SMOCK LOCK

GROUP 39

KENNETH MCDONALD

GABRIEL COUTO

ERIC SAYEGH

MATTHEW NAVARRO

Matthew Navarro

MOTIVATION

Providing safety and security to homeowners.

Utilizing the app, the homeowner would be able to unlock the door from anywhere as well as designate keys.

Provide a security feature that will use facial recognition to detect who is at the homeowner's door.

Similar products in the market offer minimal features and remain expensive.

To apply Computer Vision and App development from our Computer Engineering Experience to a project.

Matthew Navarro

OBJECTIVES

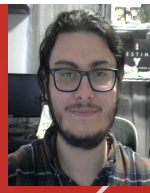
Our smart lock should contain a secure system that provides multiple forms of authentication/security

Our app will allow the homeowner to approve access to people at the door without them having too physically be there

Our smart lock should be affordable and competitive with other smart locks

Our functionality and features of the app and lock should be seamless and easy to understand.

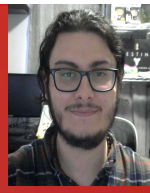
Gabriel Couto



SPECS AND REQUIREMENTS

#	Component	Measure	Description
1	Power Supply	Power Capacity	The lock should be able to fully function using the input voltage of 6 – 9 volts
2	Size of Lock	Size	To keep within a 6" by 6" box
3	Speed of Facial Recognition	Time	To have a positive ID or a false provided within 10 seconds
4	Speed of Fingerprint Scanner	Time	To have a positive ID or a false provided within 10 seconds
5	Speed of RFID Sensor	Time	To have a positive ID or a false provided within 10 seconds.

