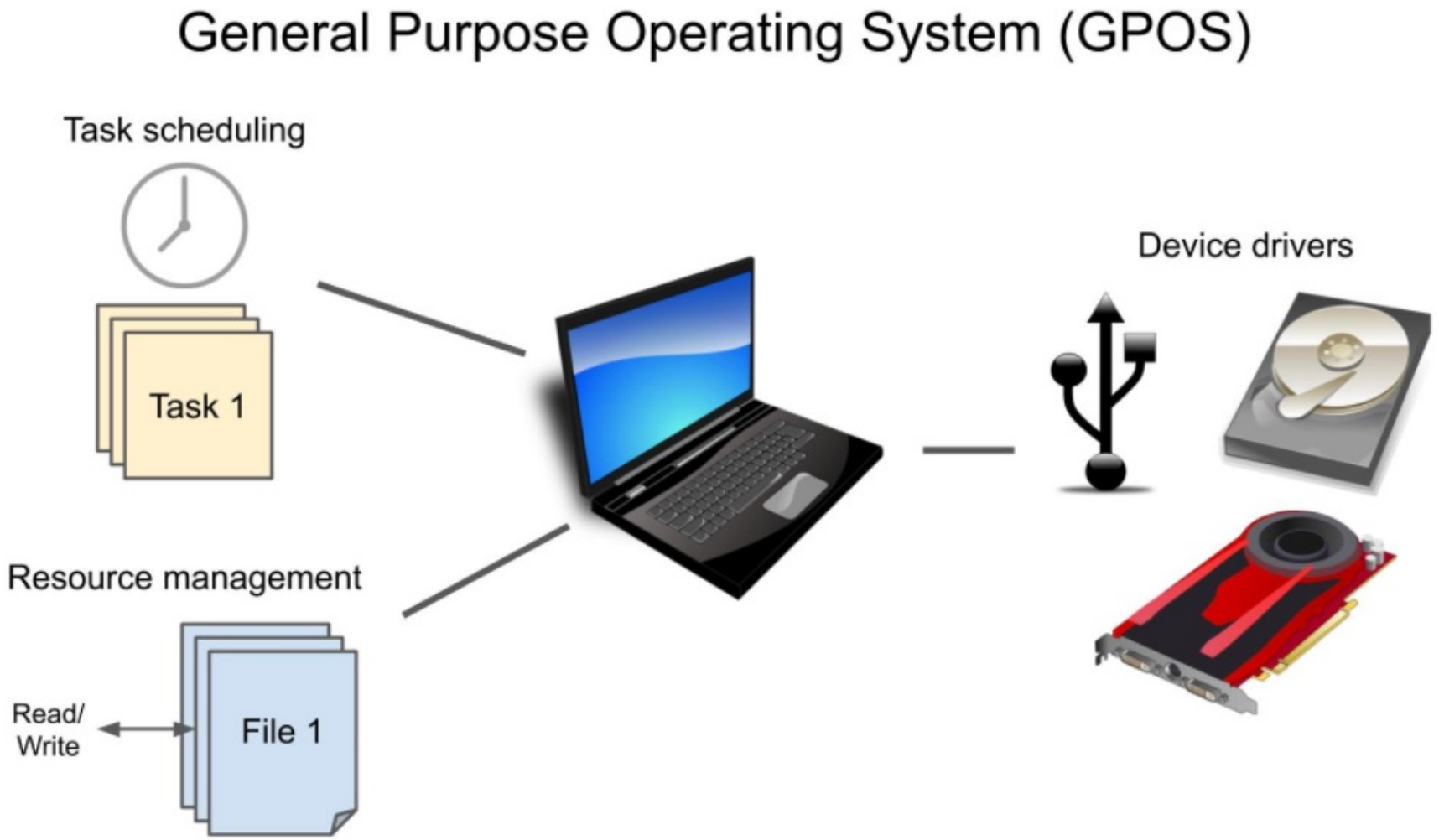
1. Introduction

- General Purpose Operating System vs. Real-Time Operating System
- Loop vs. Multi-threaded Application
- RTOS requirements

2. Example with FreeRTOS on an ESP32

3. Task Scheduling

Introduction



Source: https://www.digikey.com/en/maker/projects/what-is-a-realtime-operating-system-rtos

