# 1. Introduction

## 1.1 Problem:

Mail is one of the biggest forms of communication in today's world and sees the transfer of sensitive information such as bank statements and checks to millions of households throughout the nation. While apartment buildings have keys which are only possessed by a mailman and tenant that unlocks a unit's mailbox, many single family and townhomes have a conventional mailbox which can be easily opened by anyone. This means that millions of Americans do not have any means of securely storing their mail as they often do not pick their mail up immediately, leaving mail unprotected and easily stolen for long periods of time. As seen in the WFMY local news article, checks in the mail are frequently stolen and authorities warn citizens to not leave sensitive material in mailboxes overnight and instead hand them directly to the mail carrier. Currently, electronically locking boxes exist which let packages be stored outside of your door securely, but a similar solution does not exist for mail that is both secure and can be mounted in place of an existing mailbox.

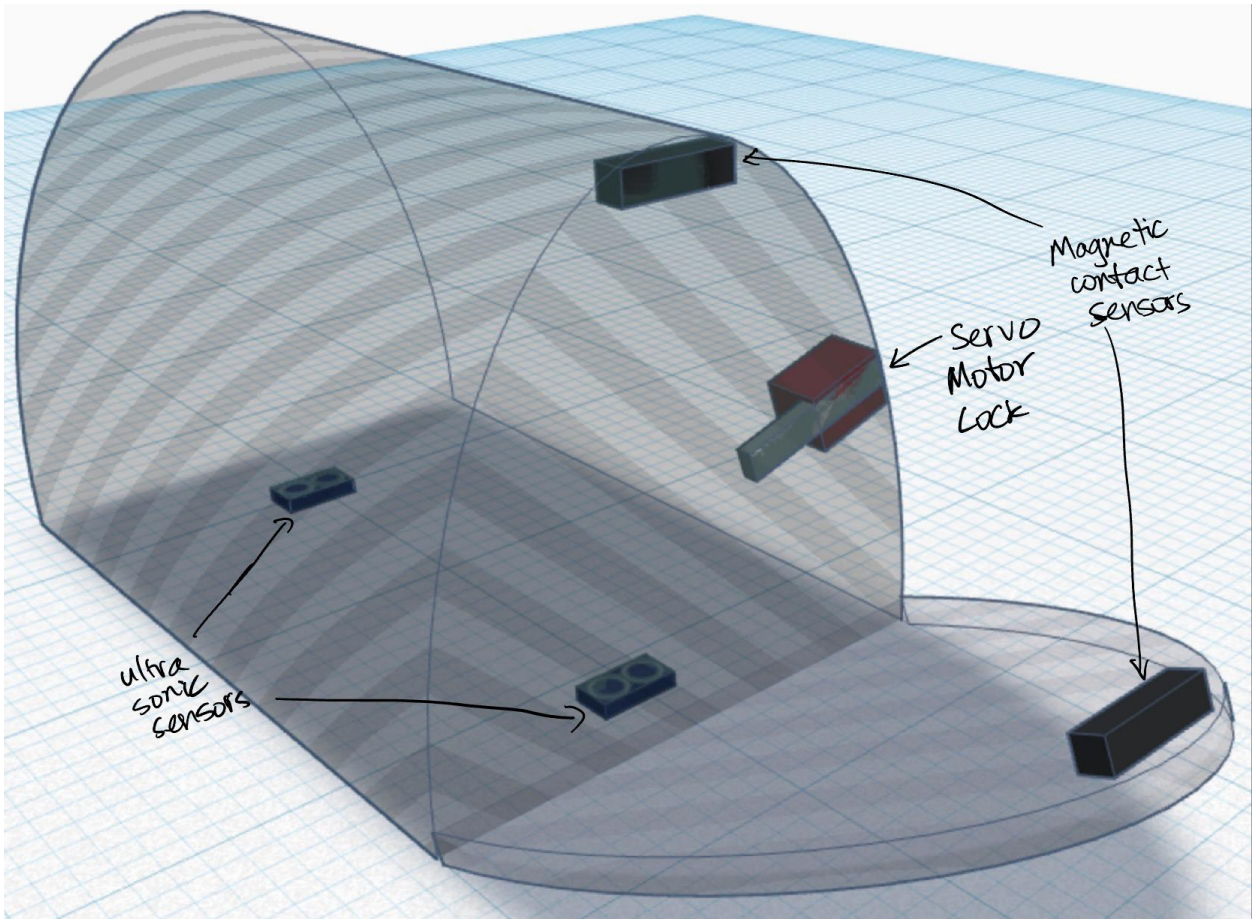
https://www.wfmynews2.com/article/news/local/2-wants-to-know/stop-putting-checks-in-your-mailbox-thieves-steal-checks-wash-change-amount-cash-dont-put-mail-in-blue-usps-mailboxes-overnight-post-office/83-fc6b3146-5565-4a32-8a58-e22b2bab835d

