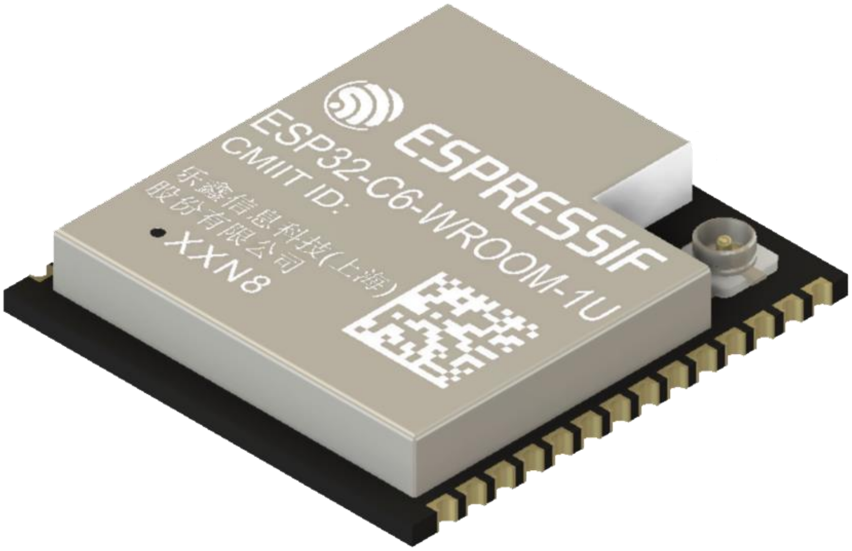
Day 1

Introduction to RTOS and FreeRTOS

freeRTOS



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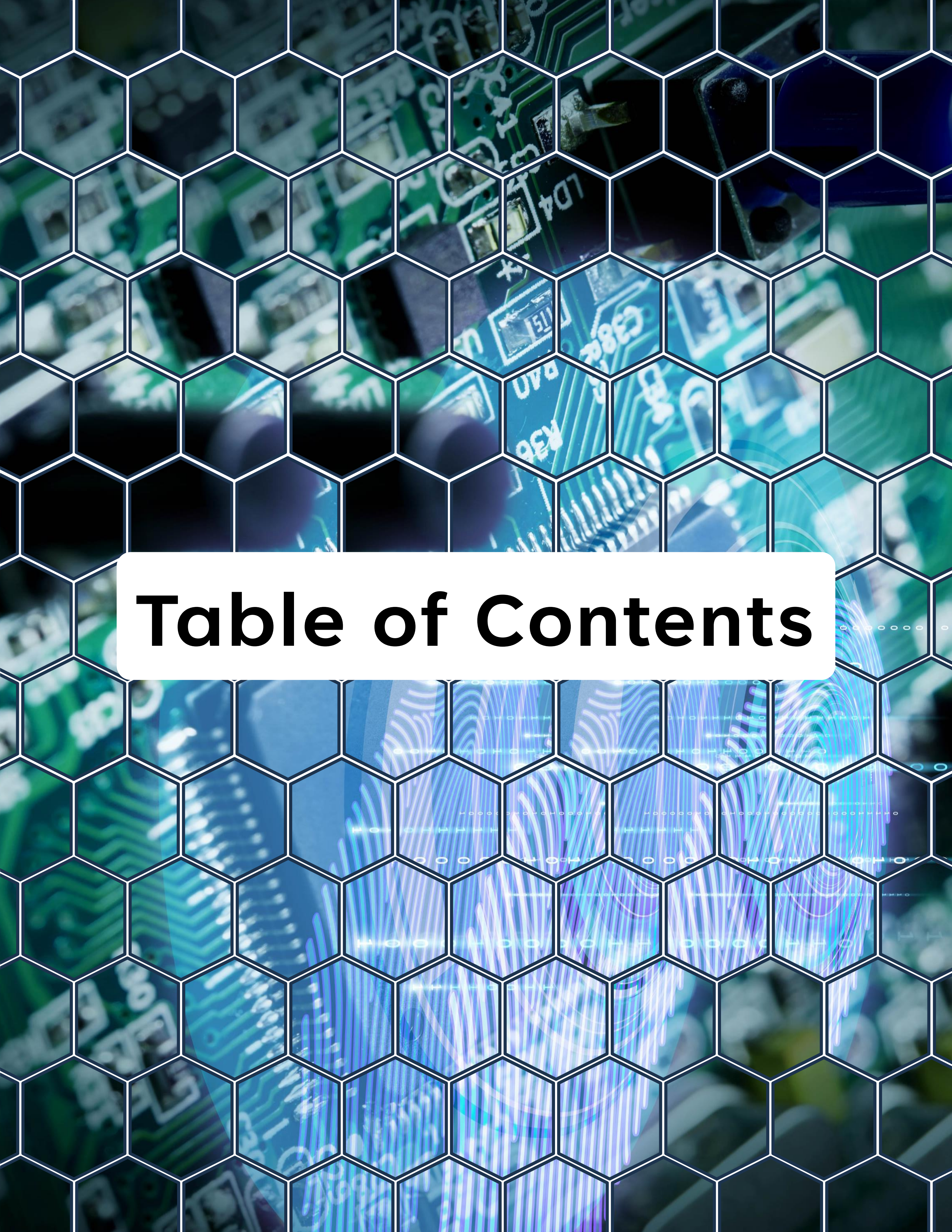