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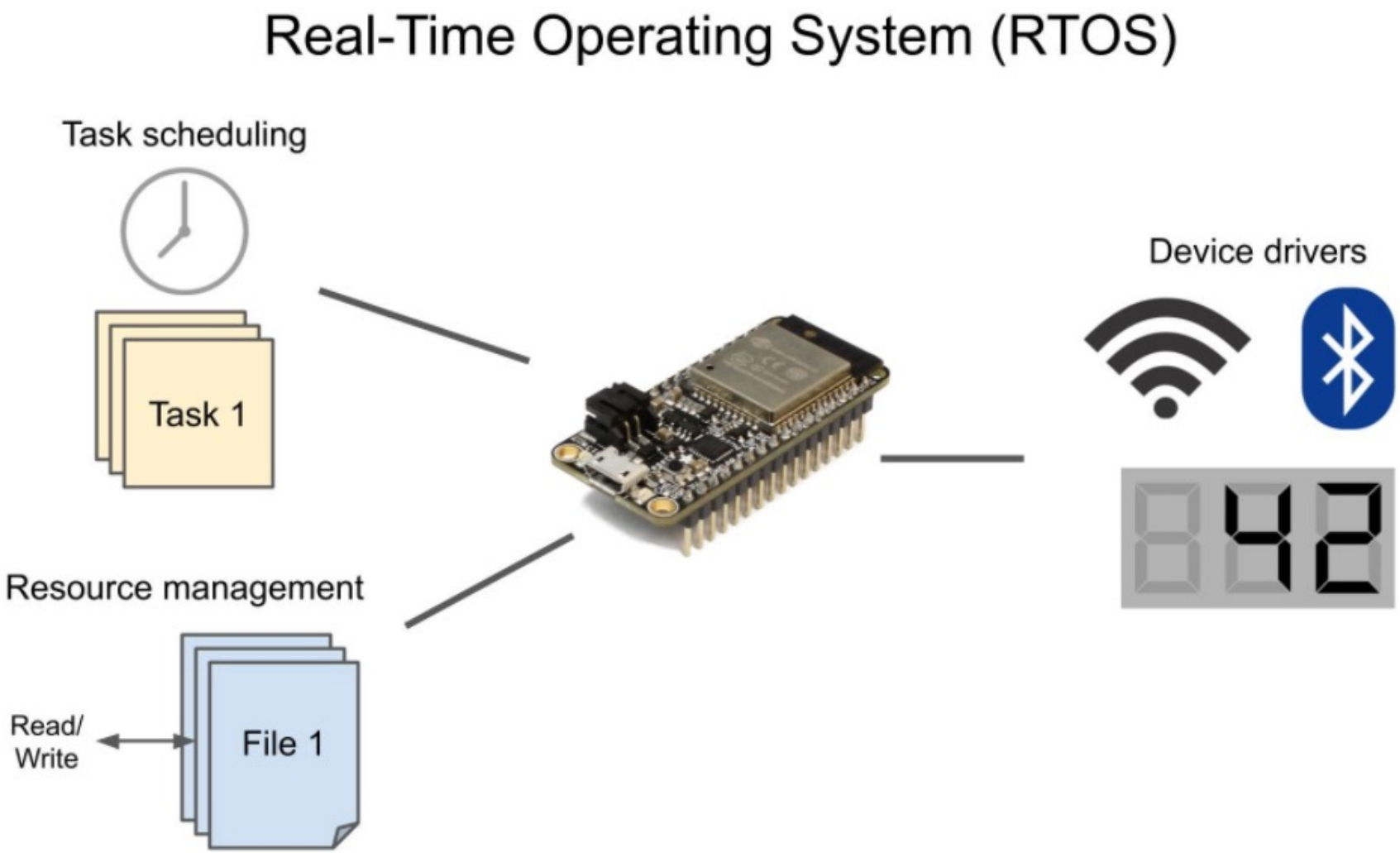
Introduction



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A Beginners Guide to RTOS

(Real Time Operating System)