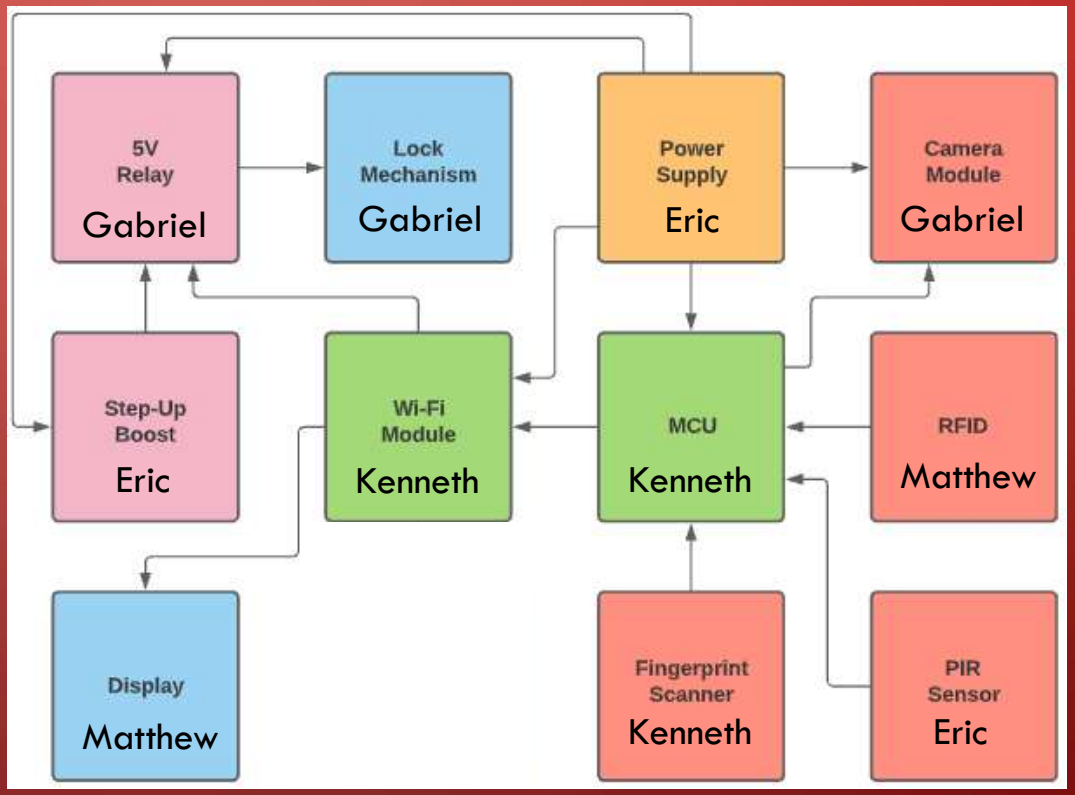
Gabriel
Couto



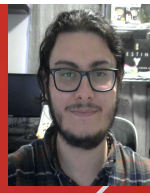
PROJECT BLOCK DIAGRAMS

Gabriel Couto

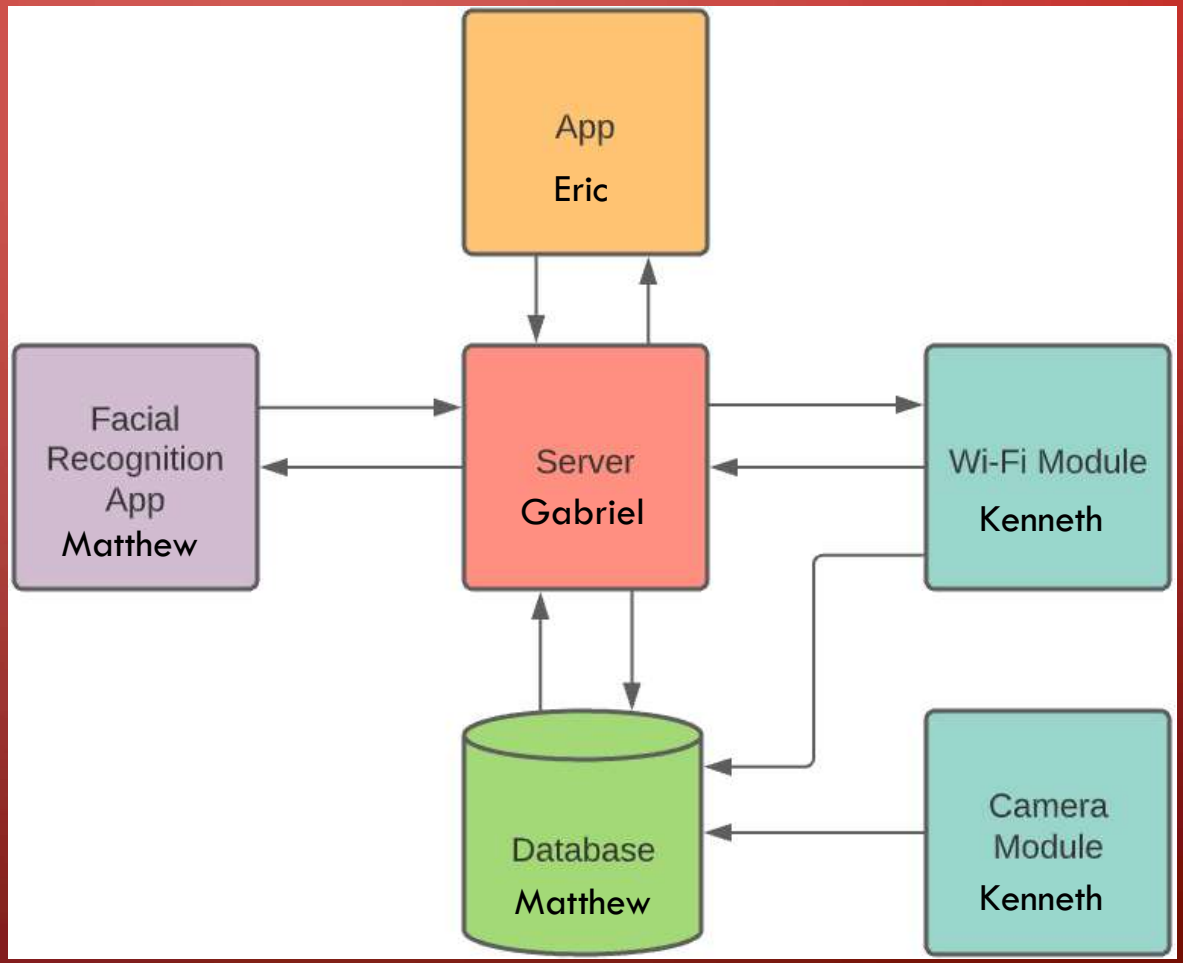
HARDWARE BLOCK DIAGRAM



Gabriel Couto



SOFTWARE BLOCK DIAGRAM



Eric
Sayegh

SOFTWARE IMPLEMENTATION

Eric
Sayegh

SOFTWARE APPROACH

To conduct operations such as facial recognition locally would increase the cost of the lock by a large amount.

Thus, we decided to conduct most of the computational processing server-side in the cloud. Allowing us to not have to spend as much on a powerful microcontroller and will allow us to conserve power.

This influenced us to use a MERN technology stack to provide all the necessary tools to build the lock software, mobile application, server, and APIs.

