Mail Gobbler 9000

Team 31

Brendan Truong
Luan Vo
Adam Cytrynowski
Jackie Chan
Problem Statement

Ongoing Pandemic (1+ years)
1. Package Security
2. Closing of retail stores
3. Transition to online shopping
Mail Gobbler 9000 Specifications

I. Barcode authentication functionality
   A. barcode scanner and wi-fi communication with AWS backend

II. Lock/unlocking mechanisms
   A. unlock request from MG9K mobile app
   B. correctly identified barcode scan

III. Fully functional mobile application
   A. unlock request,
   B. system logs
   C. reliable communication with backend

IV. Ergonomic features
   A. rechargeable batteries with long life span
   B. wireless setup
   C. physical backdoor
   D. sensibility (system timings, security measures, size)
<table>
<thead>
<tr>
<th>Performance</th>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wake-up Response</td>
<td></td>
<td>&lt;1 sec.</td>
</tr>
<tr>
<td>Authentication and Unlocking</td>
<td></td>
<td>&lt;5 sec.</td>
</tr>
<tr>
<td>Grace Period</td>
<td></td>
<td>2 Min. Grace Period for Delivery.</td>
</tr>
<tr>
<td>Extended Battery Life</td>
<td></td>
<td>12V, est. 90 days.</td>
</tr>
<tr>
<td>Round Clock Operation</td>
<td></td>
<td>LED Allows for Night Time Illumination.</td>
</tr>
</tbody>
</table>
## System Spec: Security

<table>
<thead>
<tr>
<th>Security</th>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Security</td>
<td>AWS Cognito User Sign Up with Limited Privileges.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data Storage in AWS DynamoDB Secured with Limited Write Privileges.</td>
<td></td>
</tr>
<tr>
<td>Hardware</td>
<td>Hidden Circuitry Inside the Dropbox.</td>
<td></td>
</tr>
<tr>
<td>Convenience</td>
<td>Specification</td>
<td>Value</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------------------------</td>
<td>------------------------------------------------------------</td>
</tr>
<tr>
<td>Mobile App</td>
<td>Stable Mobile App with Full Functionality.</td>
<td></td>
</tr>
<tr>
<td>Unlocking Alternatives</td>
<td>Remote Unlocking via App and Physical Backdoor.</td>
<td></td>
</tr>
<tr>
<td>Envelope Compartment</td>
<td>Compartment for Envelopes with Arrival Notifications.</td>
<td></td>
</tr>
<tr>
<td>Wireless Set Up</td>
<td>No External Wires or Connections Outside of Box.</td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>24” Height x 24” Width x 15.4” Length.</td>
<td></td>
</tr>
</tbody>
</table>
System Overview

1. The mailbox can be opened in 2 ways:
   - successful barcode scanned from delivery personnel.
   - user issued an unlock request via application

2. On a successful unlock, box will stay on for 2 minutes before turning off.

3. Mailbox communicate with AWS database wirelessly.

4. User app allows user to set up mailbox wifi manually.

5. Remains locked if the presented barcode does not exist.
Hardware Modules
- ESP-WROOM-02 (WiFi Module)
- Microcontroller (ATMega328P)
- Barcode Reader (PS/2)
- Solenoid
- Rechargeable Battery (12-Volt 7AH)
- Miscellaneous: LED, Capacitors, Diodes, Resistors, and Inductors

Hardware Programming
- Atmel Studio

PCB Modules
- Altium PCB Designer Tool

Backend Modules
Amazon Web Services (AWS)
- IoT Core
- Lambda
- AppSynch
- DynamoDB
- Cognito
- SNS

Frontend Modules
- xCode (Swift)
- Google Drawing
- Github

Website Modules
- HTML/CSS
- Github Pages
Software Diagram

Communication Back Bone

- **AWS DynamoDB**: 1. Barcode Table, 2. Mall Log Table, 3. Package Log Table
- **Amazon Cognito**: authentication of users

**iOS Application**

**AWS Lambda**
- dynamic functions
  - rules call functions
  - mutations call functions

**AWS AppSynch**
- GraphQL API

**ESP**

Hardware Side

**AWS IoT Core**
- communication with hardware

**AWS SNS**
- Notifications

**AWS IAM**
- Roles and policies

User Actions

- **Display of Logs**
- **User**

Front End Side

**User Actions**
- Functionalities:
  1. Store Barcodes
  2. Delete Barcodes
  3. Unlock Requests
**Sleep Mode**
1. uC always on
2. ESP on standby
3. Solenoid Latch off to reserve power.
   - LED Off

**Wake Up:**
1. Power on sleeping systems.
2. ESP establish connections.
   - LED On

**ESP**
Establishes connection with AWS IoT

**AWS**
Service used to handle our backend functionalities

**Backdoor**
User may open the both compartment via key and lock.

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**Package DropoffCompartment**
1. Sends barcode to ESP
2. If barcode query is valid, solenoid unlocks.
   - or
3. If unlock request received, solenoid unlocks.