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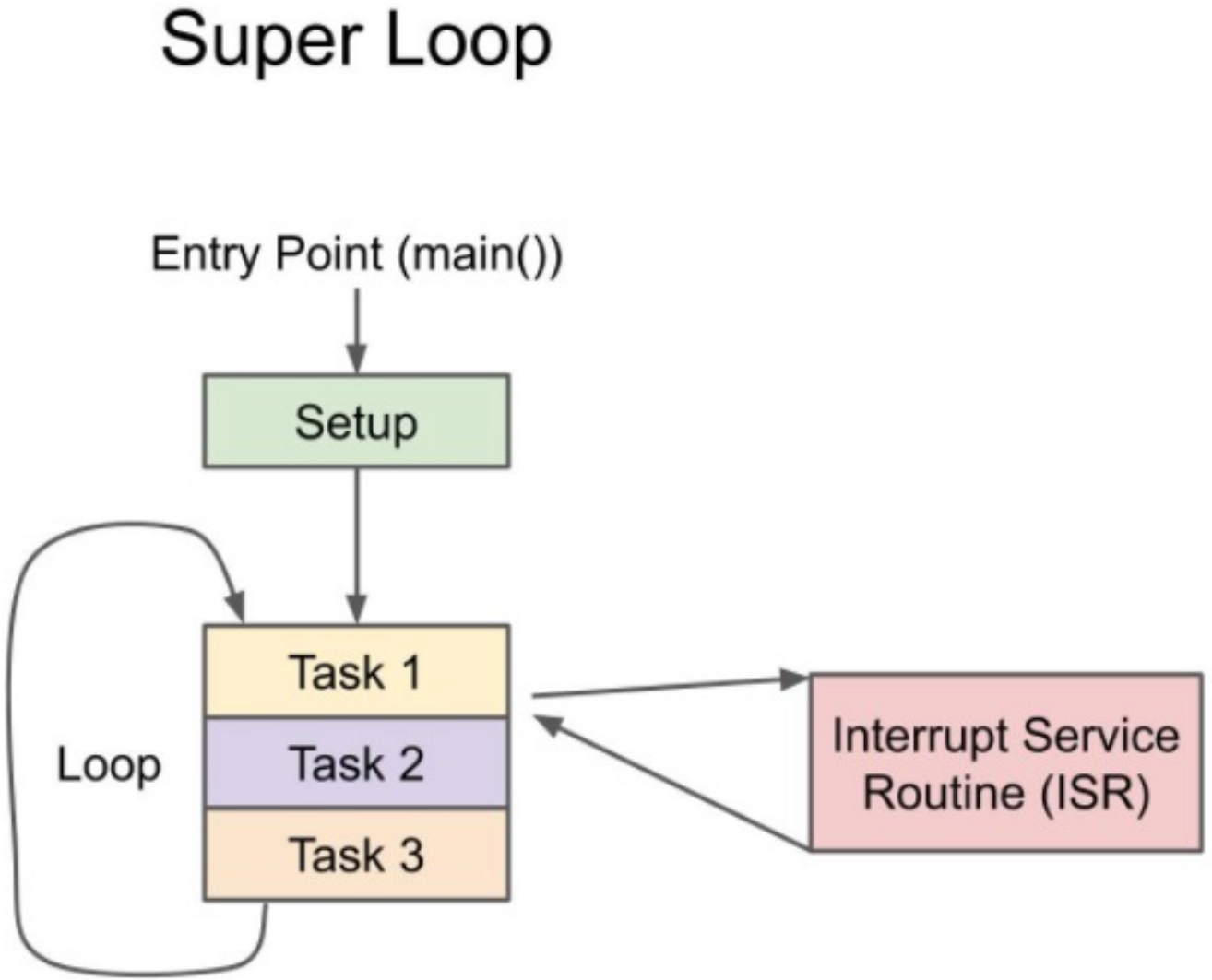
1. Introduction

Loop vs. Multi-threaded Application



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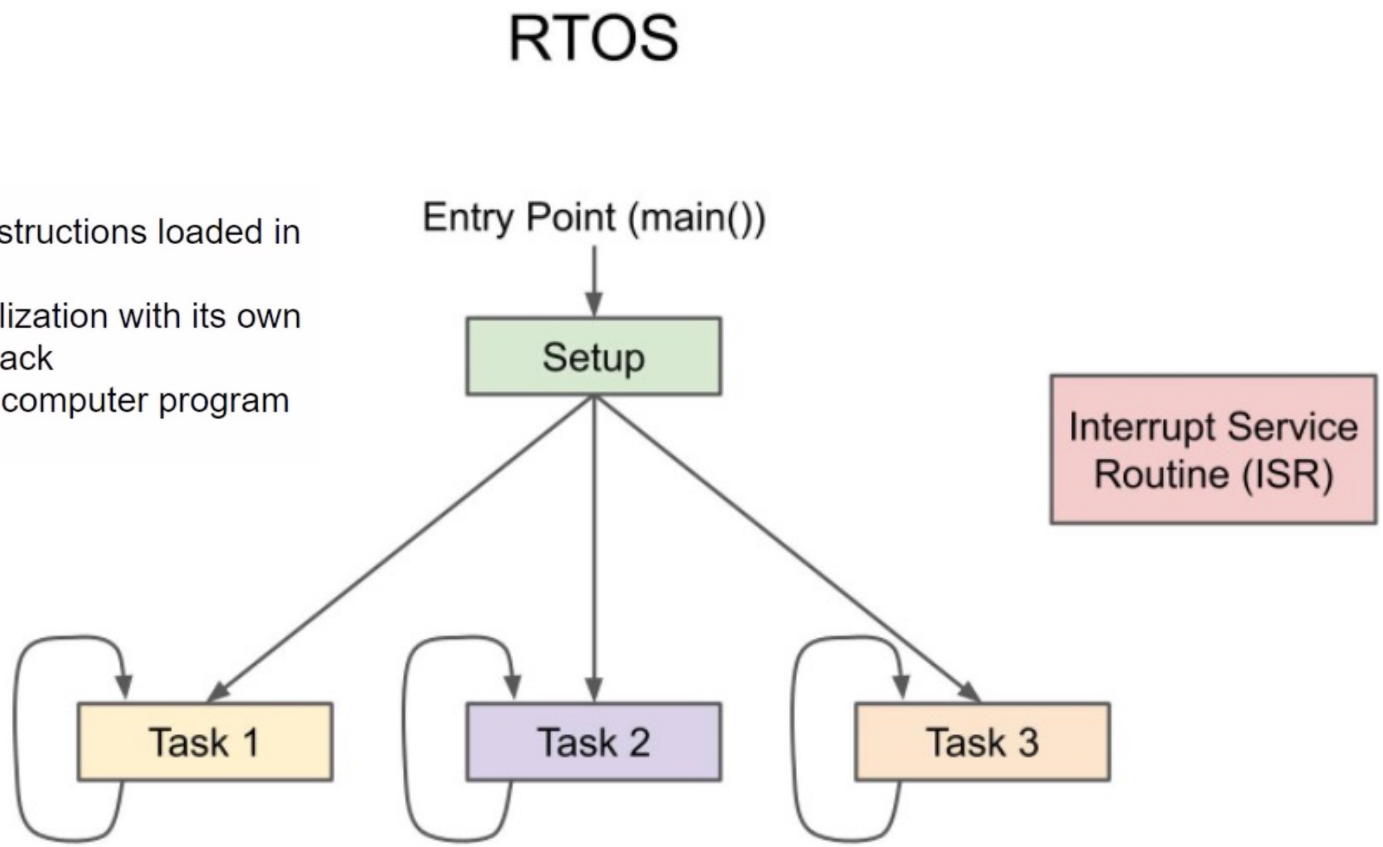
1. Introduction