Gabriel Couto

FACIAL RECOGNITION

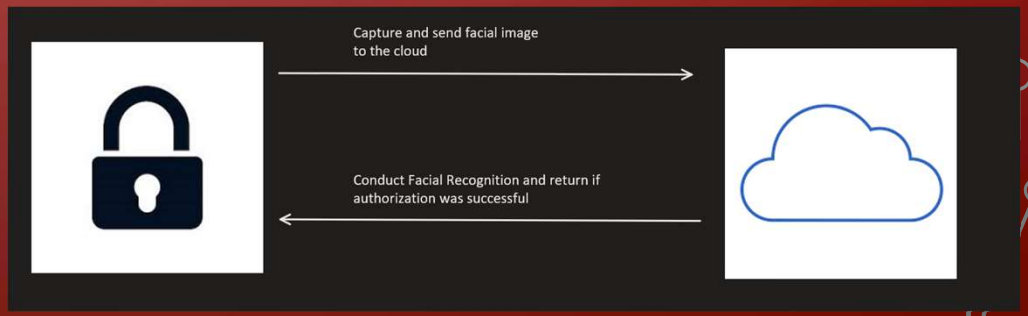
Facial recognition is conducted by capturing an image with the ESP32-CAM on the lock, then sending the facial image through an http request to one of our APIs. This API will run a script that conducts facial recognition against the facial images stored in the database.

Algorithm

- Uses a histogram of oriented gradients supported by a Linear Support Vector Machine to create the encodings for the pictures.
- Much less dependent on expensive hardware to run at full efficiency

Reason for Choosing

- Fast and kept within requirement response time
- Compatible with our system



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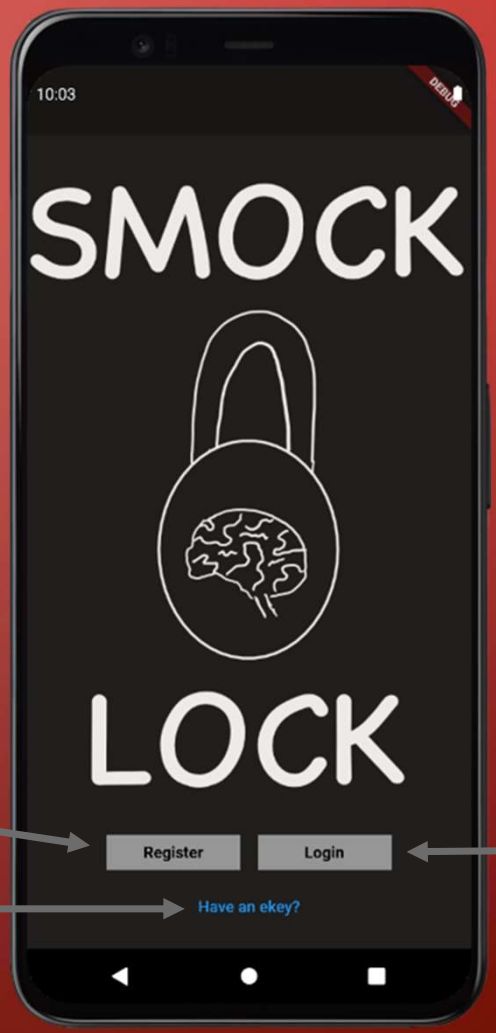
INTRO SCREEN