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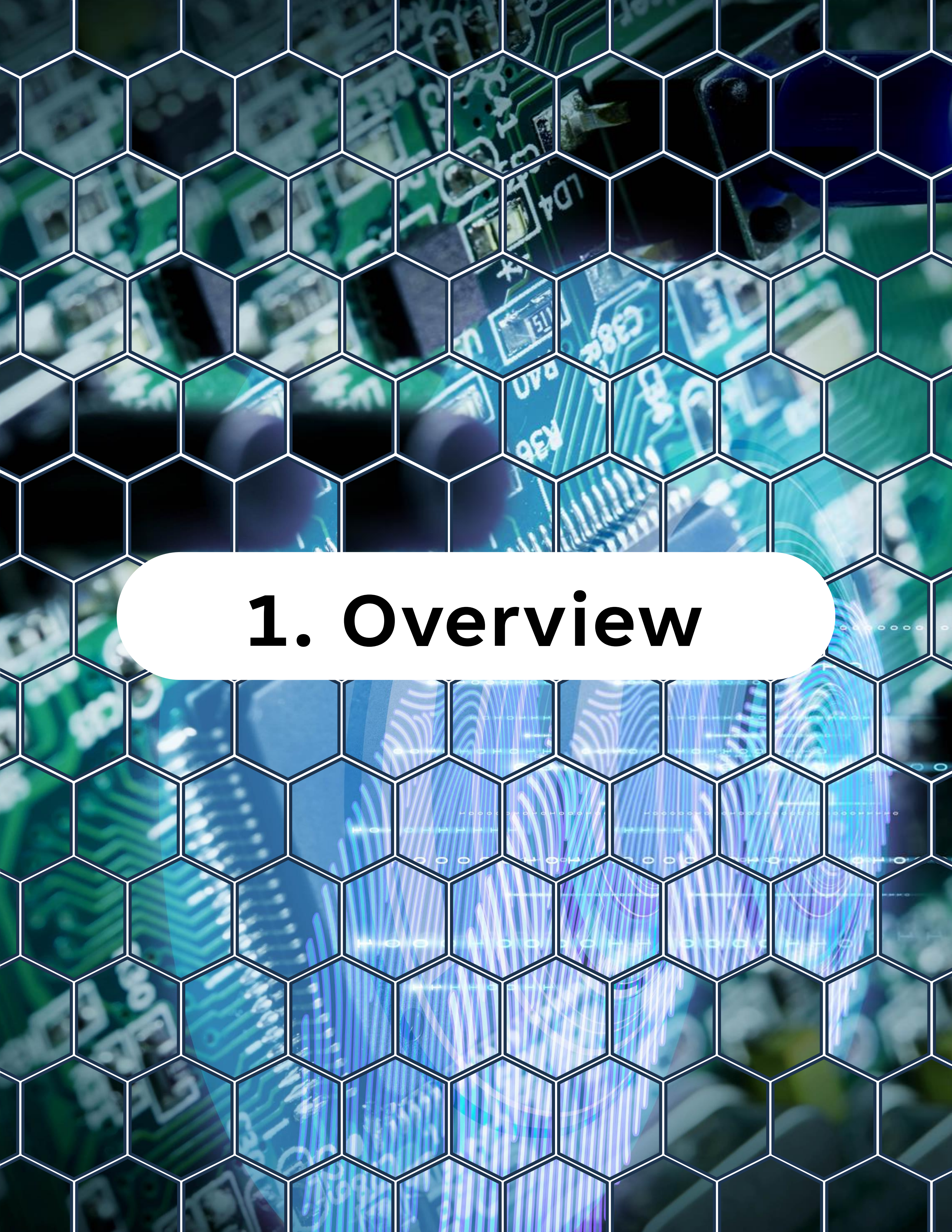
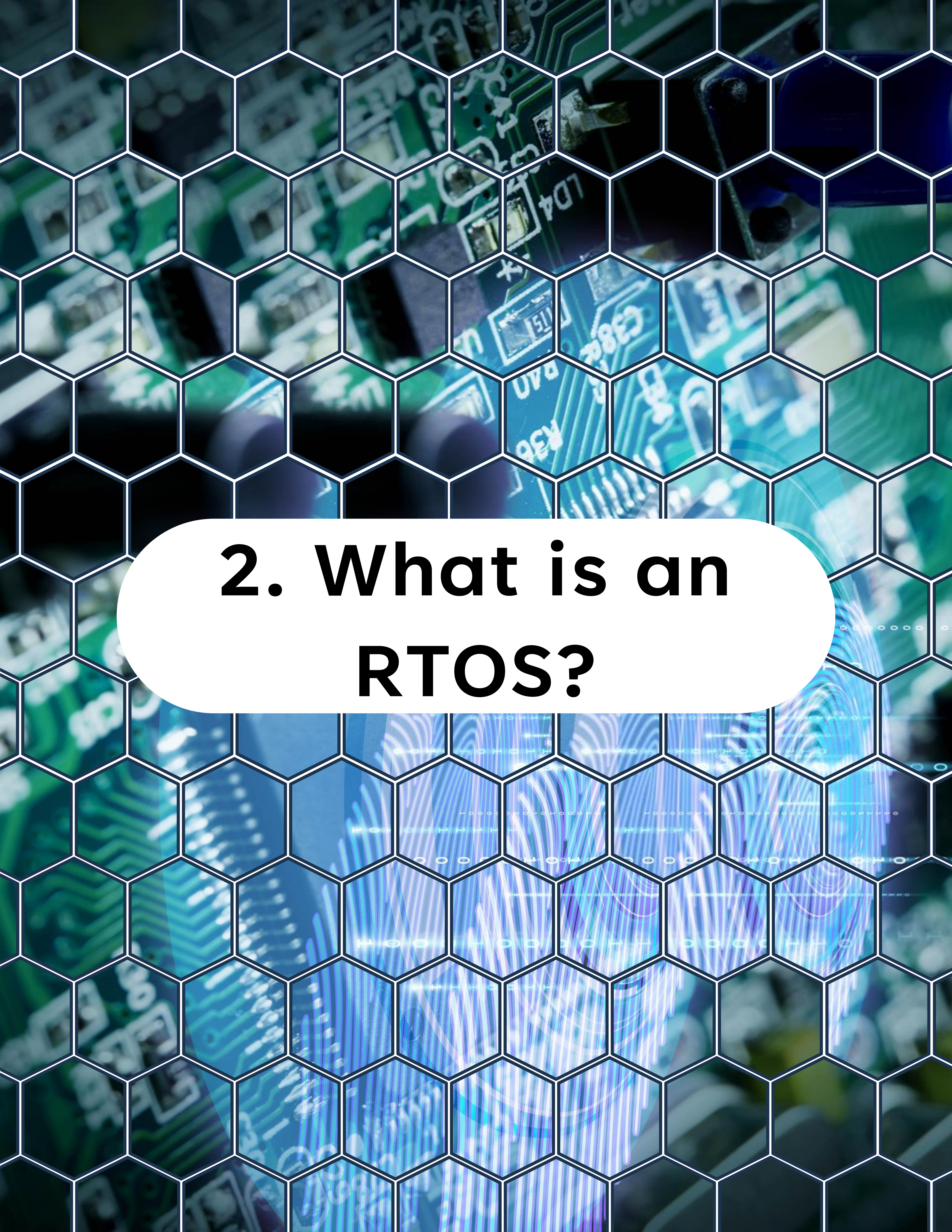