Loop vs. Multi-threaded Application

- **Task**: set of program instructions loaded in memory
- **Thread**: unit of CPU utilization with its own program counter and stack
- **Process**: instance of a computer program



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1. Introduction

RTOS Requirements

ATmega 328p
- 16 MHz
- 32 kB flash
- 2 kB RAM

STM32L476RG
- 80 MHz
- 1 MB flash
- 128 kB RAM

ESP-WROOM-32
- 240 MHz (dual core)
- 4 MB flash
- 520 kB RAM

Super Loop → RTOS

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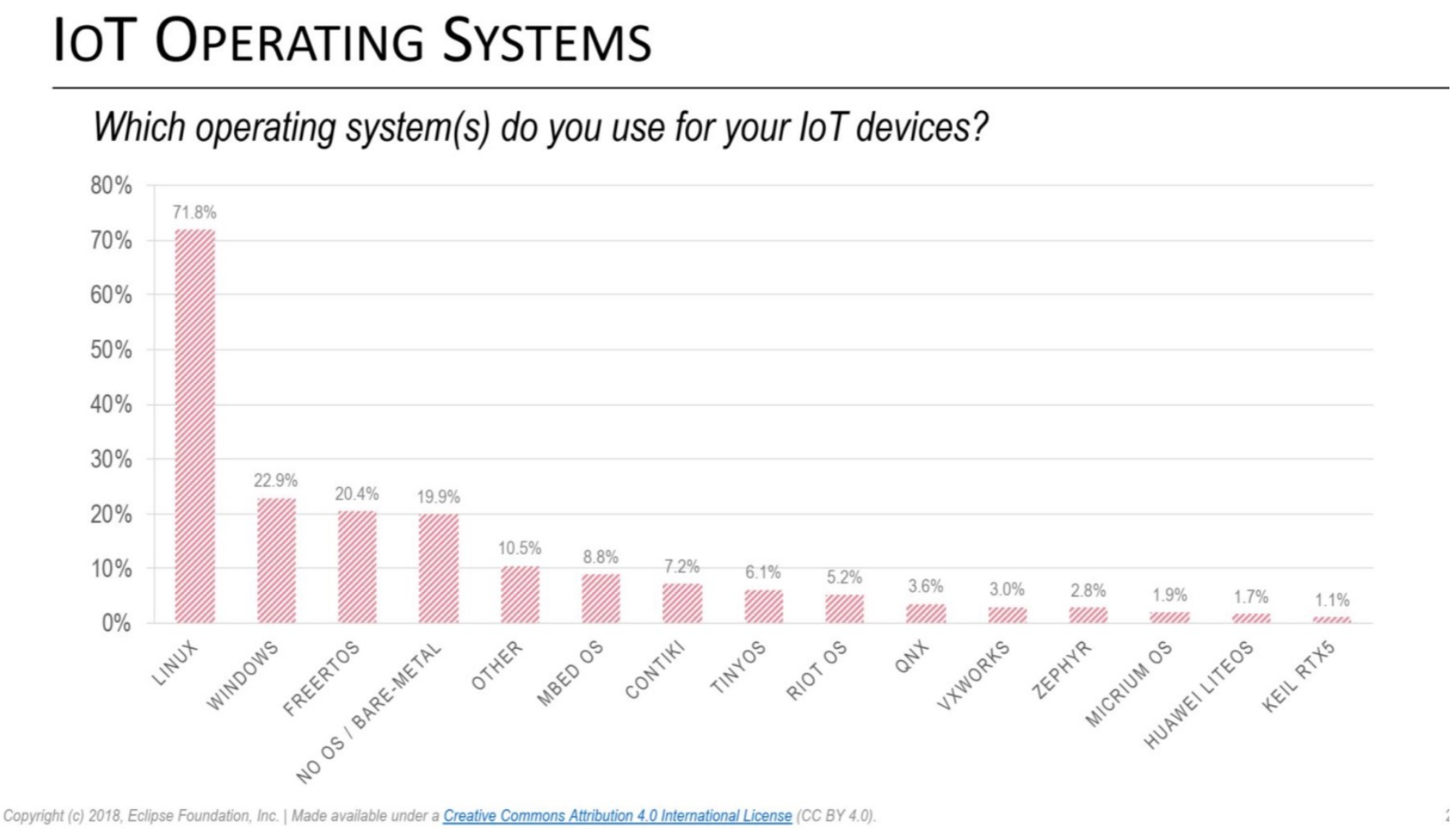
1. Introduction