Register

Ekey
Login

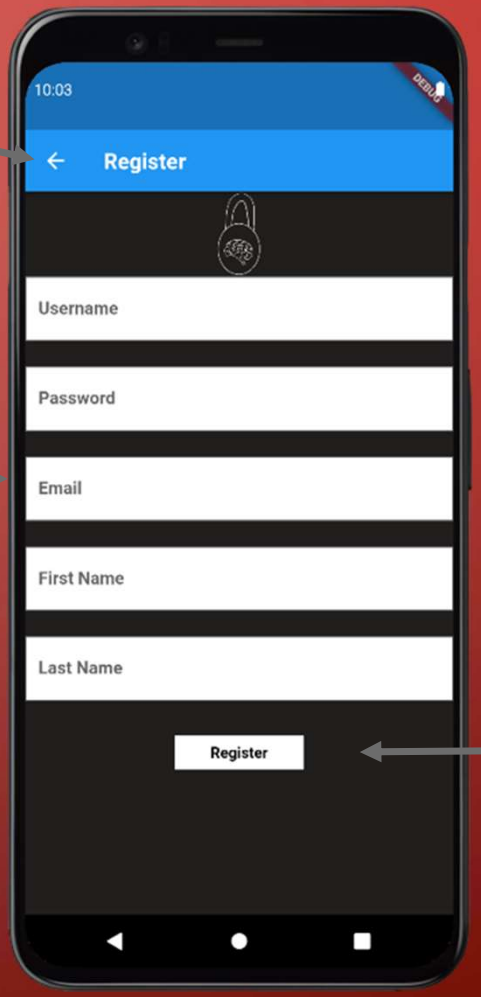
Login

Eric Sayegh

REGISTER SCREEN

Return to intro screen

User input fields



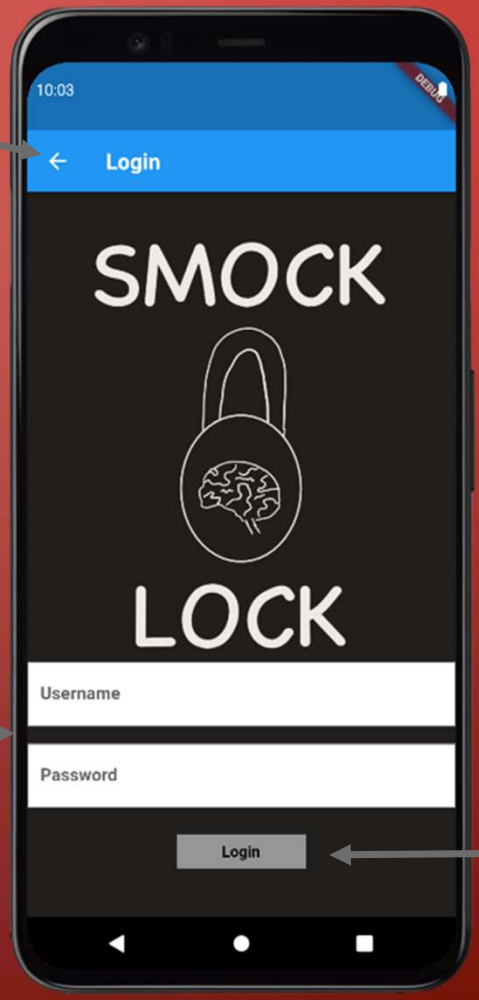
Register

Eric Sayegh

LOGIN SCREEN

Return to intro screen