**Open with Key**

**Hinge will cause lid to close by its own weight**

**On button pushed**

**2 min. timeout**

**Forwards barcode info**

**Returns barcode query results**

**Returns unlock requests**
9V Cell Rechargeable Batteries
200mAh Ni-MH
80% capacity for 24 months

Cycle expectancy for 9V: ~23 hours - 36 hours

12-Volt Rechargeable Battery
7AH Sealed Lead Acid (SLA)
“Can be used in enclosed/indoor environments without leak and maintenance”

Cycle expectancy for 12V:
~1460 hours - 2190 hours
~ 2 month - 3 months

Dimensions:
5.94 inch x 2.56 inch x 3.94 inch
(Cross section ~ small phone)
PCB Schematic

Red (Major):
- U1: 3.3 V Regulator
- U2: ATMega328P uC
- U3: ESP-WROOM-02

Blue (Secondary):
- D1: Solenoid
- D2: Switch
- D3: Scanner
- D4: LED indicator

Gold:
- Z1: Headers
PCB Board Layout

Red (major):
- U1: 3.3 V Regulator
- U2: ATMega328P
- U3: ESP-WROOM-02

Gold (connectors):
- Headers (6x)

Placing ESP-WROOM-02 [U3] on PCB

1. Option 2. Placing at the edge with the antenna outside of the host board
Photos of PCB
Atmel Studio vs Arduino IDE

Setting up Arduino environment as external tools

Create new Atmel Studio project from Arduino. Code can be written in both C and C++
Promised Deliverables for FPR:

I. Functional integrated system situated within a physical dropbox
   A. cardboard dropbox to avoid costly woodwork
   B. conveys operational concept of the system

II. Fully populated and functional PCB

III. Robust prototype that avoids solderless breadboard

IV. Prototype compliant to system specifications
Integration Failures

Failures:

1. Barcode Scanner
   The biggest hurdle was not knowing what our output was, so when we would scan a value, we had no way to see what data was being transmitted. Having an LCD display would’ve helped in this process. This was figured out too late in design.

2. Serial Communication
   The only communication we have between the ATMega328P and the ESP-WROOM-02 is setting pins high and low. We were unable to have the UART communication occur. There were issues with our frequency and baud rate. This could be due to a lack of external clock, which was found too late in the design process.
What We Learned

Improvements:

1. More planning could have gone into the operation modes of ESP-WROOM-02 during CDR.
2. Should have put more thoughts into future stages.
3. Avoids tunnel vision.

Sample PCB circuit for WROOM configuration
Integration Successes and System Upgrades

Success:
1. Mobile application
2. Functional backend
   a. Unlock request propagates to hardware
3. Populated PCB that avoids solderless breadboards (WIP)
4. System incorporated into physical mailbox

Upgrades:
1. Wi-Fi setup manager
I. Introduction of mobile app: MG9K
II. Walkthrough of backend and functionalities
III. Physical box demo
MG9K WiFi Setup

[Image of smartphone interface showing network options and setup network named MG9K_SetUp]
MG9K WiFi Setup
Demo: Back Up Recording

*NO BREADBOARD IN FINAL PROTOTYPE
Demo: Back Up Recording
Luan
- PCB Soldering
  - Solder SMT components
  - Header Integration
  - Verification and testing PCB
- Atmel Studio
  - Program ATMega328P

Adam
- Integrate ATMega328P with ESP-WROOM-02 in final prototype
- Physical Hardware
  - Physical Box Remodel
  - Circuitry Integration into Box

Brendan
- ESP-WROOM-02
  - Soldered Pins
  - Programmed ESP
  - Wi-Fi Set Up process
- Collaborative Testing

Jackie
- Improved PCB
  - Added Headers
  - Modified ESP Placement
  - Reroute Traces
- Mobile App Testing
  - Test all Functionalities on iOS Phone
  - Small Changes
    - Hide keyboard (on-screen keyboard)
    - Remove Redundant Package Log
## Budget Expenditure