IoT Operating systems



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1. Introduction
2. Example with FreeRTOS

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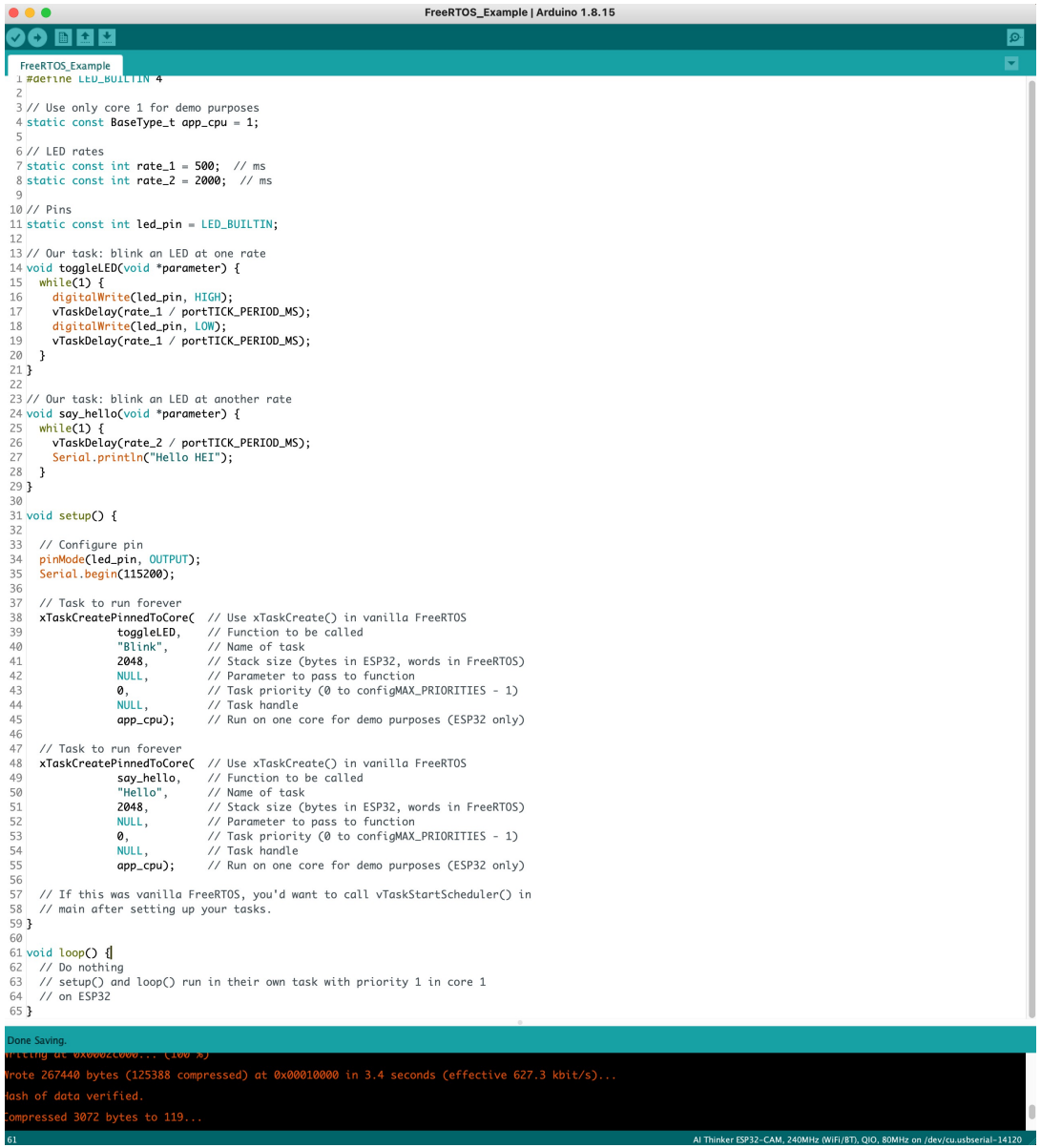
Example with FreeRTOS on ESP32