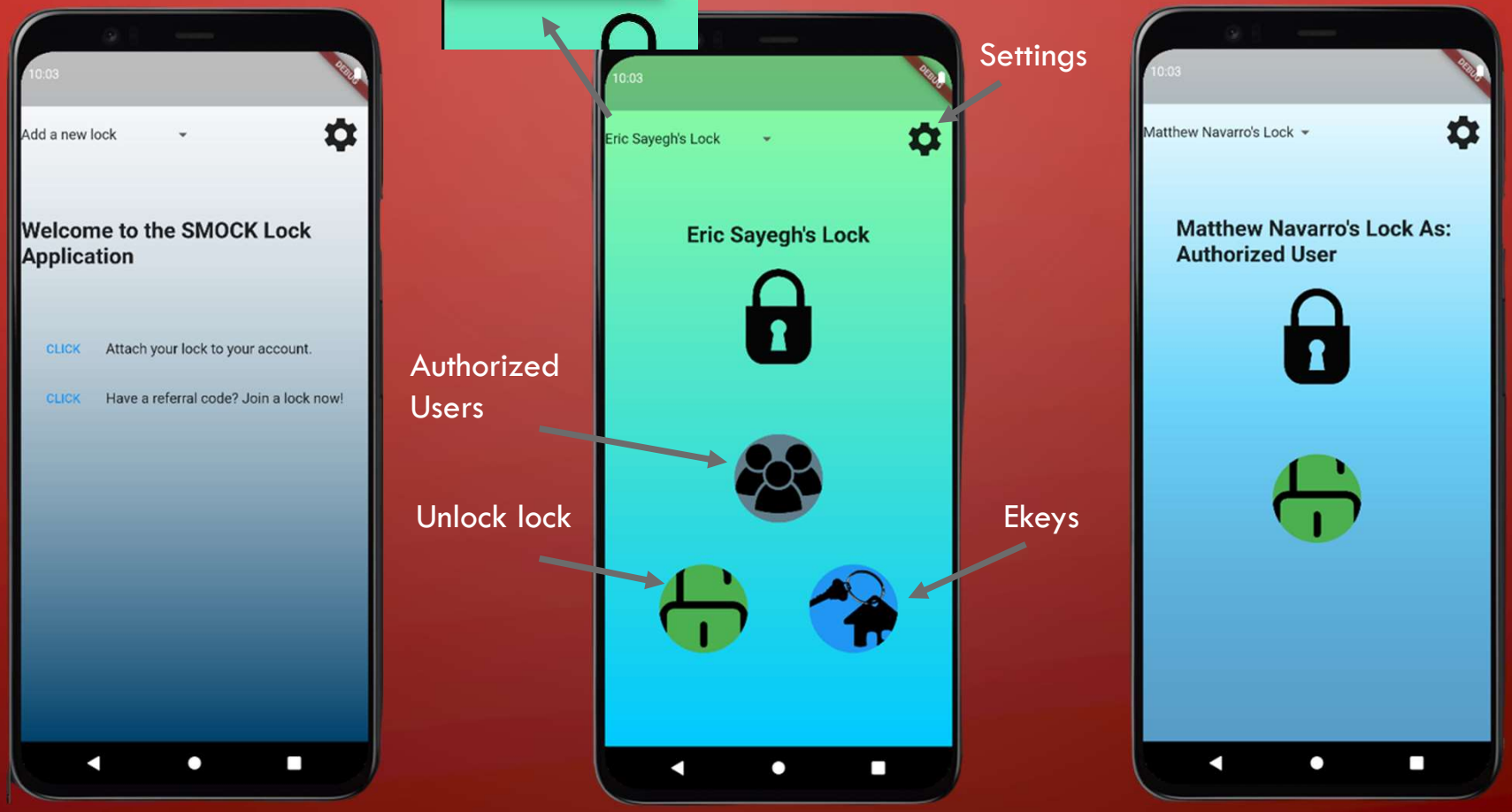
User input fields



Login

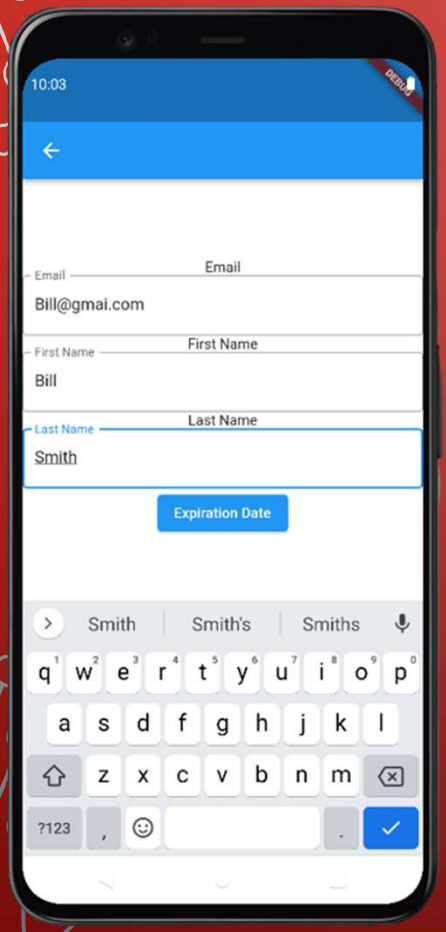
HOME SCREEN

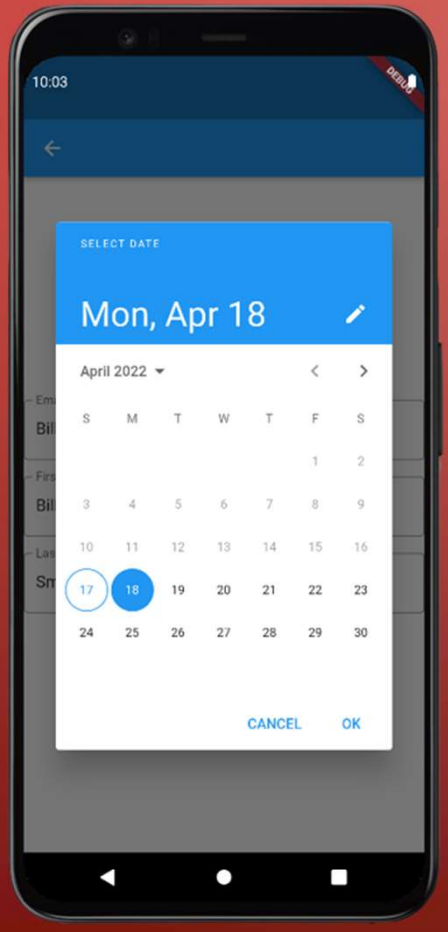
Eric Sayegh

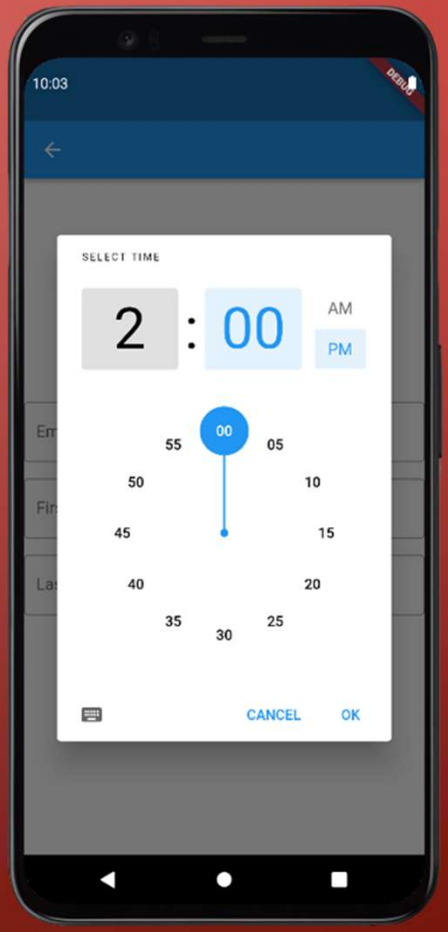


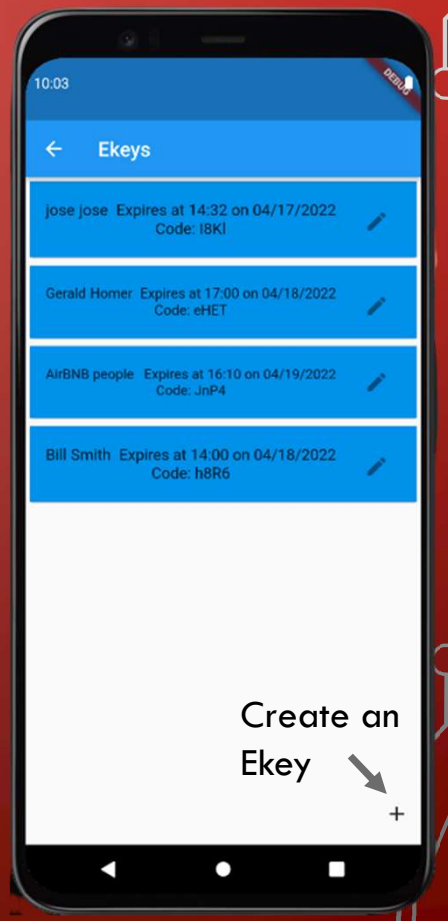