1. Overview

On Day 1, you will learn:

- What an RTOS is and why it's useful.
- The basics of FreeRTOS and its relevance to embedded systems.
- Why ESP32 and ESP-IDF are a perfect match for FreeRTOS development.
- What to expect from the upcoming days.



2. What is an RTOS?

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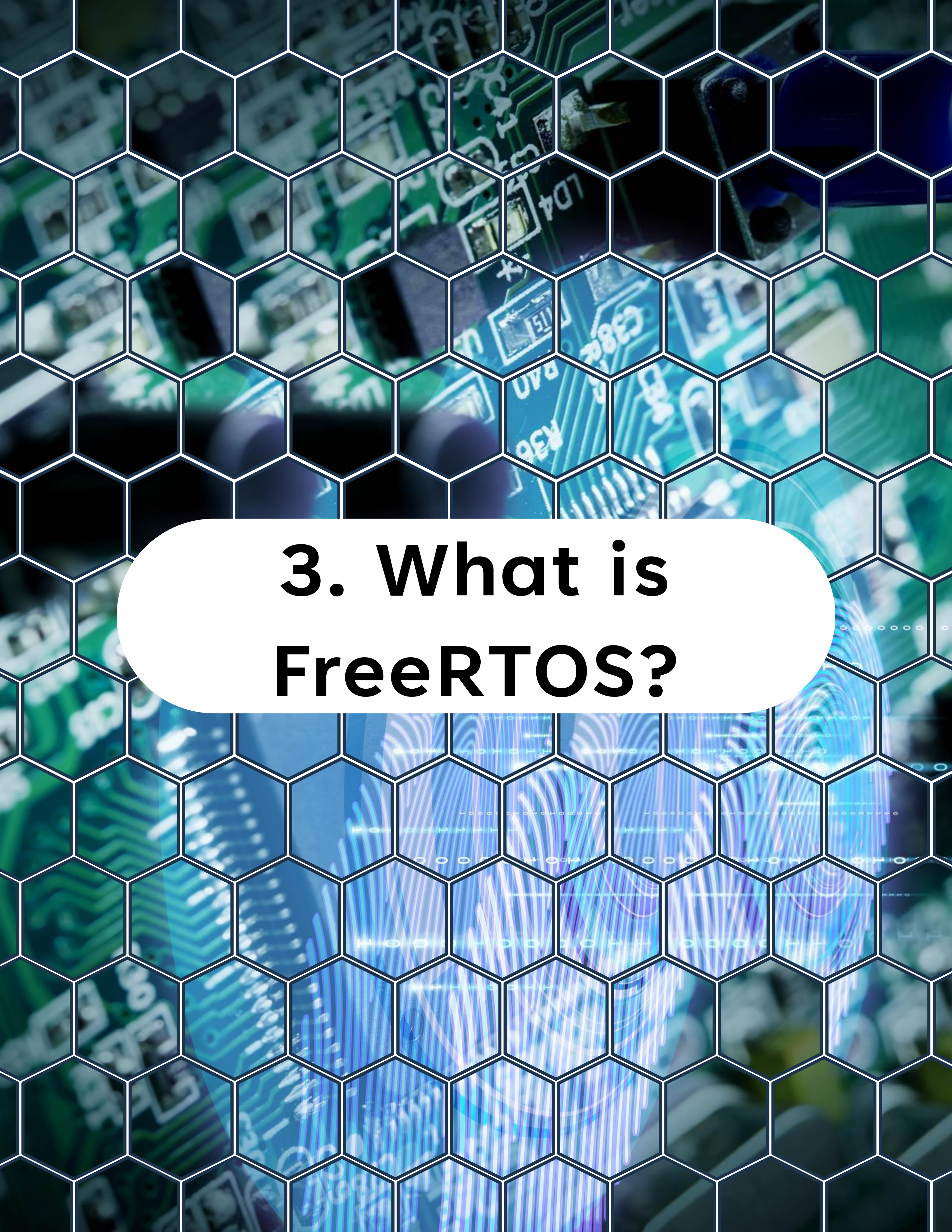
A **Real-Time Operating System (RTOS)** is a specialized OS that enables deterministic task scheduling with guaranteed response times. Unlike general-purpose OSs, it focuses on predictability and timing constraints, critical for embedded applications such as motor control, data acquisition, or communication systems.

Key Characteristics:

- **Multitasking** with preemptive or cooperative scheduling.
- **Real-time constraints** (e.g., deadlines).
- **Minimal latency**.
- Support for **inter-task communication** and **resource synchronization**.

