

Node System Documentation

T. Buckingham

June 8, 2021

Contents

| | | |
|----------|------------------------|----------|
| 1 | Introduction | 1 |
| 2 | Device | 1 |
| 2.1 | Boards | 2 |
| 2.1.1 | ESP32 | 5 |
| 2.1.2 | ESP8266 | 5 |
| 2.2 | Sensors | 5 |
| 3 | Network | 6 |
| 3.1 | Documenation | 6 |
| 3.2 | HTTP vs MQTT | 6 |
| 3.3 | LoRa | 6 |

1 Introduction

As part of the Engineers without Borders challenge we were tasked with coming up with a solution to a problem that the people of Lobitos and Periditas in Peru, face. Among those described within the document we chose to focus on their water supply; which they have problems with water tapping and sanitisation. Our team's application works in conjuncture with a network of nodes that log data about their respective areas, allowing workers to locate the areas with problems more effectively and reducing the man hours needed to find and fix regularly occurring problems

2 Device

The nodes within the network can work on a plethora of IoT devices all with their benefits and draw backs, a few will be mentioned here however, the key requirements will be network capabilities and data storage connectivity such as an SD card. Systems such as these are

designed to be as cost effective as possible however, this will largely be beyond the scope of this project as the development and documentation will be on development versions of the ESP32 and ESP8266 which provide a much simpler and easier interface but with elements unnecessary to this project.

2.1 Boards

<https://www.espressif.com/en/products/modules> The are a wide range of network orientated boards available all with different benefits, features and costs. The ESP series of boards is among the most popular and as the project was developed on two of these boards (ESP32 and ESP8266) this report will also look at others from the same family. Both boards used in this project were already sourced and were not chosen specifically for it, as such the ESP32 was chosen to be the bridge node due to it's dual core processor and the ESP8266 was chosen to be the logging node for its lower cost.

Table 1: Comparison of key features between ESP models

| | ESP32-C3 | ESP32-S2 | ESP32 | ESP8285 | ESP8266 |
|----------|-------------------------------|-------------------------------|---------------------------|-----------------------------------|-----------------------------------|
| CPU | Single core, 160MHz | Single core, 240MHz | Dual core, 160 or 240 MHz | Single core, 80MHz (up to 160MHz) | Single core, 80MHz (up to 160MHz) |
| RAM | 400KB | 320KB | 520KB | 160KB | 160KB (36KB user) |
| ESP-MESH | Yes | Yes | Yes | Yes | Yes |
| WiFi | 802.11b/g/n | 802.11b/g/n | 802.11b/g/n | 802.11b/g/n (up to 65Mbps) | 802.11b/g/n (up to 65Mbps) |
| SPI | 3 | 4 | 4 | 2 | 2 |
| Security | secure boot, flash encryption | secure boot, flash encryption | secure boot | x | x |

Power Consumption ::

- ESP32-C3

| Work mode | Description | Typ | Unit |
|-----------------------------|--|---------|-------|
| Modem-sleep ^{1, 2} | The CPU is powered on ³ | 160 MHz | 20 mA |
| | | 80 MHz | 15 mA |
| Light-sleep | — | 130 | μA |
| Deep-sleep | RTC timer + RTC memory | 5 | μA |
| Power off | CHIP_PU is set to low level, the chip is powered off | 1 | μA |

- ESP32-S3

| Work mode | Description | Current consumption (Typ) |
|-------------|--|---------------------------|
| Modem-sleep | The CPU is powered on | 240 MHz |
| | | 160 MHz |
| | | Normal speed: 80 MHz |
| Light-sleep | — | 450 μA |
| Deep-sleep | The ULP co-processor is powered on | ULP-FSM |
| | | ULP-RISC-V |
| | ULP sensor-monitored pattern | |
| | RTC timer + RTC memory | |
| | RTC timer only | |
| Power off | CHIP_PU is set to low level, the chip is powered off | |

- ESP32

| Power mode | Description | Power consumption |
|---------------------|--|----------------------------|
| Active (RF working) | Wi-Fi Tx packet 13 dBm ~ 21 dBm | 160 ~ 260 mA |
| | Wi-Fi / BT Tx packet 0 dBm | 120 mA |
| | Wi-Fi / BT Rx and listening | 80 ~ 90 mA |
| | Association sleep pattern (by Light-sleep) | 0.9 mA@DTIM3, 1.2 mA@DTIM1 |
| Modem-sleep | The CPU is powered on. | Max speed: 20 mA |
| | | Normal speed: 5 ~ 10 mA |
| | | Slow speed: 3 mA |
| Light-sleep | - | 0.8 mA |
| Deep-sleep | The ULP co-processor is powered on. | |
| | ULP sensor-monitored pattern | |
| | RTC timer + RTC memory | |
| Hibernation | RTC timer only | |

- ESP8285

| Power Mode | Description | Power Consumption |
|--------------------------|---------------------|----------------------------|
| Active (RF working) | Wi-Fi TX packet | Please refer to Table 5-2. |
| | Wi-Fi RX packet | |
| Modem-sleep ^① | CPU is working | 15 mA |
| Light-sleep ^② | - | 0.9 mA |
| Deep-sleep ^③ | Only RTC is working | 20 uA |
| Shut down | - | 0.5 uA |

- ESP8266

| Power Mode | Description | Power Consumption |
|--------------------------|---------------------|----------------------------|
| Active (RF working) | Wi-Fi TX packet | Please refer to Table 5-2. |
| | Wi-Fi RX packet | |
| Modem-sleep ^① | CPU is working | 15 mA |
| Light-sleep ^② | - | 0.9 mA |
| Deep-sleep ^③ | Only RTC is working | 20 uA |
| Shut down | - | 0.5 uA |

2.1.1 ESP32

2.1.2 ESP8266

2.2 Sensors

- Turbidity
- Total Dissolved Solids (TDS)
- Pressure
- Flow rate
- pH
- Temperature

3 Network

3.1 Documenation

3.2 HTTP vs MQTT

3.3 LoRa