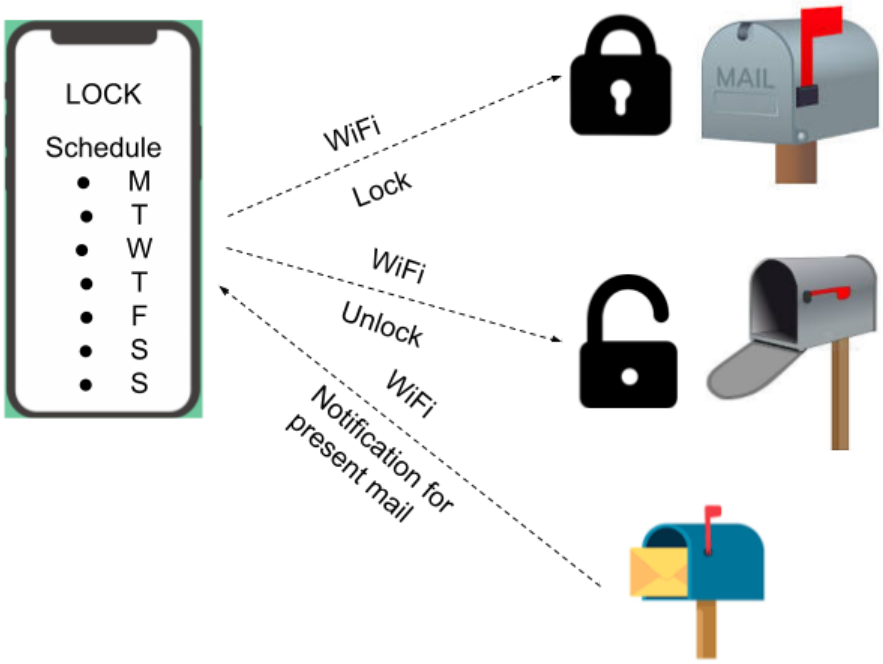
## 1.2 Solution:

Our solution is to create a mailbox that will have two primary features. The first feature will be the ability to automatically lock once mail is placed inside of it. The second feature allows the user to schedule a time period for the mailbox to remain unlocked in the case of multiple deliveries happening throughout the course of a day. Any time the mailbox is opened, closed, or mail is placed inside the mailbox the user will be notified. These notifications will be sent to the user via a mobile application. Additionally this mobile application will allow the user to interact with the mailbox. In the application the user will be able to manually unlock/lock the mailbox and set a schedule for the mailbox to remain unlocked. If there is no schedule set, the mailbox will act under the assumption that only one mail delivery will occur that day and will lock after mail is placed into the mailbox for the first time and the door is closed.

When it comes to the implementation, the mailbox will use a magnetic contact sensor to determine when the mailbox is opened and then send a signal to the PCB that sets a ready state and waits for the close signal. Once the door is closed, the magnetic contact sensor will send another signal to the PCB which in turn instructs the lock to close. The PCB will also interface with the mobile application, via a wireless module, which will send unlock and lock signals to the PCB to control the actions of the locking mechanism. This system will also be used for unlocking the mailbox during a scheduled window which can be controlled in the app. In order to notify the user if mail is present in the mailbox, multiple ultrasonic sensors will be used to detect if mail is covering any one of them. This information will be sent back to the PCB and then be sent to the mobile application to alert the user of mail. A small, low powered, motor will be used to lock and unlock the mailbox. It will be attached to a metal extension to secure the lock.