3. What is FreeRTOS?

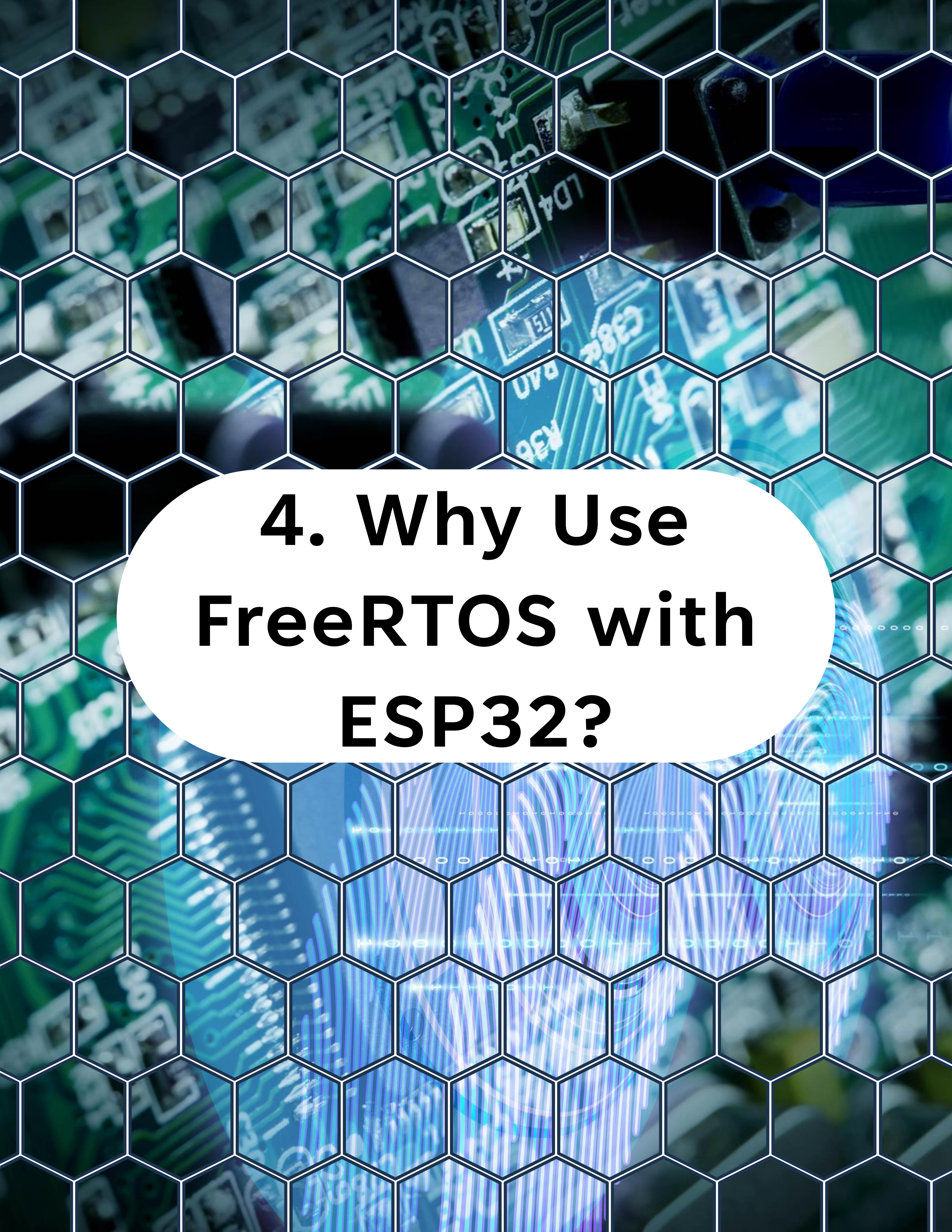


3. What is FreeRTOS?

FreeRTOS is an open-source real-time operating system kernel for embedded devices. It provides lightweight but powerful APIs for multitasking, synchronization, and timing.

Why Use FreeRTOS?

- Small footprint (few KBs of ROM/RAM).
- Portable (runs on many MCU architectures).
- Rich feature set: tasks, queues, semaphores, timers, etc.
- Large community and official support from Espressif for ESP32.



4. Why Use FreeRTOS with ESP32?

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ESP32 is a dual-core Xtensa microcontroller with built-in Wi-Fi and Bluetooth. FreeRTOS runs natively on ESP32 using Symmetric Multiprocessing (SMP), enabling efficient multitasking on both cores.

ESP-IDF, Espressif’s official development framework, integrates FreeRTOS by default. That means no extra installation is needed, you're ready to write multitasking code out of the box.

5. What’s Under the Hood?

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When you run a FreeRTOS-based ESP32 project via ESP-IDF:

- **Tasks** are distributed across **Core 0** and **Core 1**.
- The **main application runs as a FreeRTOS task.**
- ESP-IDF sets up **system tasks** for Wi-Fi, Bluetooth, and other components.

