

Group 4 - Secure Access Locking System with NFC and Biometrics

Requirements Specifications

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1. Overview

Purpose:

Many people today take security for granted and do not realize how much it improves their quality of life. Through the Secure Access Locking System with NFC and Biometrics device, users will have an intuitive yet simple way to protect all of their valuables. Users can unlock the device through a variety of methods such as a fingerprint sensor and NFC card reader. The device will be enhanced further by adding an LCD screen to better inform users on the current status of the device such as if it is currently locked, unlocked, and which user(s) have accessed it, and a web application that will provide detailed instructions on how to use the device and include a function to add more users so they can gain access to the device. A physical key switch may be added to act as a failsafe should other methods fail to work at any point and to cater to users who prefer a more traditional method of locking and unlocking.

Objective:

The Secure Access Locking System with NFC and Biometrics device aims to improve people's quality of life and security by offering an intuitive and easy to use device to protect all of their valuables. Adding an LCD screen will improve the device's ease of use as it will give useful messages such as the current status of the lock and when it is unlocked or locked. In addition, a physical keyswitch will act as a failsafe should other methods of unlocking cease functioning and offers a more traditional method of unlocking should a user prefer it over other methods. Along with quality of life and security, the system addresses AI for Social Good (AI4SG) in many ways. An AI learning model will be trained as users continuously use the lock. With enough data, the AI model will be able to preemptively prompt the user to lock or unlock the device. As the model perfects each user's schedule, their quality of life will further be improved as the device can be managed more passively.

2. Statement of the Problem

Design Needs:

- Lock unlocks when using fingerprint sensor, NFC card reader, physical key, or smartphone
- Physical keyswitch to act as failsafe
- Web application with instructions on how to use lock
 - Add additional users to use lock (additional fingerprints, NFC cards, etc.)
- LCD screen to give user(s) latest status on lock (i.e. currently locked/unlocked, invalid fingerprint/NFC card, etc.)

Expected Benefits:

- Boosted security
- Improves quality of life
- Increased ease of use through additions of LCD screen and web application

Key Considerations:

- Creation of PCB board with schematic
- Have all methods of unlocking working together within one Python file
- Physical key working independently from other unlocking methods and Raspberry Pi
- Creating and connecting web application with unlocking methods

3. Operational Description

- Features:
 - The project offers a range of unlocking methods. You can unlock the door remotely via the web app, with the included NFC keycard, or using the built-in fingerprint scanner, which will be located above the door handle. Lastly, as a safety measure, the lock comes with a physical key, which will be at the base of the door handle.
- User Manual:
 - For this section of documentation, we will briefly go over the initial setup of pairing your lock with your mobile device, connecting the lock to Wi-Fi, and adding your fingerprint(s). The very first time you open the app, it will prompt you to create a new account. This can be done using Google Login or by email and password. After registering and logging in successfully, the app will walk you through connecting the lock to your Wi-Fi network, which enables remote unlocking. The last step in setting up is to add a fingerprint. As of now, the amount of fingerprints that will be able to store has not been determined yet.
- User Interface:
 - Our app is designed to be user friendly and supported on both iOS, Android, and on any laptop/PC as it is a web application. The web app is developed using React and styled by Tailwind CSS. The design of the app is UX focused and easy to navigate. The primary screens are the Login Screen and the Main Screen. The most visible item, and main feature on the Main Screen, is a large button that will enable remote unlocking. Another key feature in the app is the hamburger button in the top left corner, which shows options for Device Info, Account Settings, adding or deleting fingerprints, and options related to NFC authentication.

