**Smart Package Lock    
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Engineering Design Report**

**Problem Statement**

Homeowners need a reliable method to secure their mail and packages so that their deliveries aren’t frequently targeted by porch pirates.

**Problem Description**

Porch piracy, the theft of packages from residential doorsteps, has become a significant concern in recent years. In 2023, an estimated 260 million packages were stolen across the United States, resulting in an economic loss of approximately $19.5 billion. From security.com, it was found based off a survey that they conducted that in 2024: 58 million Americans have been victims of porch pirates, and the total value of packages that have been stolen was $12 billion.

Those who own apartments were found to be more likely to have their packages stolen since it is harder to identify who could have taken the package due to living alongside many more people in apartment buildings. For example, if someone took your package, you may think your neighbor took it by mistake, thus giving time for the pirate to get away. Those who live in rural areas were also victims of porch pirates due to the area being less dense, so if someone takes your packages, there would be less witnesses to testify that it was the pirate who committed the porch pirating.

These statistics from 2023 and 2024 show that Americans lose billions of dollars' worth of packages every year, and if we don’t find a solution that could prevent this, then Americans will continue to lose even more billions of dollars in packages in the coming years. This is why we must come up with a solution at this very moment, that could end this epidemic from carrying on.

2024 package Theft Annual Report and statistics. Security.org. (2024, November 12).

[https://www.security.org/package-theft/annual-report/](https://www.security.org/package-theft/annual-report/%20)

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**Background Work**

Ring doorbell - The Ring Doorbell is a doorbell that allows you to use any device to survey your property. It allows you to view your property in real time, and you can speak to anyone who is on your property in real time. This product can deter porch privacy just by the presence and the reputation of the ring doorbell of how it caught many people on the act of committing porch piracy. It also allows you to communicate with the porch pirate without being in front of them in person. One limitation to the rind doorbell is that it doesn’t prevent porch piracy, it is only an intimidation tactic, and a way to identify who the porch pirate may be. If the porch pirate wasn’t deterred by the ring doorbell, then they could just run off with the package.

[https://ring.com/products/battery-doorbell](https://ring.com/products/battery-doorbell )

Lockbox - The lockbox allows the delivery driver to put the package in at the top, and then once they close it, it goes down to a compartment at the bottom, which keeps it safe for the owner to open with a key. This helps protect packages from being pirated away by porch pirates because it only allows packages to be put in by an outsider but only allows the package to be withdrawn by the owner. A limitation with the lockbox is a size constraint, as it only allows for smaller packages to be protected. These lockboxes are also often expensive, as the material costs for a giant metal box is high.

[https://www.wayfair.com/lockbox](https://www.wayfair.com/lockbox )

**Design Constraints**

• The system must be within the budget of $150.

• The system must be finalized and prototype ready within 2 months.

• The system must be user friendly, operational without training or complex installation.

• The system must not harm anybody in the process of protecting the package

• The system must allow access to only the delivery driver and owner

**Use Case Diagram**

**A diagram of a system

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* The homeowner has their face scanned by a scanner
* The delivery driver shows the package to scanner (shows name and address as well as barcode)
* The lock unlocks if valid user or package information
* Once lock unlocks, package could be delivered or retrieved

These functionalities fulfill the requirements set by the team. The lock keeps the pirate out, the scanner allows the owner and delivery driver to unlock the lock, by verifying that the face scanned, or the package scanned matches one of the users. All the listed requirements were fulfilled by this use case diagram.

**System Requirements**

* System must be able to lock to keep the pirate out
* System must be able to unlock for valid users
* System must be able to recognize the face of its valid users
* System must be able to recognize the name and address of its users, to unlock for packages

**High Level System Design**

**A diagram of a high-level server

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* Delivery driver scans package with the camera
* User scans face with the camera
* The camera sends that information to the processor where the image is compared to the information set by the user
* If the face or package info matches the info set by the user, then the lock is unlocked, and the storage of choice could be opened

The processor could recognize both the name and address on the package, as well as the face of a valid user, with the camera getting the information. If a valid user is recognized, then the lock unlocks, allowing the user to retrieve the package, as well as the delivery driver to deliver the package. If a valid user isn’t recognized, then the lock remains locked. All the components of the high-level system design fulfill the requirements set by our team.

**Design Justification**

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We considered three possible choices: the smart lock, the camera fence, and the motion camera. The smart lock is a lock that recognizes its user’s face and the user's name along with their address, only unlocking for valid users, or the delivery man. The camera fences a fence that surveys the area, and it also locks and unlocks the gate allowing valid users and delivery men to come in. The motion camera is a camera that just detects motion. It is mainly for keeping a log of when and where motion was detected, and at what time. These three were analyzed based on how well they do in the criteria’s of: informative, complexity, package access, cost, and security. The smart lock ended up with the best score amongst the three due to how well it does in the criteria of security, which was also identified as our most important criteria. The camera fence scored the lowest due to how complex it was to build, and how expensive it would be to build as well. The motion camera came second place, but due to it only detecting motion and not keeping intruders out, it scored a zero in security, making it come second to the smart lock. The smart lock is the best choice out of the three because you can use it on anything, it keeps whatever you lock secure, it isn’t that expensive to implement (costs less than the budget of $200), and it is simple to use.

**Physical Design**

**A diagram of a circuit board

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The raspberry pi has both wired and wireless engineering standards, including Wi-Fi 802.11 and Bluetooth 4.2 using specified ports, I2C (Inter-Integrated Circuit), SPI (Serial Peripheral Interface), and UART on the GPIO pins, and CSI (Camera Serial Interface) using a port for a camera module. These are essential in communicating with the photo recognition software, camera, and motorized locking mechanism. An MSP processor as well as an Arduino microcontroller were considered, however these do not allow for direct communication with the camera, or the desired recognition software (Python –OpenCV).

**Bill of Materials**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Item** | **Part #** | **Item Cost** | **Quantity** | **Total Cost** | **Purchase Link** |
| **Door Latch** | **1** | **$10** | **4** | **$10** | <https://a.co/d/iOhjrZj>) |
| **SD card** | **2** | **$10** | **1** | **$20** | [SD/MicroSD Memory Card (8 GB SDHC) : ID 1294 : Adafruit Industries, Unique & fun DIY electronics and kits](https://www.adafruit.com/product/1294) |
| **Raspberry Pi** | **3** | **$25.00** | **1** | **$45.00** | [Raspberry Pi Model 3 A+ : ID 4027 : Adafruit Industries, Unique & fun DIY electronics and kits](https://www.adafruit.com/product/4027?src=raspberrypi) |
| **DC Motor** | **4** | **N/A (Owned)** | **2** | **$0.00** |  |
| **Wire** | **5** | **N/A (Owned)** |  | **$0.00** |  |
| **Breadboard** | **6** | **N/A (Owned)** | **1-2** | **$0.00** |  |

The raspberry pi is critical to our design, as it is the microcontroller that allows the python ai photo recognition system to run, allowing the recognition to interface with the camera and the lock.

**Implementation & Testing Plan**

* Implement and test the motored lock by April 5th
* Get the face scanner working by April 17th
* Have the entire prototype implemented and tested by April 20th

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