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Example with FreeRTOS on ESP32

```
#define LED_BUILTIN 4

// Use only core 1 for demo purposes
static const BaseType_t app_cpu = 1;

// LED rates
static const int rate_1 = 500;  // ms
static const int rate_2 = 2000;  // ms

// Pins
static const int led_pin = LED_BUILTIN;
```

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Example with FreeRTOS on ESP32

```
// Our task: blink an LED at one rate
void toggleLED(void *parameter) {
  while(1) {
    digitalWrite(led_pin, HIGH);
    vTaskDelay(rate_1 / portTICK_PERIOD_MS);
    digitalWrite(led_pin, LOW);
    vTaskDelay(rate_1 / portTICK_PERIOD_MS);
  }
}

// Our task: blink an LED at another rate
void say_hello(void *parameter) {
  while(1) {
    vTaskDelay(rate_2 / portTICK_PERIOD_MS);
    Serial.println("Hello HEI");
  }
}
```

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1. Introduction
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Example with FreeRTOS on ESP32

```
void setup() {

  // Configure pin
  pinMode(led_pin, OUTPUT);
  Serial.begin(115200);

  // Task to run forever
  xTaskCreatePinnedToCore(  // Use xTaskCreate() in vanilla FreeRTOS
            toggleLED,    // Function to be called
            "Blink",      // Name of task
            2048,         // Stack size (bytes in ESP32, words in FreeRTOS)
            NULL,         // Parameter to pass to function
            0,          // Task priority (0 to configMAX_PRIORITIES - 1)
            NULL,         // Task handle
            app_cpu);     // Run on one core for demo purposes (ESP32 only)

  // Task to run forever
  xTaskCreatePinnedToCore(  // Use xTaskCreate() in vanilla FreeRTOS
            say_hello,    // Function to be called
            "Hello",      // Name of task
            2048,         // Stack size (bytes in ESP32, words in FreeRTOS)
            NULL,         // Parameter to pass to function
            0,          // Task priority (0 to configMAX_PRIORITIES - 1)
            NULL,         // Task handle
            app_cpu);     // Run on one core for demo purposes (ESP32 only)

  // If this was vanilla FreeRTOS, you'd want to call vTaskStartScheduler() in
  // main after setting up your tasks.
}
```

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Example with FreeRTOS on ESP32

```
void loop() {
  // Do nothing
  // setup() and loop() run in their own task with priority 1 in core 1
  // on ESP32
}
```

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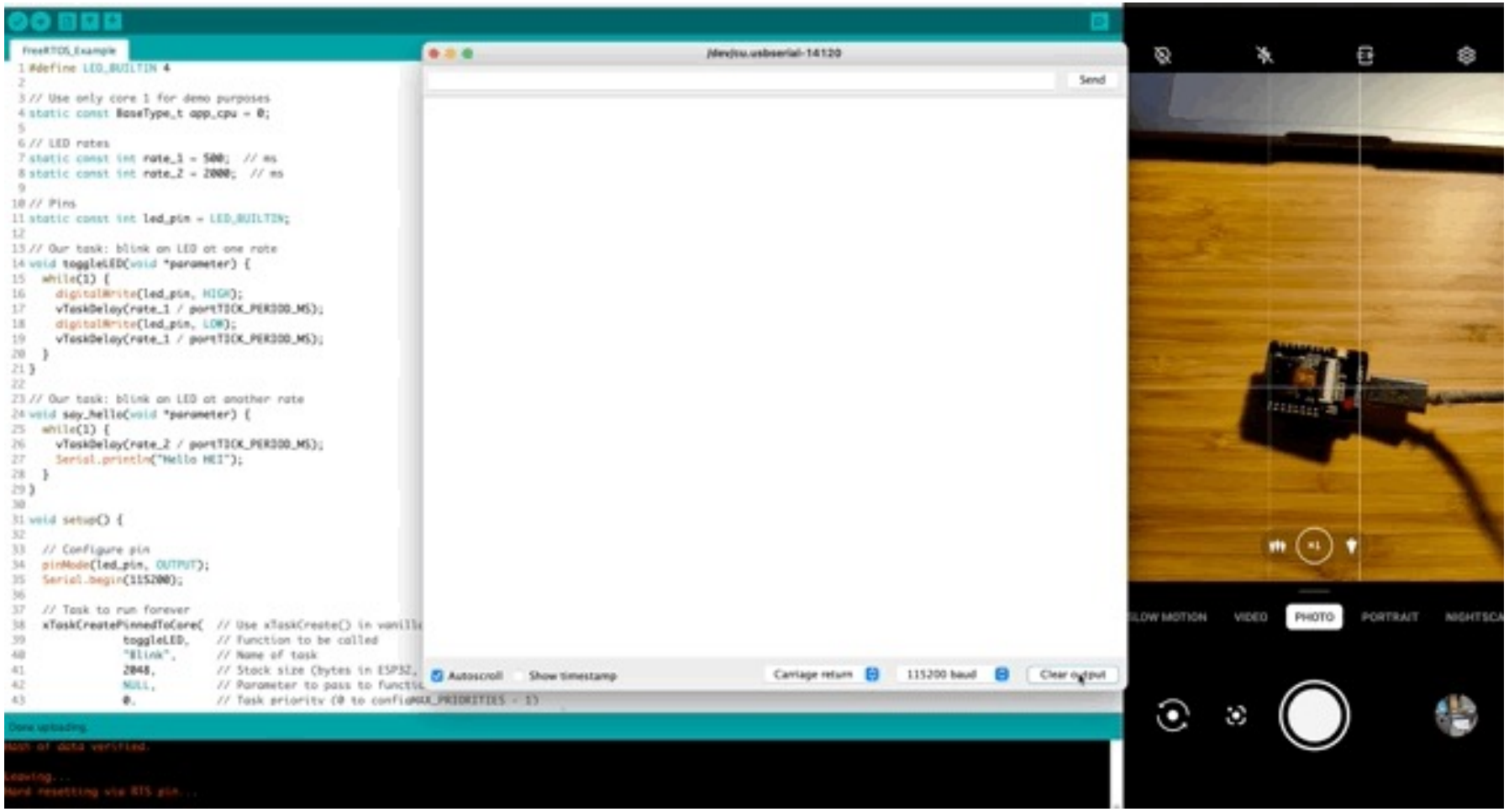
1. Introduction
2. Example with FreeRTOS