4. Requirements Specification

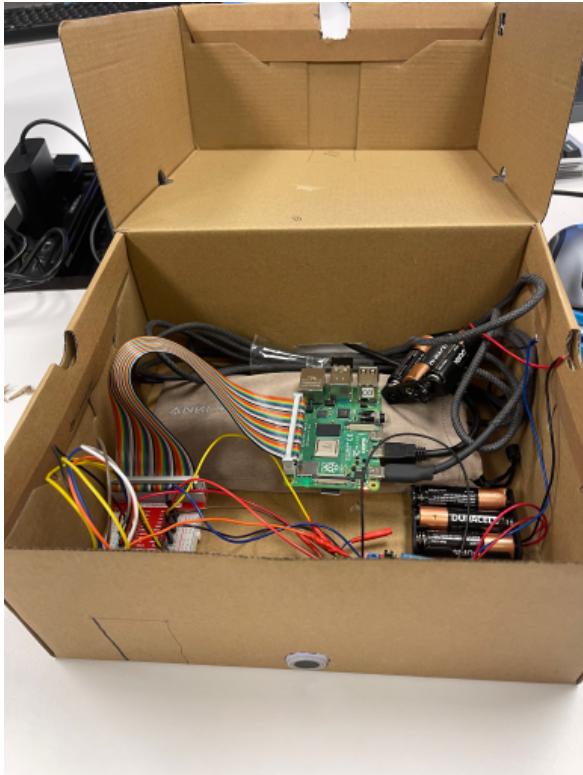
- Power Source:
 - 6 AA batteries OR USB Power Bank
 - In case of power loss or battery depletion, a manual key entry will serve as an emergency access method.
 - The lock cylinder will be accessible behind the fingerprint sensor.
- Locking Mechanism:
 - The locking mechanism is powered by a high-precision solenoid, ensuring smooth and secure lock/unlock actions.
 - The solenoid directly responds to authorized inputs from access sensors.

- Auto-Lock Feature: Another one of our standout features here at iOpen!! is the auto-lock feature. Meaning that after you have unlocked the door, iOpen will automatically re-engage the lock after a preset amount of time (you the user decides the time) if no activity is detected. We know sometimes we're in a hurry and we forget to close the door, so this feature ensures your home remains secure, even if you forget to lock the door manually.
- Security and Access:
 - Fingerprint Sensor: iOpen will include a fingerprint sensor, which will allow you to unlock the door with just a touch of your finger.
 - NFC/RFID Sensor: Then for those who prefer to use cards/key fobs or even want to relive those dorm days at college don't worry with an NFC/RFID sensor will provide quick, contactless access.
 - Physical key Switch: Failsafe method of unlocking should fingerprint sensor or NFC reader malfunctions
 - Bluetooth/Wi-Fi Connectivity: For remote access, iOpen is equipped with Bluetooth and Wi-Fi capabilities, allowing you to control and monitor your lock from our mobile app, no matter where you are at.
- Web-based application
 - Provides remote control and monitoring of the lock.
 - Allows users to manage access permissions and check entry logs
 - Compatible with various devices for seamless user experience.

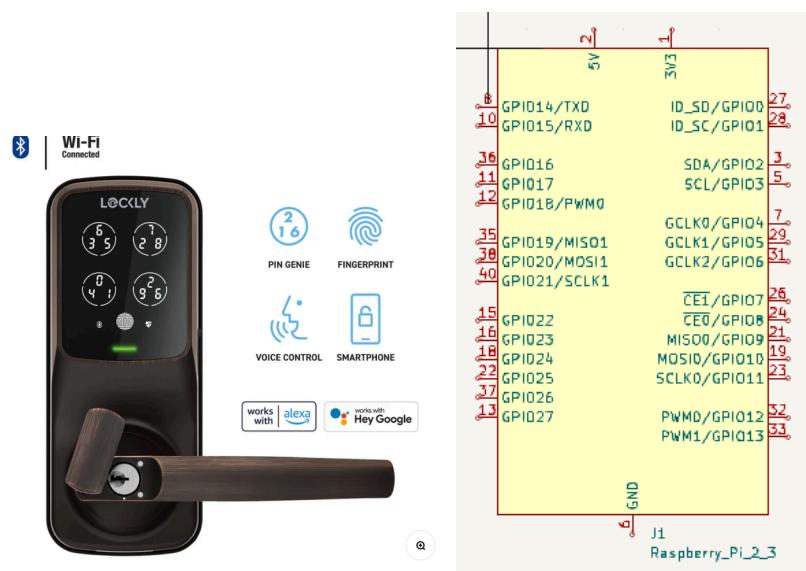
Component	Input	Output
Solenoid	Electrical signal from MCU	Unlocks lock mechanism
Fingerprint Sensor	Fingerprint scan	Binary access signal (granted/denied)
NFC/RFID Sensor	Card/tag proximity	Binary access signal (granted/denied)
6 AA/Power Bank	Electrical power	Powers the system
Backup Key	Manual entry using key	Mechanical unlock
LCD Display	Fingerprint/NFC/key detected	Latest status of lock

