ELEC-H423 – Labs

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1 Introduction

The Internet of Things (IoT) is getting a lot of attention from the IT companies, which pushes the investments for research and development in the academics. Even though the real need for this trend can be discussed, especially in time of ecological pressure and scarcity of resources, the aim of these lab sessions will be to give you a hand-on with the development of IoT setups, which we hope will help you to have a better understanding of the technology. The lab sessions will be organized as a project, and you will be able to work on your own on the tasks, with the lab sessions to help you when you are stuck and to evaluate you.

IoT devices are very versatile, and can be used in many applications, ranging from home automation, to so-called smart factories and cities. In our case, we will use a ESP32 microcontroller, which is the smallest and most affordable device of this kind with a built-in WiFi connection, and we provide you with a handful of sensors to be connected. You will be able to read temperature and humidity, and to light up LEDs using push buttons. On top of that, you will be able to connect the two microcontrollers to a server running on your computer to exchange data.

One of the hottest topic surrounding IoT is the secure IoT, namely the implementation of secured protocols and features on IoT setups. This is important because vulnerabilities of IoT devices, stemming for instance from their computational power constraints, can be exploited by attackers to penetrate an IT system, or to damage the IoT setup itself. Therefore, we will ask you to have a special focus on the security of your construction and to achieve a specific set of security requirements.

This assignment document first focuses on the different features that should be implemented, and then tackles the security aspects of your projects.

2 Expected Features

2.1 Microcontroller

The device provided is a ESP32v4. We advise you to program it using the Arduino IDE, because it has all the tools to help you with the development,

such as the drivers for the different supported devices, the built-in libraries and the ability to upload and flash the software on the microcontrollers. There are many tutorials online showing how to install and configure arduino IDE for ESP32 as well as how to get started with the development on this platform. There is also examples already available in the Arduino IDE. We also provide you with a push button, two LEDs, and a DHT temperature and humidity sensor, as well as 4 resistors per ESP32. The relevant datasheets are to be found in the Teams directory, as well as the schematics of the system.

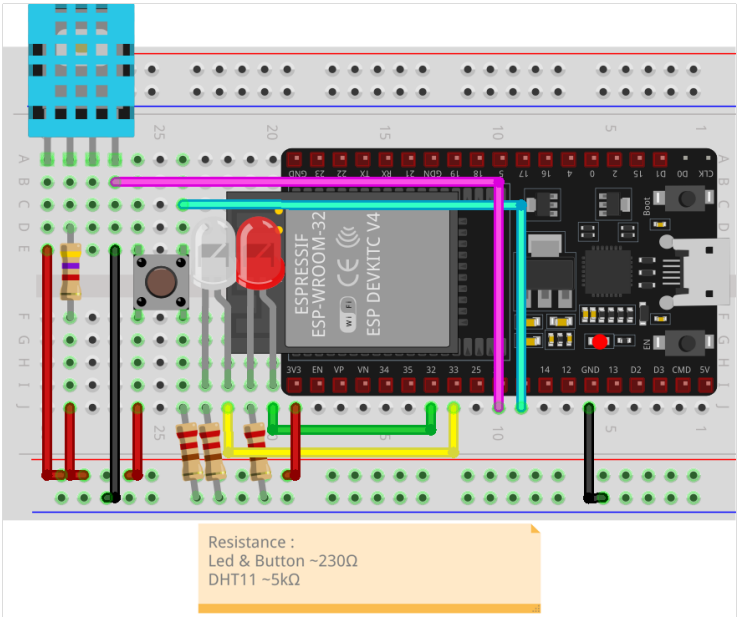

Figure 1: Schematic

You should start with wiring your setup as shown on the schematics, and then you should move on to the implementation of the features. You should build the same setup twice, once for each ESP32, in such a way that they will be able to exchange data, as explained in the next section about the server. For each microcontroller, you should be able to:

- Light up a LED when you click on the push button.
- Collect the temperature and humidity data from the DHT11.
- Have an exchange of data with the server.

Moreover, we want you to be creative and to implement at least one extra feature of your choice that uses the ability of the devices to communicate. You can ask us for additional basic components if needed.

2.2 Server

To gather and display the data from the devices, you will need to use a server running on your computer. We suggest you to use the *publish subscribe* model

for this server, and to implement the Message Queueing Telemetry Transport (MQTT) protocol. You do not have to code it from scratch, there are existing software doing it, and you can use them, as long as you configure them properly.

Formally, we want your server to achieve the following properties:

- Collect and serve data according to the needs of your setup.
- Display the data from the sensors on charts.

3 Security

As explained in the introduction, we want you to design and implement protocols to achieve the following properties:

- Authentication of the data
- Integrity of the data
- Encryption of the data

First, you should theoretically design a security protocol that fulfils the properties. Keep in mind that the ESP32 is limited in terms of computing power, it should help you to decide which kind of security approach you should follow. You can assume that you have a secure channel to exchange keys, if you can provide an explanation on how this could be achieved in an actual setup.

4 Lab sessions practical information

The project is divided in two milestones, the first one about the implementation of the features, the second one concerned with the security. You will have one lab session per week (2h), which is not mandatory, but every three lab session, you will be evaluated on a milestone, which IS mandatory. It will be a discussion during which you will demonstrate that your setup behaves as expected, and you will explain what you did and how you did it.

The schedule of the labs can be found on the Teams directory. If you cannot attend the lab sessions, you can contact us, either with a concrete question, or to schedule an appointment with us. If you send us a message for help, please provide us with relevant debugging information, like screenshots or logs.