Example with FreeRTOS on ESP32



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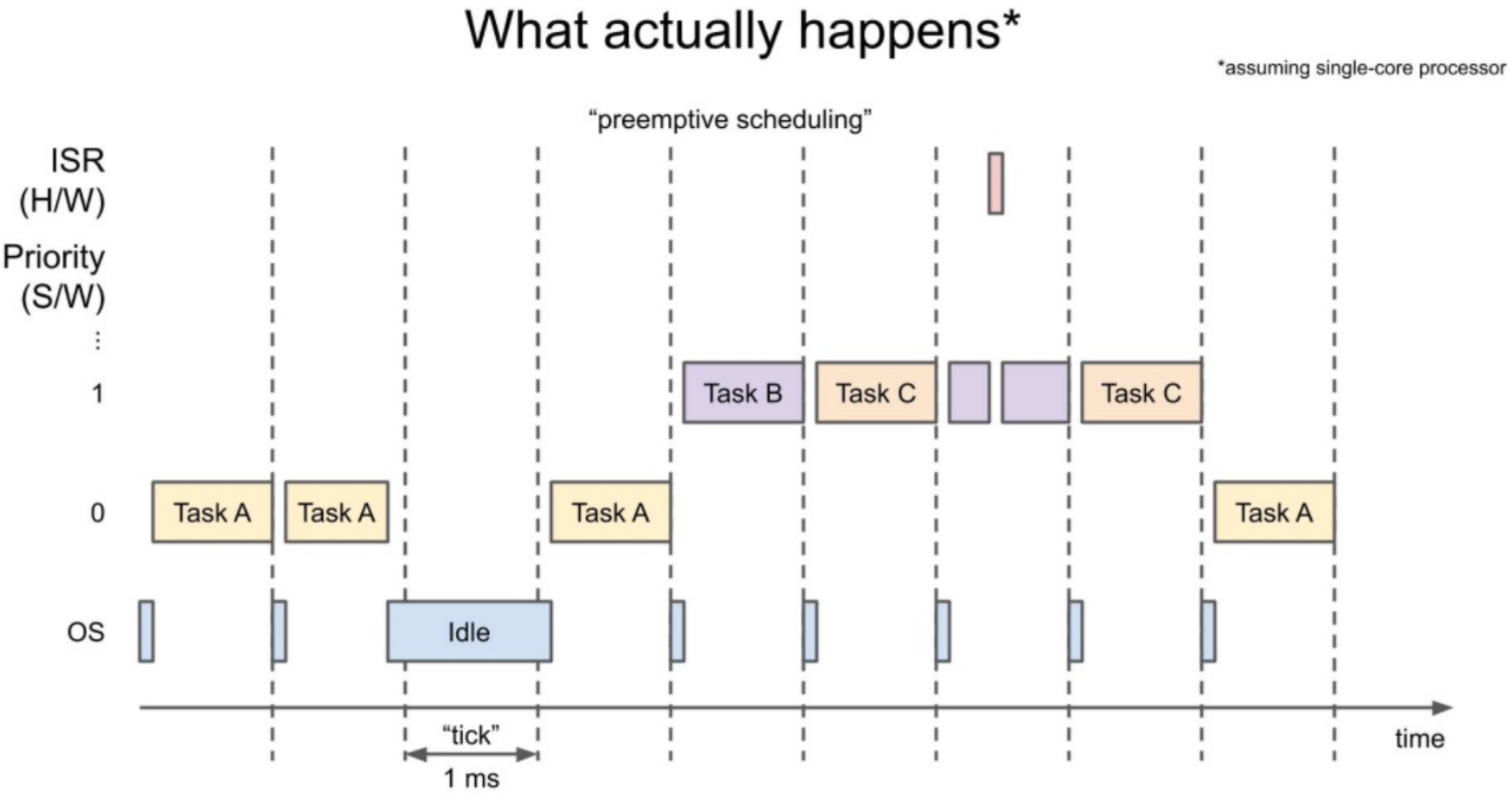
Example with FreeRTOS on ESP32