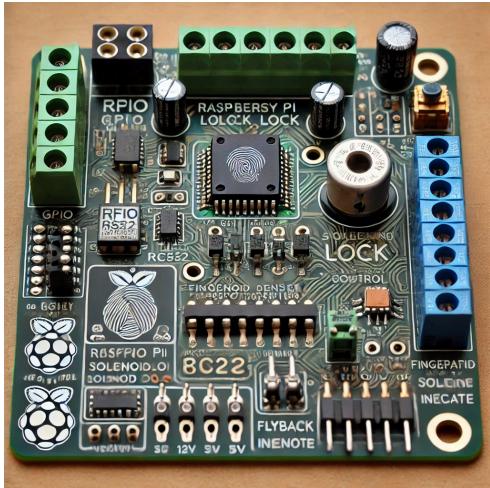
5. Design Deliverables

Here we have the card that will allow access to the iOpen to unlock.



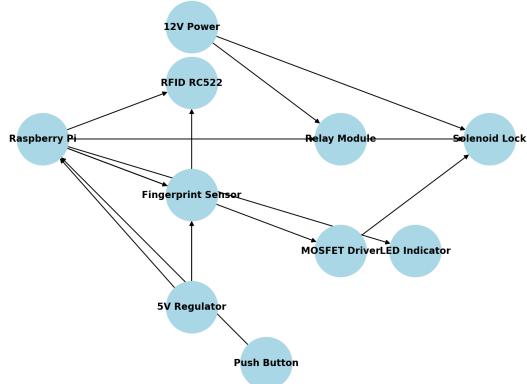
Here above, we have our prototype in the box. Where now it looks messy but in the future we're planning to have the final design as the image below or the top right image.





The picture is the PCB layout that we want to design. I have the KiCAD version but still figuring out some little tweaks for jlcpcb.com to have design. Still, some little tweaks to make.