EKEY SCREEN

Eric
Sayegh









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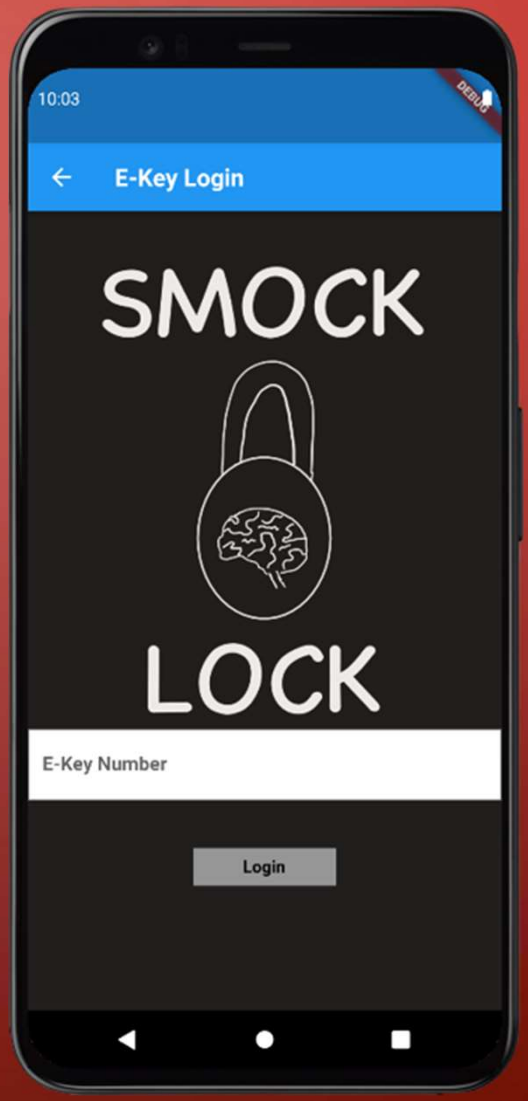
EKEY LOGIN SCREEN



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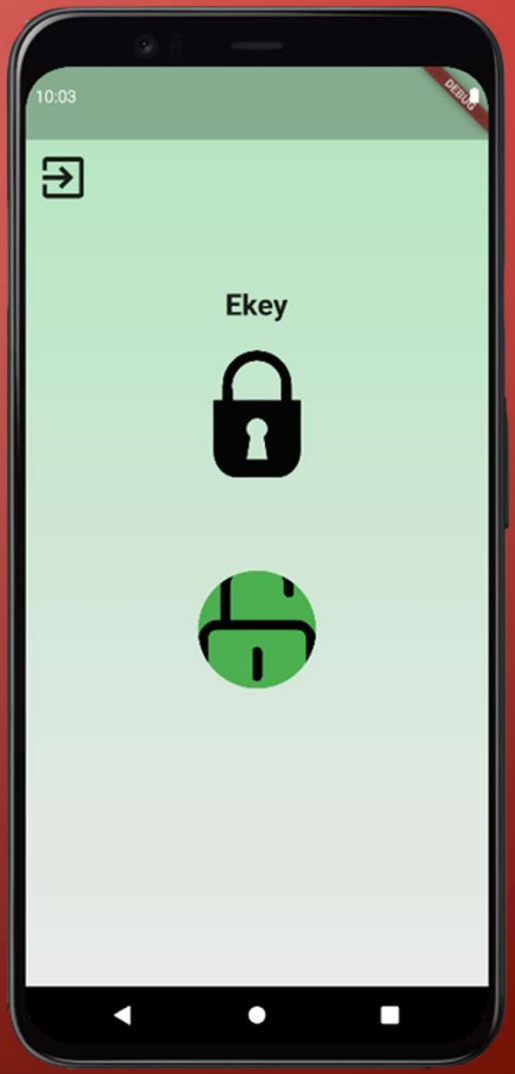
EKEY HOME SCREEN