6. First Look at a FreeRTOS Task

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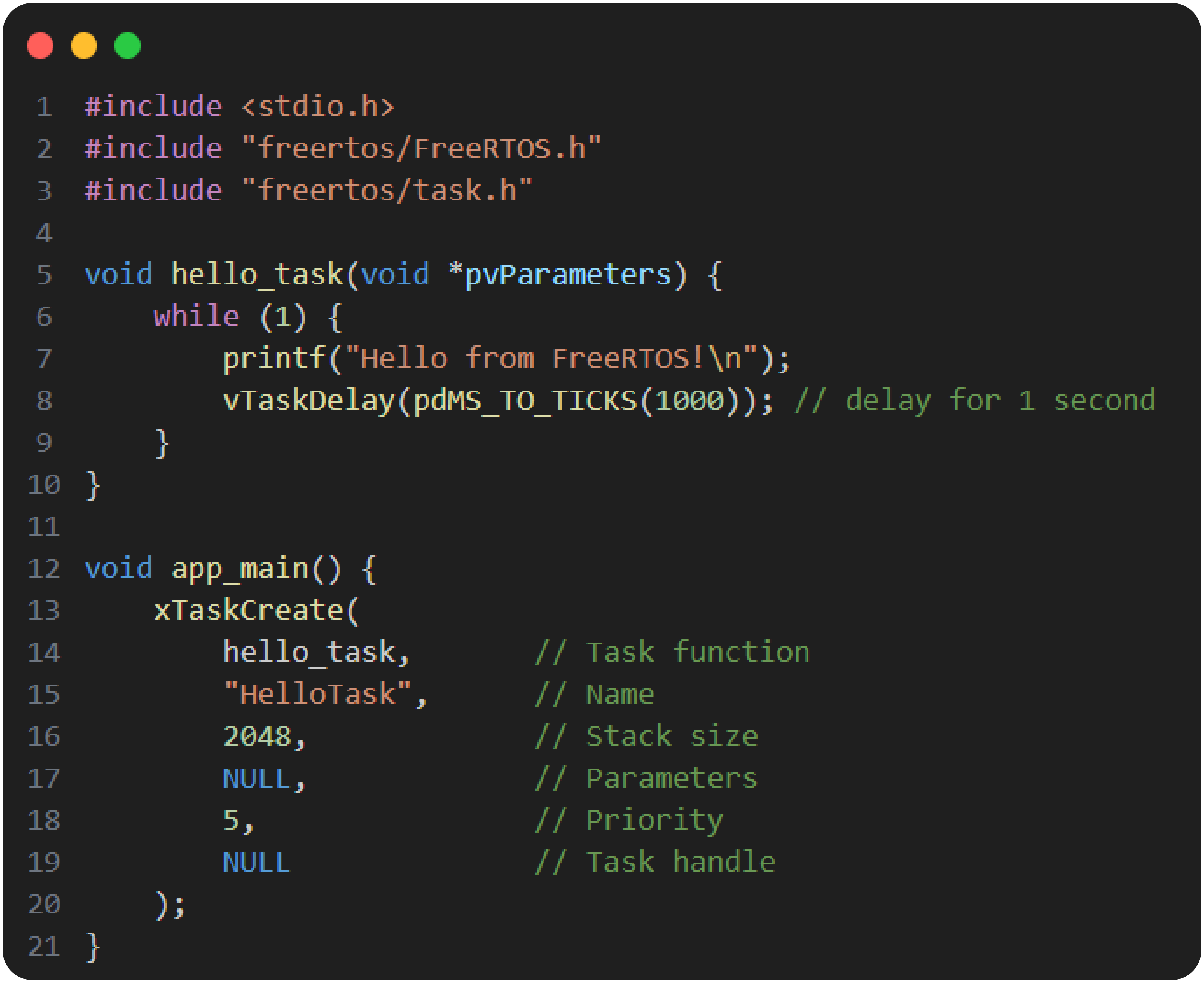
Let’s look at what a simple FreeRTOS task looks like in ESP-IDF.