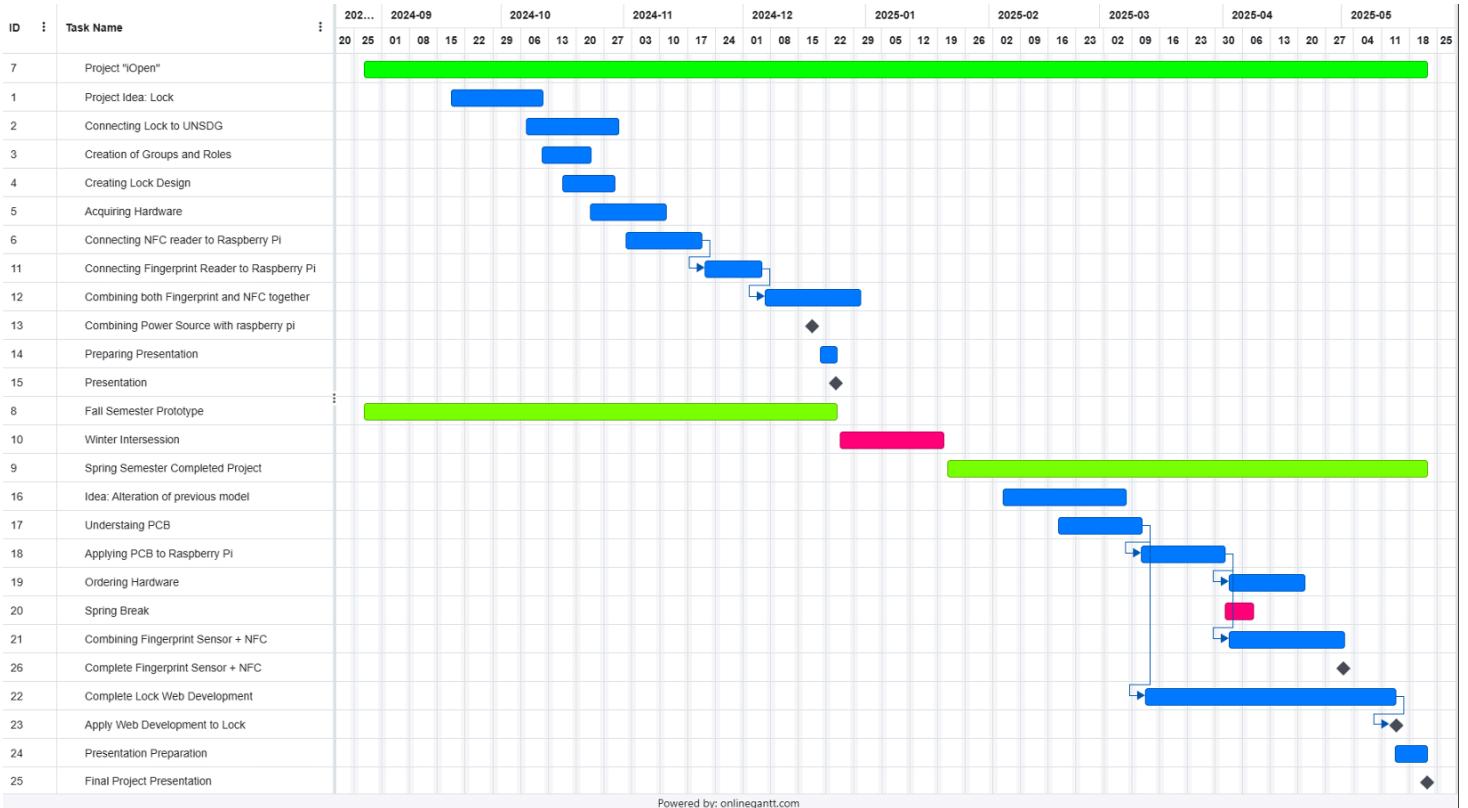
Schematic Diagram for Raspberry Pi Solenoid Lock System



6. Preliminary System Test Plan

1. Fingerprint Scanner Functionality
 - a. Ensure that scanner correctly registers and verifies user fingerprint
 - i. Test fingerprints of multiple users for authentication and rejection.
 - ii. Response time for authentication.
 - iii. Smudged fingerprint testing.
2. NFC Card Reader
 - a. Ensure that NFC Reader correctly reads and authenticates keycard and fob
 - i. Register multiple cards and fobs.
 - ii. Test range of reader.
 - iii. Response time for authentication.
3. Raspberry Pi System Integration
 - a. Test combinations of keyfobs and fingerprint scans.
 - b. Make sure the system responds to a hierarchy when multiple authentication methods are presented.
 - i. What happens when the keycard and fingerprint are both presented?
4. Solenoid and Security
 - a. Make sure the solenoid locks and unlocks correctly.
 - b. When fetching data from the Flask server from the web app, ensure security for no signal interception (MITM).
 - c. With the addition of a physical lock, ensure its longevity of closing/opening and locking/unlocking.
5. Environmental Testing
 - a. How does it function under cold, heat, rain, etc.
 - b. How will water affect the components? How should we make it splash/water resistant?

7. Proposed Project Schedule



Spring 2025

Idea: Alteration of precious model:

- 2/02 - 3/07
- Has to come first, this will create the general basis and idea of what the entire group will be working on
- Possible risks can be that we decide that the idea/model does not fit with future equipment or ideas that we may have. We may need to go back and change the ideas. The only way to fix this would be to withhold an adaptive mindset and be ready and flexible for change.
- All team members will work together in proposing ideas and topics.

Understanding PCB:

- 2/16 - 3/09
- This can occur while discussing the ideas, it's always a good idea to start early to understand the core of our project.
- The current issue may be caused by a delay in understanding how the PCB works. The PCB needs to be understood first before working with applying it with the Raspberry Pi and Completing the web development.
- Each group member will get a firm grasp of how the PCB works and work together to create one.