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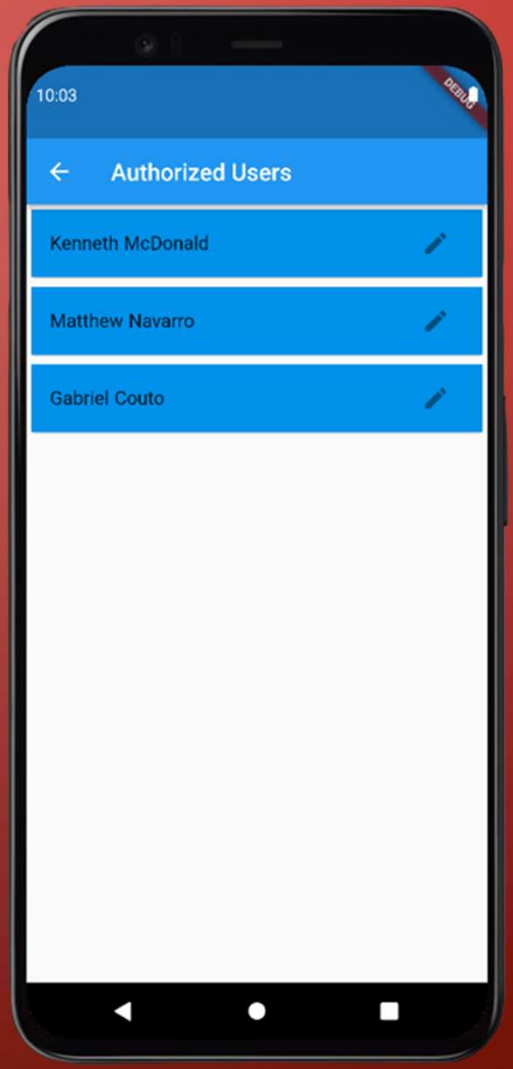
AUTHORIZED USERS SCREEN



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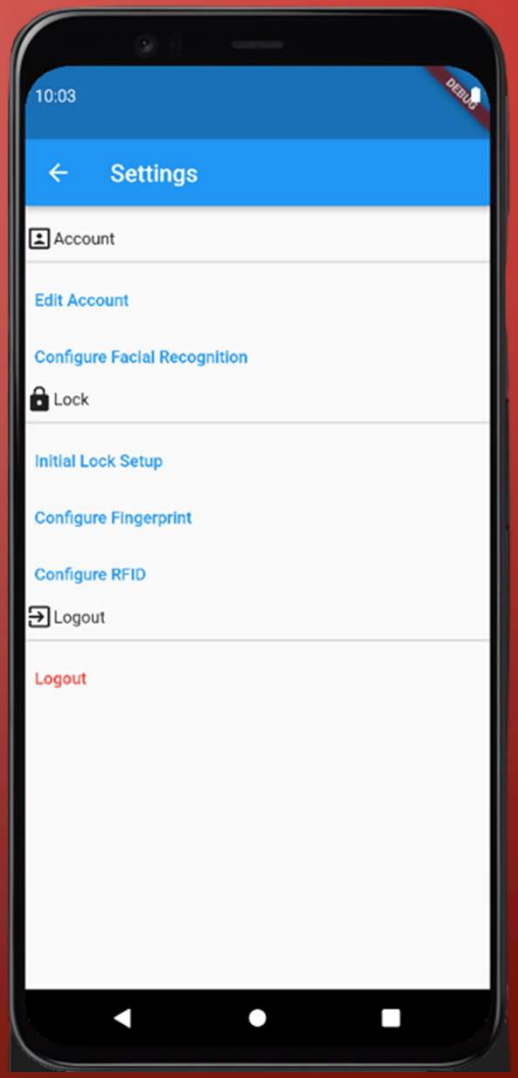
SETTINGS SCREEN



