

# ECE 445, Senior Design

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## **Secure Smart Locker for Doorstep Delivery**

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# 1. Introduction

## 1.1 Objective:

Package theft is a real issue that several of our group's members have dealt with personally. You might receive a delivery notification from USPS or Amazon only to find that the box has disappeared within the hour it took for you to retrieve it. This is especially frustrating because there isn't much that delivery service providers can do about the issue if you didn't purchase insurance.

Our solution is to design a secure smart locker to be placed on one's doorstep. Delivery drivers will scan a temporary QR code using a reader mounted to the locker, upon which the door will open. Once the package is placed inside and the door is closed, the locker will use the owner's WiFi to notify him/her of the delivery. Both the owner and the delivery person will interact with the locker using a mobile app that we develop. The locker will also function in the reverse direction, allowing one to stage packages for pickup.

## 1.2 Background:

The current global pandemic has moved many people's shopping habits online as e-tailing is much safer than retailing. Digital Commerce 360 put together a good analysis of data released by the US Department of Commerce, which indicates that online spending over the first 6 months of 2020 is up over 30% from the same period in 2019 [1]. The result is many more packages sitting idle on doorsteps, vulnerable to package thieves. Your best bet is to order to something like an Amazon Locker or P.O. Box, but those add a layer of inconvenience to "home" delivery and are essentially just as COVID-risky as retail is. Our solution intends to keep home delivery easy and safe.

## 1.3 Physical Design:

Our locker will have a rectangular footprint sized roughly 14"x16", and will be 2-3 feet tall. We want the longest dimension of our locker to be height, so as to take up the least amount of space on one's doorstep. Both the QR reader and camera will be mounted to the locker's exterior, while the electronics will be housed in a compartment inside the locker. This container will be at least IP 65 rated, protecting the electronics from low-pressure water jets and dust, so as to withstand the elements.

#### 1.4 High-level Requirements List:

- ❖ Our locker should use a QR code reader to scan a QR code presented on our mobile app in order to unlock the container.
- ❖ Our locker should use a speaker to give an audible indicator when the door is left open, and also double as an alarm when the locker is unplugged from the wall or when the motion sensor detects malicious activity.
- ❖ Our solution should include a mobile app that allows the owner to remotely unlock the container and receive delivery/pickup notifications.

