ARC Machine Monitoring System

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1. Introduction

1.1 Problem

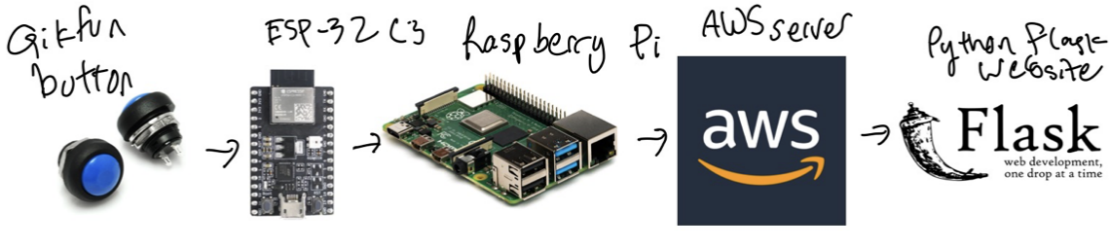
One question that is always on a college student's mind is: "Is the ARC busy?". There have been many times throughout our college career where we have gone to the ARC expecting a quick workout just to see lines to the machines we wanted to use. We've always wished that we could see what machines were being used and what were not. To combat this, we would like to create an interface where students can use their phone to visually see which equipment at the ARC are being used and which are not.

1.2 Solution

We would like to create an interface where students can use their phone to visually see which equipment at the ARC are being used and which are not. This way, students can anticipate whether or not they should go to the ARC. At a high level, there would be a button by the equipment being used. The button, upon being pressed by the user when a machine is being used, would then send a signal to an IoT device which would then send a signal to an AWS server. Our website will then use this server to update a UI which users can utilize to see which machine is being used.

1.3 Visual Aid

The diagram below depicts the full process of how our system works. First, a user will press a button on an ARC machine. Then, the System on Chip (ESP-32) on the PCB will wirelessly communicate the machines used to a Raspberry Pi. This Pi will then send this information to AWS, where our website will get information about whether or not a machine is in use. The UI will then depict to a viewer that a machine is in use.



1.4 High level requirements list

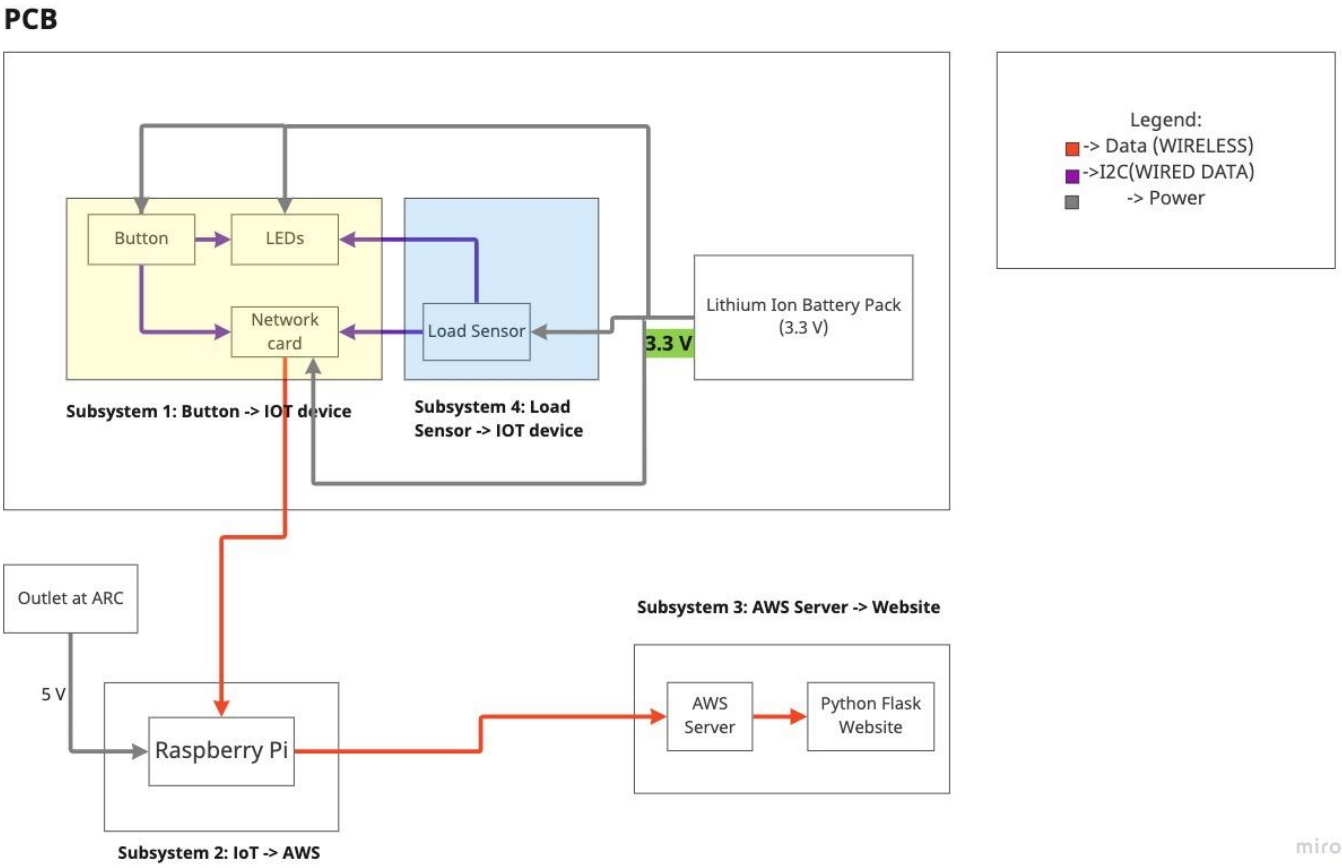
Battery Life: PCB should be able to last for multiple hours without a direct power source.