Applying PCB to Raspberry Pi:

- 3/09 - 3/30

- Since the PCB is a new aspect, it may take longer than the other tasks so it has an additional week added for the Gnatt chart. Once this task is completed, it will open up the path for ordering the necessary hardware and combining the fingerprint and NFC sensor
- Issues can arise with the lack of knowledge with the PCB or if there is some type of printing error. This can be solved by double checking work or accurately studying the components of the PCB board
- Each group member can apply their knowledge in connecting the PCB with the raspberry pi

Ordering Hardware:

- 3/30 - 3/15
- The hardware has to be ordered after the PCB is properly applied to the Raspberry Pi
- Current issues can come with ordering the wrong components or shipping issues where the components are lost in travel. The best solution would be double check measurements and composition of the components to make sure they are proper. Checking tracking orders and knowing where the components are coming from can also help keep track of anything shipped and purchased.
- Shun and Rafael are in charge of purchasing the items and having them shipped at places where we may pick them up. Everyone will be in charge of looking for the pieces needed.

Spring Break

- 4/1 - 4/5
- Issues can be that groupmates may be busy
- Make sure to check data and work schedule is still on track

Combining Fingerprint Sensor + NFC:

- 3/30 - 3/15
- The fingerprint sensor and the NFC can only be started once we have successfully applied the PCB to the Raspberry Pi. We want to make sure that the PCB can run everything the way it is supposed to before adding more components.
- Problems that may arise can be troubleshooting problems or coding problems regarding the PCB and coding. This can be solved through testing and trial and error with debugging.
- Rafael will be in charge of the primary hardware issues and advances while Shun will be in charge of the software advances. Chris and Matthew can float between the two and help where needed.

Complete Fingerprint Sensor + NFC:

- 3/15
- MILESTONE: really big and necessary part of the project.

Complete Lock Web Development:

- 3/09 - 5/06
- Complete Lock Web Development can be started once the PCB is understood. This is because the web app is responsible for communicating with the PCB. It will be beneficial if we attempt to connect these two pieces once we understand how they work. This segment is given more time because regarding the web application, raspberry pi, and PCB, there are new components to use so more learning is required. Hence, more time will also be needed.

- Some problems that may arise can be an issue in connectivity or issues with the code. I think the best solution for this can be to solve it through more research or through immense debugging.
- Shun will be responsible for leading the web application development while having the rest of the group as support. The rest of the group can help develop code, connectivity, and debugging.

Apply Web Development to Lock:

- 5/06
- MILESTONE: Being able to activate and connect the web development is a big part of the project and will allow for more efficiency and convenience for the user. This has to be completed after the completion of the web development application.
- Problems that we may run into can include debugging, but as discussed above, will be solved with the whole group working on the issues of proofreading or coming up with better ideas.

Presentation Preparation:

- 5/06 - 5/13
- Presentation Preparation is important. It will take about one week to be able to apply everything into a presentation. During this time, we can also make sure that everything is working as intended.
- Some issues that may arise during this test can be that something does not work out while we are so close to the finish. Items or topics where this can happen can be solved if worked effectively on it the second it shows up. We have about a week to make sure that the project meets our expectations.
- For this part each group member will be responsible for their duties in studying the presentation and confidently know every piece of the lock.

Final Project Presentation:

- 5/13
- The Final Presentation is the last piece of the Gnatt chart and will call the close and end of our lock project.
- MILESTONE: Final part of the project

8. Attachments

Items to buy -

Part	Need	Specs	Price
12V Solenoid Lock	Locking/Unlocking of door	<p>12VDC (you can use 9-12 DC volts, but lower voltage results in weaker/slower operation)</p> <p>Draws 650mA at 12V, 500 mA at 9V when activated</p> <p>Designed for 1-10 seconds long activation time</p> <p>Max Dimensions: 41.85mm / 1.64" x 53.57mm / 2.1" x 27.59mm / 1.08"</p> <p>Dimensions: 23.57mm / 0.92" x 67.47mm / 2.65" x 27.59mm / 1.08"</p> <p>Wire length: 222.25mm / 8.75"</p> <p>Weight: 147.71g</p>	\$15
Fingerprint Sensor	Unlocking mechanism for door	<p>Up to 80 fingerprints can be stored in the onboard FLASH memory, Black to GND, Yellow to Microcontroller TX (data <i>out</i> from microcontroller), Green to Microcontroller RX (data <i>in</i> from microcontroller), Red to 3.3V VIN, White to IRQ (can leave disconnected), Blue to 3.3V VCC (can leave disconnected)</p>	\$20