Code Snippet: Basic Task

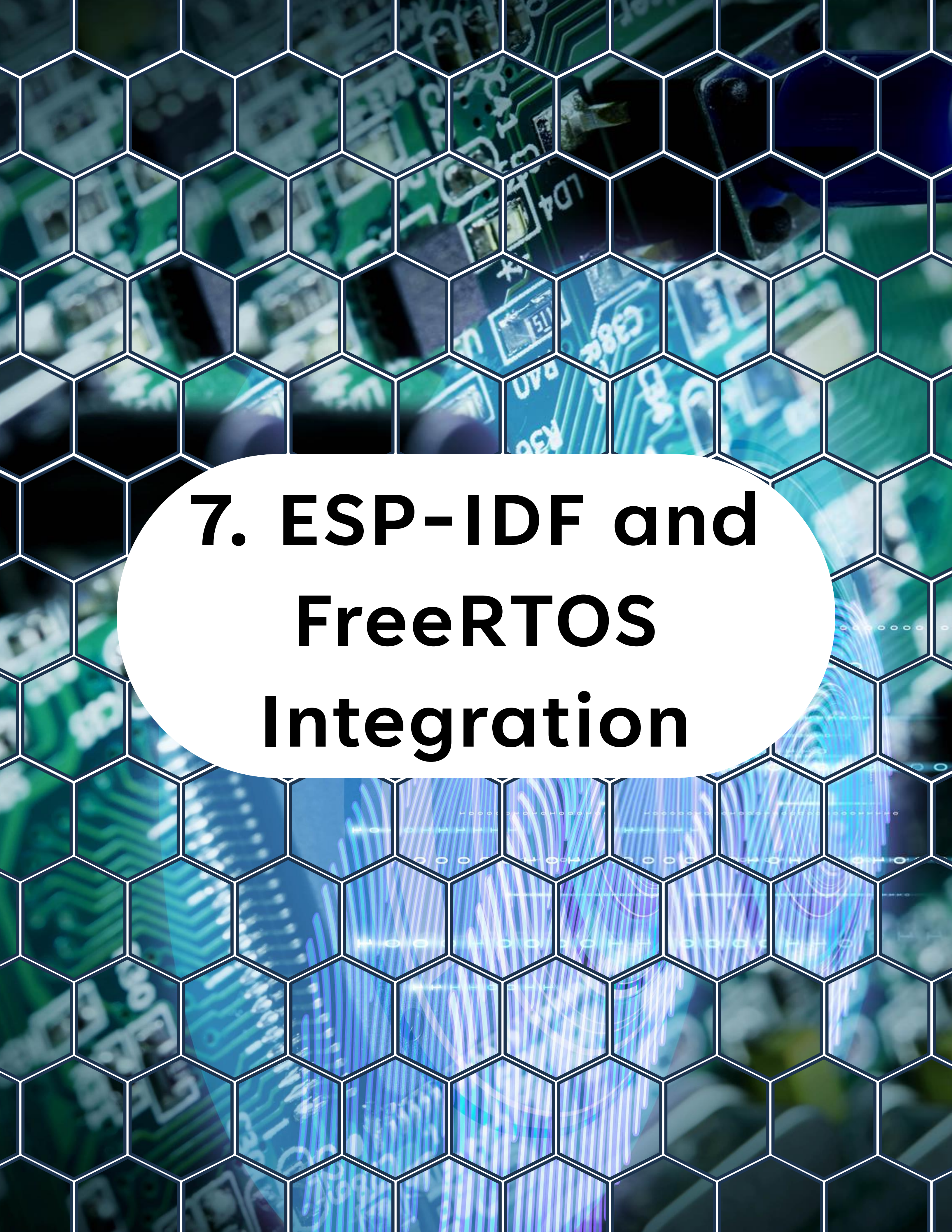


```c
#include <stdio.h>
#include "freertos/FreeRTOS.h"
#include "freertos/task.h"

void hello_task(void *pvParameters) {
    while (1) {
        printf("Hello from FreeRTOS!\n");
        vTaskDelay(pdMS_TO_TICKS(1000)); // delay for 1 second
    }
}

void app_main() {
    xTaskCreate(
        hello_task,       // Task function
        "HelloTask",      // Name
        2048,             // Stack size
        NULL,             // Parameters
        5,                // Priority
        NULL              // Task handle
    );
}
```

6. First Look at a FreeRTOS Task

Explanation:

- xTaskCreate() creates a task.
- The task runs in a loop and prints a message.
- vTaskDelay() pauses the task without blocking others.
- ESP32 handles the scheduling.