## 1.3 Visual Aid:





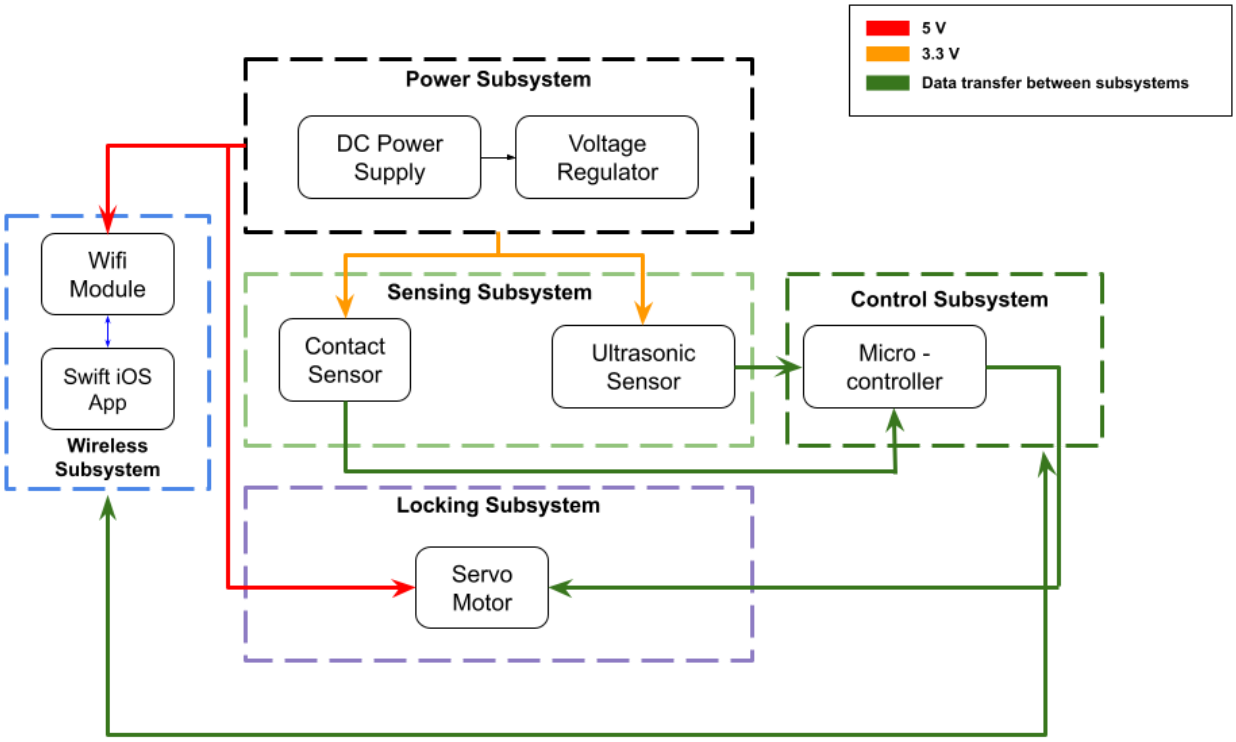

### 1.4 High-level Requirements List:

For our project to be successful, we will implement these requirements:

1. The mailbox must automatically lock within 10 seconds of the door being closed if mail is placed inside and there is no schedule set to leave it unlocked.
2. The mailbox must lock and unlock within 5 seconds of pressing the corresponding button on the application.
3. The mailbox must send a notification within 30 seconds of an action being made on the mailbox. This includes opening and closing the mailbox as well as whether mail is present.

## 2. Design

### 2.1 Block Diagram:




1. **Physical Design (if applicable):**
   A physical diagram of the project indicating things such as mechanical dimensions or placement of sensors and actuators. The physical diagram should also be accompanied by a brief one paragraph description.
2. **[Subsystem X]**
   For each subsystem in your block diagram, you should include a highly detailed and quantitative block description. Each description must include a statement indicating how the block contributes to the overall design dictated by the high-level requirements. Any and all design decisions must be clearly justified. Any interfaces with other blocks must be defined clearly and quantitatively.
   Include any relevant supporting figures and data in order to clearly illustrate and justify the design. Typically a well justified block design will include some or all of the following items: Circuit schematics, simulations, calculations, measurements, flow charts, mechanical diagrams (e.g. CAD drawings, only necessary for mechanical components).
   You must include a **Requirements and Verifications** table. Please see

the R&V page for guidance on writing requirements and verification procedures.

3. **[Subsystem Y]**
   ...
4. **[Subsystem Z]**
   ...
5. **Tolerance Analysis:** Through discussions with your TA, identify the block or interface critical to the success of your project that poses the most challenging requirement. Analyze it mathematically and show that it can be feasibly implemented and meet its requirements. See the Tolerance Analysis guide for further guidance.

2. **Cost and Schedule**

   1. **Cost Analysis:** Include a cost analysis of the project by following the outline below. Include a list of any non-standard parts, lab equipment, shop services, etc., which will be needed with an estimated cost for each.
      - Labor: (For each partner in the project)
        Assume a reasonable salary
        ($/hour) x 2.5 x hours to complete = TOTAL
        Then total labor for all partners. It's a good idea to do some research into what a graduate from ECE at Illinois might typically make.
      - Parts: Include a table listing all parts (description, manufacturer, part #, quantity and cost) and quoted machine shop labor hours that will be needed to complete the project.
      - Sum of costs into a grand total
   2. **Schedule:**
      Include a time-table showing when each step in the expected sequence of design and construction work will be completed (general, by week), and how the tasks will be shared between the team members. (i.e. Select architecture, Design this, Design that, Buy parts, Assemble this, Assemble that, Prepare mock-up, Integrate prototype, Refine prototype, Test integrated system).

3. **Discussion of Ethics and Safety:**

   1. Expand upon the ethical and safety issues raised in your proposal to ensure they are comprehensive. Add any ethical and safety concerns that arose since your proposal.
   2. Document procedures to mitigate the safety concerns of your project. For example, include a lab safety document for batteries, human/animal interfaces, aerial devices, high-power, chemicals, etc. Justify that your

design decisions sufficiently protect both users and developers from unsafe conditions caused by your project.
Projects dealing with flying vehicles, high voltage, or other high risk factors, will be required to produce a Safety Manual and demonstrate compliance with the safety manual at the time of demo.

4. **Citations:**

   Any material obtained from websites, books, journal articles, or other sources not originally generated by the project team **must be appropriately attributed with properly cited sources** in a standardized style such as IEEE, ACM, APA, or MLA.