ELEC-H423 – Labs

October 29, 2024

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.

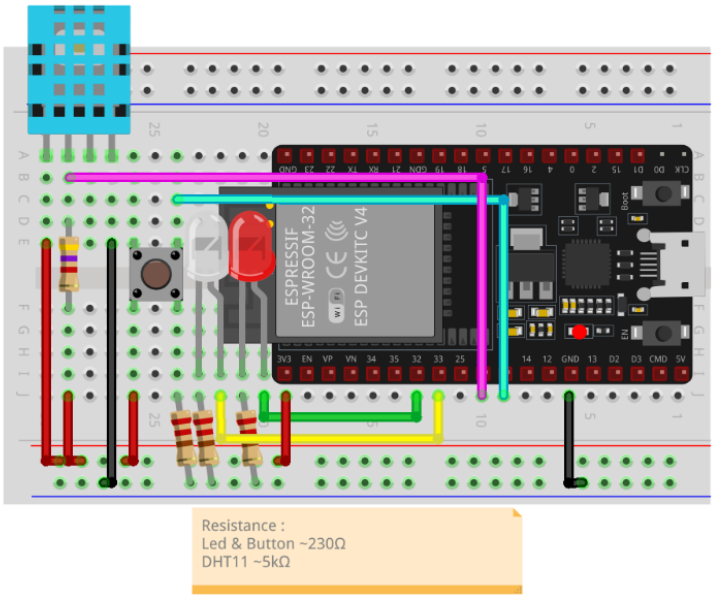

Figure 1: Schematic

You should start with wiring your setup as shown on the schematics (be careful, theses component typically does not have any electrical protection and you can easily damage them by wiring them incorrectly). Then you should move on to the implementation of the features describe below. 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 by yourself and implement protocols to achieve the following properties:

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

Keep in mind that the ESP32 is limited in terms of computing power. Have a look at the documentation to understand what are the available operations on this platform, and design the protocols using those as building block. It should help you to decide which kind of security approach you should follow. Keep the protocols as simple as possible.

You can assume that a keys exchange is already done, but only if you provide an explanation on how this could be done in reality for this context. Paid attention on how the keys can be store. Once again, have a look at what are the options offered by the platform (WARNING: make sure that you do not permanently alter the state of the device in any way during this step).

Try to be inventive, do not try to mimic existing protocols that may not be relevant in the context of IoT system. You can use additional assumptions as long as you provide a justification.

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 explain your choices (no need for report/slide or preparation of any kind).

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.

5 Evaluation

The project will be evaluated at the end of the semester (before the exam period) by two part:

Report
You will need to write a quick summary of your work (less than 10 pages) where you explain how you designed the protocols and the different features. If you used some assumptions, explain why are they valid in this context. Highlight any additional features or choices specific to your implementation. Do not include codes or computation, only focus on the key aspect of your project.

Demonstration
Similarly to the two milestones, we will have a final discussion (about 10 minutes) where you will be able to show us to operation of the device in practice and we will ask you some question. One again, put in highlight any aspect that you are proud of. You can used diagram or figure from you report if you need visual support to explain the protocols. There is no need for presentation slides.

6 Contact

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