## 2. Design

### 2.1 Block Diagram:

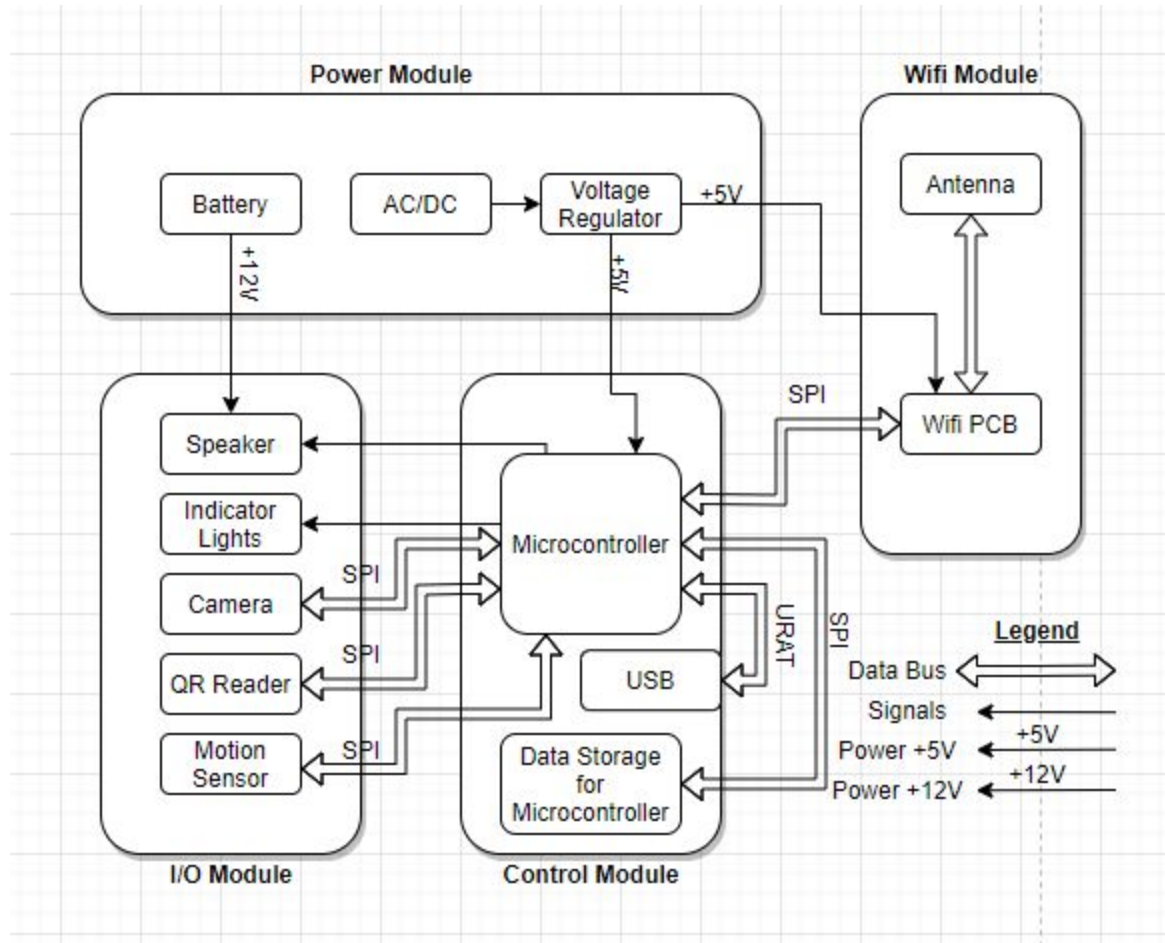


Figure 1: Block diagram of our project

Figure 1 shows our system design diagram that will contain four major modules. The Wifi module, the Power module, the I/O Module and the Control module. This will satisfy the high level requirements in terms of having camera hardware for reading a QR code, having a way to alert others from an intruder with a motion sensor and alarm, and having an internet connection to control via a smart device. Our design is very accessible and lucrative.

## 2.2 Functional Overview:

- ❖ Wifi Module
  - Antenna: We will need an Antenna for the Wifi Module. The antenna will be used as a transceiver for the communication between our microcontroller and the owner's home Wifi, allowing our mobile app to interact with the locker.
  - Wifi PCB: We will buy a Wifi PCB that will connect to our main board and communicate using SPI. Depending on our product choice this PCB might have an integrated antenna as one Wifi module PCB.
- ❖ Control Module
  - Microcontroller PCB: The microcontroller PCB will contain the microcontroller IC, capacitors, resistors, crystal oscillator, JTAG connector for programming, and power protection/conversion. The microcontroller will contain software for communication with our IO, and will send and receive information via the Wifi PCB module, probably using SPI communication.
- ❖ IO Module
  - QR Reader: The QR Reader will read the QR code presented on the mobile app. It will transfer the information to the microcontroller to allow access to the locker door.
  - Camera: The camera will be used for two purposes in security. First, the camera will be used as taking pictures of an individual when they come close to the box and try to open the box without approval. Second, it will be used to scan a QR code to access the box. It will use Wifi to send data to the user's phone for delivery/pickup notifications .
  - Motion Sensor: The motion sensor is to be used for security. If there is motion that is deemed "unnatural" by our system, then it will turn on the alarm and inform the owner of potential criminal activity. It sends its data to the microcontroller which will interpret the detected activity.
  - Speaker: First, the speaker will be used as an alarm if the motion sensor detects something unusual by the motion sensor. Second, if the AC/DC connection to our microcontroller is disconnected then it will create a relayed connection from an external battery, not needed to be powered by a microcontroller. This battery will sound the alarm to make any attempt to steal the locker as loud as possible. Third, it will also be used to beep when the door opens to remind delivery people to close it.
  - Lights: The indicator lights will be used as an indication for when the door of the box is locked or unlocked. There will also be an intermediate light. The green light indicates the locker is ready to open. The red light indicates the box is locked. The blue light will be for any mechanical problems, or for the box sensor and alarm being tripped.

- ❖ Power Module
  - Battery: Battery will be an external 12 V battery. It is separate from the wall AC/DC power and will power the speaker and the blue indicator light. The speaker and blue light will be used as an alarm for criminal activity. We can also use it to power other I/O devices if necessary. The battery should be accessible from the locker interior so the owner can easily remove it if they plan to unplug the locker themselves and don't want the alarm to sound.
  - AC/DC: This will be simply the wall/outlet plug in. It will be able to convert from Alternating Current to Direct Current. It will feed into the microcontroller PCB for power protection and down conversion.
  - Voltage Regulator: The voltage regulator will be placed on the microcontroller PCB and will be used to protect from overvoltage, overcurrent, or reverse voltage inputs. The output of the power protector will then convert our 12V to any other required power (5V, 2.2V, etc.).