Multiple Machines Serviced: Our system will be able to support up to 5 machines being used.

Website Access: Multiple people will be able to access the website at one time

2. Design

2.1 Block diagram:



2.2 Subsystem Overview:

2.2.1 Subsystem 1 (Button to IoT device)

In order to detect whether or not a machine is in use, we would like to create a PCB with the following components: a button that will be pressed whenever a machine is being

used, an esp32 system on chip, and a led of different colors to indicate that a machine is being used. We will use the MQTT network protocol to communicate between the esp32 on our PCB and the Raspberry Pi. Information on machine status will be shared via the MQTT protocol to the Raspberry Pi. The Raspberry Pi will also receive information from our website that will then be communicated to the PCB. Once the button is pressed, the led on our PCB will also light up to signify the machine is in use. In order to power this subsystem, we will have disposable external lithium ion batteries, on a battery pack. These batteries can be easily replaced. In order for this subsystem to act in accordance with our high level requirements, our IoT device should be able to handle the communication of multiple machine sensor pcbs at once. Also, this subsystem should be able to last multiple hours with a single 3V lithium ion battery.

2.2.2 Subsystem 2 (IoT device to AWS Server)

This server will host all information on which machine is being used. In order to send data to the AWS cloud, we will install AWS IoT Device SDK onto our Raspberry Pi 3 Model B. All machine information that is sent to the Pi will be sent to the AWS cloud. Ultimately, the Raspberry Pi will act as a gateway of communication between all ARC machine sensors to the AWS server. Ideally, the ARC would only need one Raspberry in order to send ARC machine sensors information to AWS. Because of this, in order to charge the Raspberry Pi, we will just plug it into a free outlet at the ARC.

2.2.3 Subsystem 3 (AWS Server to website)

The website we will design will keep track and display what machines at the ARC are being used by using the AWS server configured in Subsystem 2. We will have the feature of push notifications on our website. If a student wants to be alerted that a machine is available, they can provide their email address and will be contacted when a machine is not in use. This website will be configured using the Python framework Flask. In order to act in accordance with our high level requirements, multiple users should be able to use our website without any issues.

2.2.4 Subsystem 4 (load sensor to IoT device)

If there is time in the project, we would like to attach a load or motion sensors in order to detect use of the equipment that occurred without pressing the button. This would allow our website to be changed if a person forgot to press the button. We would like to include a fail safe in order to provide the most accurate information to students. The load sensor will be on the PCB, and, thus, will be powered by the lithium battery.

2.3 Tolerance Requirements

2.3.1 Subsystem 1 (Button to IoT device)

One facet of this subsystem we will need to account for is placement of our PCB. Though we plan on implementing a weight sensor in order to detect usage of ARC equipment without the button being pressed, ideally, the button will be primarily used to indicate that

a machine is in use. For this reason, we will be testing out different locations to place our PCB, so a person at the ARC can easily locate and press the button.

Another facet of this subsystem we will need to account for is battery usage and consumption. Since datasheets may not contain accurate information about the product in use, we will need to test each component separately to ensure that we know the appropriate operating conditions to work within.

The biggest facet of this subsystem we will need to account for is how long the entire subsystem will last with an external, disposable lithium battery. Because of this, we will complete the appropriate calculations in order to maximize battery life.

Finally, the last facet of this subsystem we will need to account for is handling traffic of multiple sensors on the network. Since, multiple sensors will be communicating to the IoT device, the device must be able to differentiate between each sensor and adapt accordingly.

2.3.2 Subsystem 2 (IoT device to AWS Server)

Similarly, to Subsystem 1, the biggest facet of difficulty within this subsystem is managing the packets sent between the AWS Server and IoT Device. We need to ensure that machine information details remain intact during the communication of IoT devices and AWS servers.

2.3.3 Subsystem 3 (AWS Server to website)

The goal of the website is to provide a visually appealing interface that students can look upon to view whether or not their favorite machines are being used. We will spend ample time going through multiple designs for the front end of our website and asking our fellow students whether or not they find the website visually appealing. Initially, we would like to alert students that their machine of interest is free to be used via email notification. But, we will also survey students to see how they would prefer being notified.

2.3.4 Subsystem 4 (load sensor to IoT device)

The primary function of the load sensor is to detect use of the equipment without the button being pressed. Because of this, it needs to be in proximity to where the weights will be moved on the exercise equipment. We will need to design the PCB in a way to optimize the use of the load sensor while keeping its location in a convenient location for a student to press the button. We will test multiple different types of load sensors as well as PCB design with these constraints in mind.

3. Ethics and Safety

There are a couple ethics and safety issues that our project is facing. We will make sure that nothing in the code of ethics is breached, and that the safety of the user is the utmost priority of the project.

The first ethical issue is the data collection that is performed whenever someone presses the button to modify the machine availability. In order to make sure there are no breaches in privacy, we will not be implementing an account system such that no personal information will be tracked, nor will patterns be able to be perceived and logged. The only use we currently have in mind for our project is for people to be able to see whether or not the gym is busy regardless of who is utilizing the machines.

The other ethical issue is regarding the email notification function of our website. In order to protect our user's data, we will only be using it for notification purposes, and will make sure the user knows the implications of submitting their email information.

Furthermore, we also have a safety issue due to utilizing a battery. In order to prevent any possible hazards, we will make sure to keep the PCB casing organized, and safely use the batteries within the safe operating range.

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