NFC Card/Fob and Reader	Unlocking mechanism for door, Card and Chip can hold multiple users	13.56MHz RFID module, Operating voltage: 2.5V to 3.3V. Communication : SPI, I2C protocol, UART. Maximum Data Rate: 10Mbps. Read Range: 5cm. Current Consumption: 13-26mA. Power down mode consumption: 10uA (min)	\$0 (included with Arduino kit)
Battery Packs	Power Source	Combine 3 batteries	~\$9
Arduino Kit	Testing if equipment works	–	\$65
PCB	Raspberry Pi Connection	–	–
Solenoid & Fingerprint Sensor Shipping rate	–	–	\$27.33
			Total: ~\$156.33

Unknown Values, Need flexibility

Marketing Studies -

- In a study by *International Association of Certified Home Inspectors*, “34% of burglars enter through the front door; 22% enter through the back door” A combined 56% of robberies occur through exterior doors. This research is relevant because a secure door with proper security acts as a deterrent in robbery and other malicious activities.
 - [Burglar-Resistant Homes - InterNACHI®](#)
- A study by *Access Residential Hardware* showed that “70% of people have left their houses before without remembering whether or not they locked the door.” Additionally, “Another 60% of respondents reported that they have come home to find an unlocked door.” With proper technological advancements in a lock, one can control the status of their lock using the website that will control our lock.

This will reduce the percentage of people coming home to unlocked homes since it can be accessed via web based applications.

- [House Door Statistics & Trends | 2022 Data](#)
- *ALARMS.ORG* states that for a year, there are 1,650,000 million home break ins during a year. Producing a smart lock can reduce the percentage of home break ins.
 - [Burglary Statistics: The Hard Numbers | National Council For Home Safety and Security](#)
- *Pew Research Center* involves statistics regarding handicapped people, "...about 42.5 million Americans with disabilities..." iOpen can successfully improve the quality of life especially those who are handicapped and struggle opening doors. The door can be unlocked with web access which can help relieve the stress of struggling to unlock the door.
 - [8 facts about Americans with disabilities.](#)

Literature Review -

- Automatic Door Locks company *august* provides useful input with implementing things like smart lock or auto lock. The door can be used as an example when it picks up that the door is closed.
 - [Automatic Door Locks | Keyless Door Locks | August Home](#)
- *Autodesk Instructables* is a project that gives insight about how we can use a website to enable a door. This technique also uses Rest API and Raspberry Pi which may act as a guideline in our coding environment.
 - [Building a Web Enabled Door Lock Using Rest API and Raspberry PI : 4 Steps - Instructables](#)
- Article *Security Things to Consider When Your Apartment Goes ‘Smart’* author Lesley Carhart explains issues that may arise with smart locks. Getting information from this article can help support out lock by creating solutions to common problems with smart locks.
 - [Security Things to Consider When Your Apartment Goes ‘Smart’ – tisiphone.net](#)
- Document which explains the necessary guidelines for a smart lock. This includes security, software, and implementations
 - [ETSI TS 103 815 V1.1.1 \(2024-01\)](#)

PROFESSOR NOTES:

- **Literature Review: How to solve a problem that we are facing**
 - Not the actual hardware physical lock
 - Can use the combination of NFC and Fingerprint Sensor
- **For the literature review**
 - **Can look into the different fingerprint sensors (putting fingerprint on screen and it unlocks)**
 - How fingerprint sensors work, algorithm, technical talk
 - **How the NFC works**
 - How the NFC device works, how it communicates
- **PCB stuff (we’re late ;-;)**