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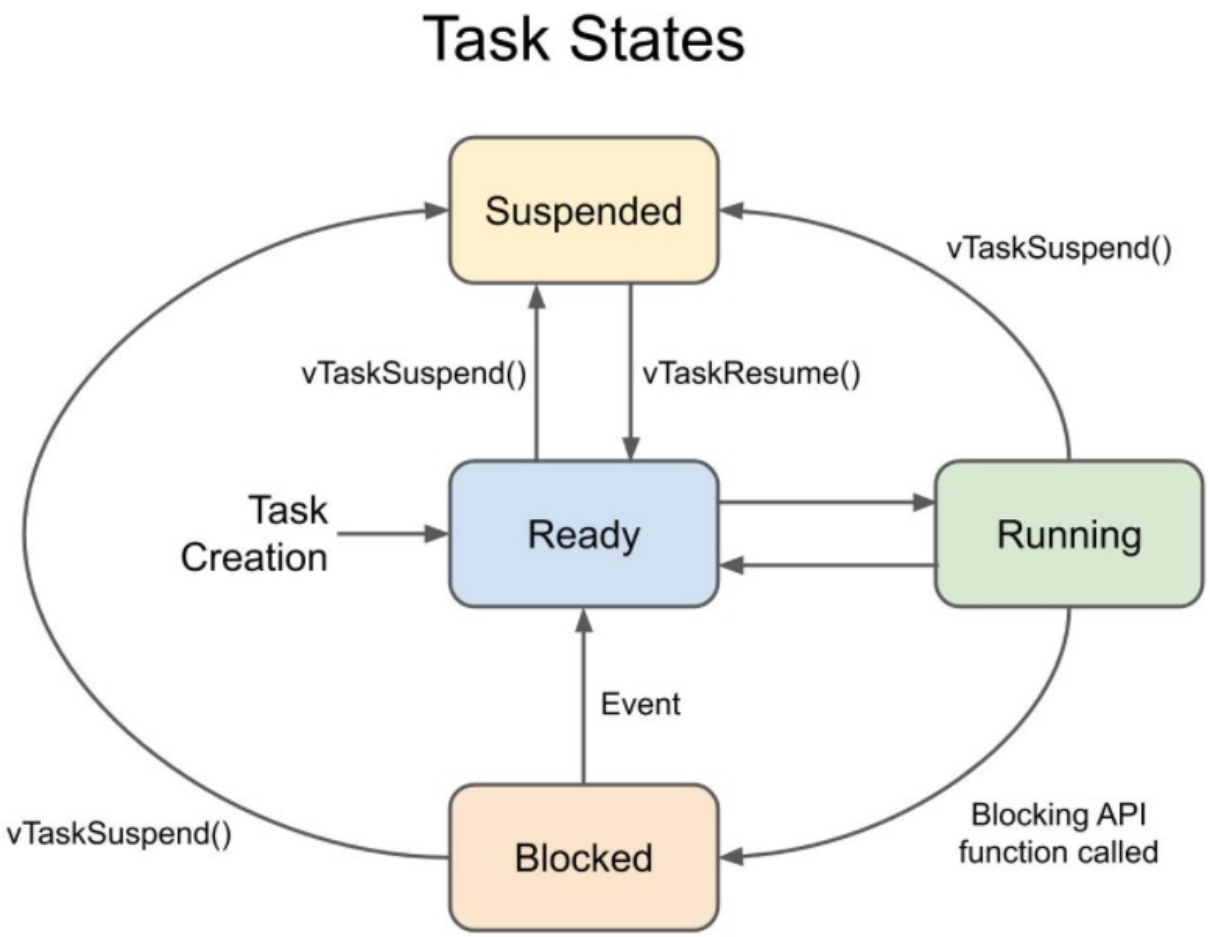
Example with FreeRTOS on ESP32



Thank you!

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