7. ESP-IDF and FreeRTOS Integration

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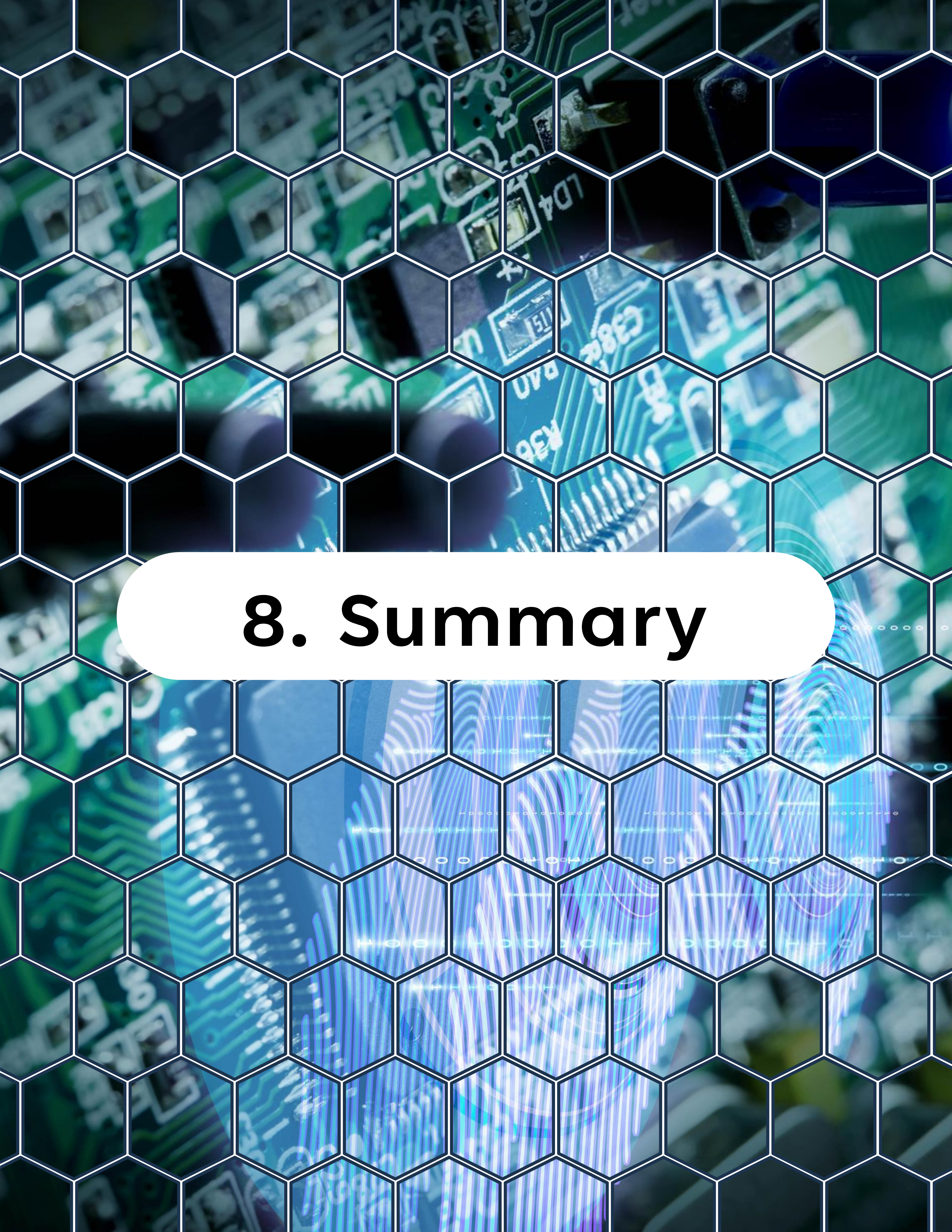
You don’t need to install FreeRTOS separately when using ESP-IDF. It's tightly integrated:

- **Headers available**: freertos/FreeRTOS.h, freertos/task.h, freertos/queue.h, etc.
- **Managed by CMake** in CMakeLists.txt.
- **Configurable via** menuconfig → Component config → FreeRTOS.

8. Summary



8. Summary

Today, you learned:

- What an RTOS is and why FreeRTOS is ideal for embedded systems.
- The basics of FreeRTOS architecture.
- How FreeRTOS is integrated with ESP-IDF.
- What a simple FreeRTOS task looks like.

9. Challenge for Today

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Modify the example task to:

- Blink the onboard LED (GPIO2) every 500ms.
- Use gpio_set_level() to toggle it.

Use the GPIO and FreeRTOS delay functions together.

This will be a warm-up for next day!