### 2.3 Block (Subsystem) Requirements:

- ❖ Wifi Module: This module must be able to receive sufficient information from propagating signals into the Antenna. It will then convert the signals to discrete signals through the Wifi PCB and be able to read the information by microcontroller. The Wifi PCB must be small, sustainable against heat, and contain the crucial part of the interface.
- ❖ IO Module: The I/O module will consist of the Speaker, Indicator Lights, Camera, QR Code Reader, and Motion Sensor. We must make sure Speaker is loud enough to alarm an individual. Indicator lights must be visible during daylight and nighttime. The Camera should be about 720p quality and resistant against any damage. The QR Code Reader should be able to read the QR code with no lag or trouble. The Motion sensor must be small enough to fit easily in our locker but yet still cover a large range of motion.
- ❖ Control Module: The microcontroller must be designed on a PCB and required to have UART for connection with USB and JTAG for other I/O devices and be able to program with C/C++. It must have a power input of +5V. It should have internal storage for our code and easy access to a computer/desktop.
- ❖ Power Module: The Power module should be able to provide consistent power in two forms. First, the 12 V battery for the speaker and blue light LED. Second, the AC/DC voltage provides power for the microcontroller. Without a power module it will not be able to do anything.

## **2.4 Risk Analysis:**

Challenge: One of the major challenges that we will face is since the members in this team project do not have enough experience for programming or designing using a microcontroller, there can be many barracades. There can be time management issues, creativity in designing good algorithms, or even getting the hardware to correspond with the software. The best way we can adapt and face this challenge is to do research beforehand on the fundamental concepts using a microcontroller.

Challenge 2: One additional challenge the team will face is to design a mobile application that can read the QR code and access the locker based on a match QR code. This will become much more difficult as the days come closer to finalize the project.

### 3. Ethics and Safety

We will take the utmost care in complying with the ethics and safety standards that IEEE and ACM have laid out. To comply with the ethics and safety standards, this project will be of a high quality, and the processes and products will derive from high-quality professional work in accordance with the ACM “Professional Responsibilities” section 2.2. Our team and its individuals will take “personal and group responsibility for acquiring and maintaining professional competence” [2].

Privacy is a very critical detail to keep in mind for any project. Our project will comply with the privacy of the delivery service, by using the camera footage only to ensure that the box is not being tampered with, and the photographs taken by the camera are only retained until the owner of the product removes the delivered item, thus, only using the data for “legitimate ends and without violating the rights of individuals and groups”. Additionally, it will be communicated to the delivery service that they may be the subjects of our camera footage. This adheres to the ACM guidelines in the section on respecting privacy, section 1.6 [2].

Power from the battery could potentially cause a safety hazard, if care is not taken. The project will comply with the safety standards concerning the power from the battery. The Lithium Ion battery must never be charged or kept in extreme temperatures (below 32° F or above 130° F), or it may be damaged or even explode [3]. Utmost care will be taken during this project to ensure that the batteries are properly inspected and in good condition to be used, thus adhering to the IEEE code of ethics stating “to hold paramount the safety, health, and welfare of the public” [4].

Finally, the project will ensure that the QR code generated by the app will be local to the user’s phone, and that the information will not be divulged anywhere else other than to the delivery service. Additionally, the QR code will be randomized for every new delivery, and confidentially stored in the user’s app storage. This will adhere to the ACM standards on confidentiality, which state that “the nature or contents of that information should not be disclosed”, according to the ACM guidelines in the section on respecting privacy, section 1.7 [2]



## 4. References

- [1] A. Berthene, "Online merchants gain an extra \$107 billion in 2020 thanks to pandemic", *Digital Commerce 360*, 2020. [Online]. Available: <https://www.digitalcommerce360.com/article/coronavirus-impact-online-retail/>. [Accessed: 17- Sep- 2020]
- [2] "ACM Code of Ethics and Professional Conduct", acm.org, 2020. [Online]. Available: <https://www.acm.org/code-of-ethics>. [Accessed: 17- Sep- 2020].
- [3] "Safety and Health Information Bulletins | Preventing Fire and/or Explosion Injury from Small and Wearable Lithium Battery Powered Devices | Occupational Safety and Health Administration", Osha.gov, 2020. [Online]. Available: <https://www.osha.gov/dts/shib/shib011819.html>. [Accessed: 17- Sep- 2020].
- [4] "IEEE Code of Ethics", ieee.org, 2020. [Online]. Available: <https://www.ieee.org/about/corporate/governance/p7-8.html>. [Accessed: 17- Sep- 2020].