<table>
<thead>
<tr>
<th>Budget</th>
<th>Current Total Cost</th>
<th>Remaining Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>$500.00</td>
<td>$353.33</td>
<td>$146.67</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Circuitry Costs</th>
<th>Status</th>
<th>Unit Price</th>
<th>Quantity</th>
<th>Total Cost w/Shipping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rechargeable Lithium Battery</td>
<td>Own</td>
<td>$17.50</td>
<td>2</td>
<td>$40.99</td>
</tr>
<tr>
<td>Battery Charger</td>
<td>Own</td>
<td>$10.99</td>
<td>1</td>
<td>$10.99</td>
</tr>
<tr>
<td>ESP- WROOM - 02</td>
<td>Own</td>
<td>$2.70</td>
<td>10</td>
<td>$51.60</td>
</tr>
<tr>
<td>USB Host BOB</td>
<td>Own</td>
<td>$4.50</td>
<td>1</td>
<td>$4.50</td>
</tr>
<tr>
<td>Scanner</td>
<td>Own</td>
<td>$69.95</td>
<td>2</td>
<td>$151.30</td>
</tr>
<tr>
<td>2-Layer PCB [80x62 mm]</td>
<td>Own</td>
<td>$0.40</td>
<td>5</td>
<td>$19.80</td>
</tr>
<tr>
<td>CP2102 Module Usb to TTL</td>
<td>Own</td>
<td>$7.89</td>
<td>6</td>
<td>$23.67</td>
</tr>
<tr>
<td>Breadboard</td>
<td>Own</td>
<td>$6.99</td>
<td>3</td>
<td>$6.99</td>
</tr>
<tr>
<td>0022112092 Molex [9 Pin header]</td>
<td>Own</td>
<td>$1.41</td>
<td>2</td>
<td>$2.82</td>
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<tr>
<td>826926-2 [2 pin header]</td>
<td>Own</td>
<td>$0.26</td>
<td>4</td>
<td>$1.04</td>
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<tr>
<td>040456-5 [5 pin header]</td>
<td>Own</td>
<td>$0.33</td>
<td>2</td>
<td>$0.66</td>
</tr>
<tr>
<td>22232071 [7 pin header]</td>
<td>Own</td>
<td>$0.44</td>
<td>2</td>
<td>$0.88</td>
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<tr>
<td>90147-1314 [14 pin header]</td>
<td>Own</td>
<td>$3.30</td>
<td>2</td>
<td>$6.60</td>
</tr>
<tr>
<td>1-826629-3 [13 Pin header]</td>
<td>Own</td>
<td>$1.67</td>
<td>2</td>
<td>$3.34</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Box Construction Costs</th>
<th>Link</th>
<th>Status</th>
<th>Unit Price</th>
<th>Quantity</th>
<th>Total Cost w/Shipping</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 oz. #P140-7 No More Drama Gl</td>
<td><a href="https://www.homedepot.com/p/B">https://www.homedepot.com/p/B</a></td>
<td>Own</td>
<td>$5.98</td>
<td>1</td>
<td>$11.97</td>
</tr>
<tr>
<td>Construction Box Materials</td>
<td>From Shira</td>
<td>Own</td>
<td>$12.49</td>
<td>1</td>
<td>$12.49</td>
</tr>
<tr>
<td>Gorilla Dual Temp Mini Hot Glue Gun Kit</td>
<td><a href="https://www.amazon.com/Gorilla-34015">https://www.amazon.com/Gorilla-34015</a></td>
<td>Own</td>
<td>$3.63</td>
<td>1</td>
<td>$3.63</td>
</tr>
<tr>
<td>Masking Tape</td>
<td><a href="https://www.amazon.com/Scotch-Office">https://www.amazon.com/Scotch-Office</a></td>
<td>Own</td>
<td>$3.63</td>
<td>1</td>
<td>$3.63</td>
</tr>
</tbody>
</table>
Concluding Remarks:
Thank you for a wonderful Senior Design Project:
- Time
- Constructive Feedback
- Empathy and Patience (regarding virtual demo)
Questions?
### Pins Needed

<table>
<thead>
<tr>
<th>Pins Needed</th>
<th>Connection To</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3V Power Supply (VDD)</td>
<td>3.3V Power</td>
</tr>
<tr>
<td>EN - Chip Enable Pin</td>
<td>Pulled up to VCC (3.3V Power)</td>
</tr>
<tr>
<td>IO15 - UART0</td>
<td>GND</td>
</tr>
<tr>
<td>IO0 - UART Download</td>
<td>GND</td>
</tr>
<tr>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>TXD</td>
<td>RXD of USB Interface</td>
</tr>
<tr>
<td>RXD</td>
<td>TXD Of USB Interface</td>
</tr>
</tbody>
</table>