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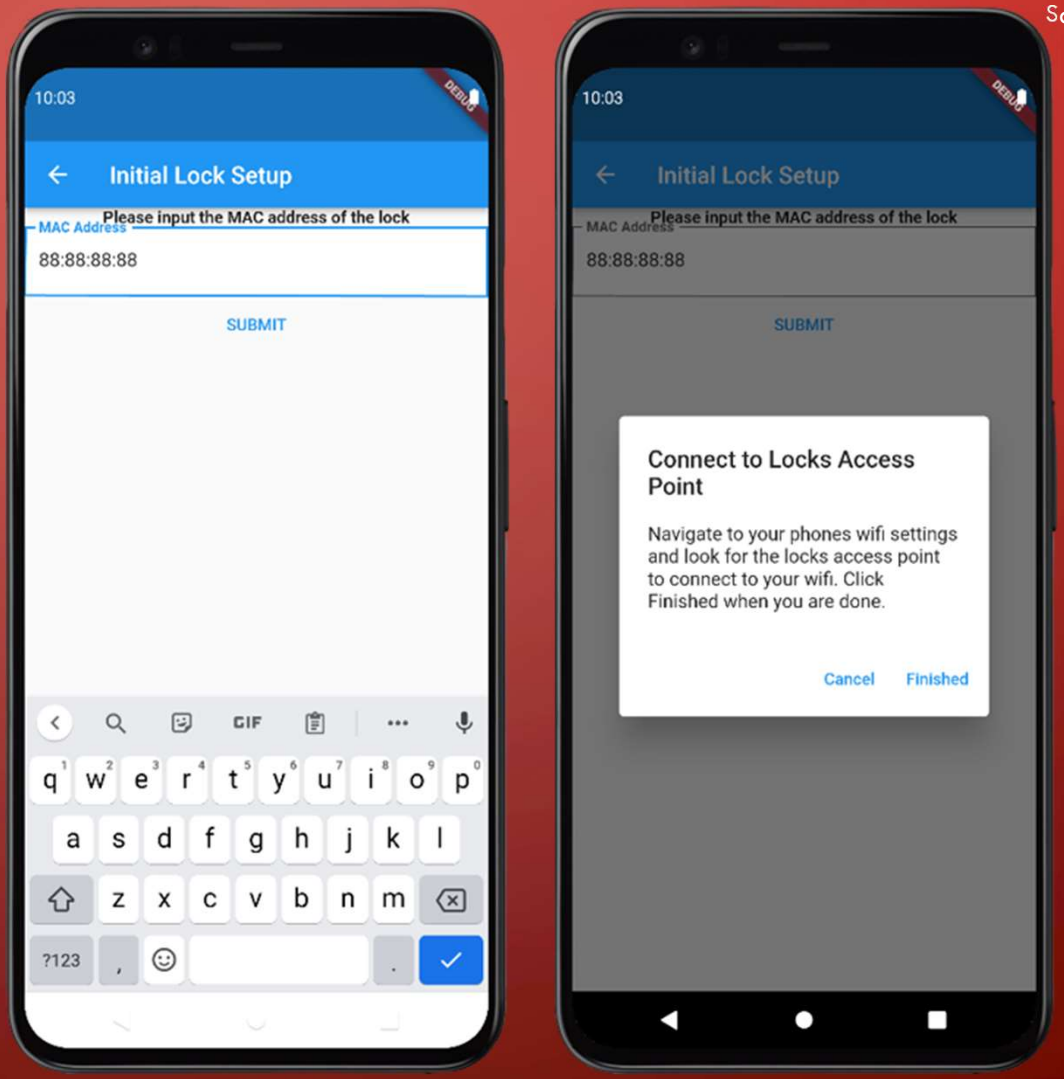
CONFIGURE FACIAL RECOGNITION

INITIAL LOCK SETUP



Eric Sayegh

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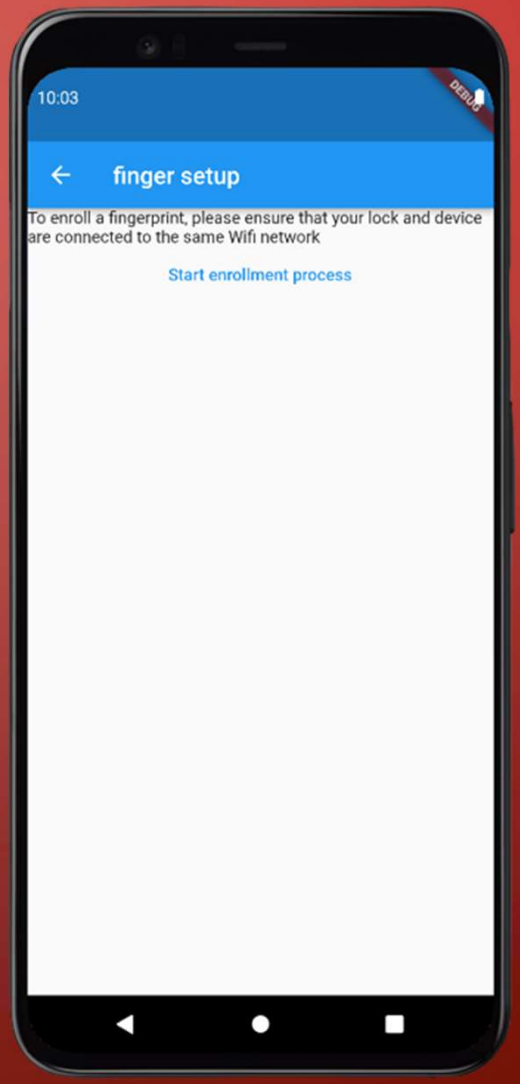
Sayegh

CONFIGURE FINGERPRINT



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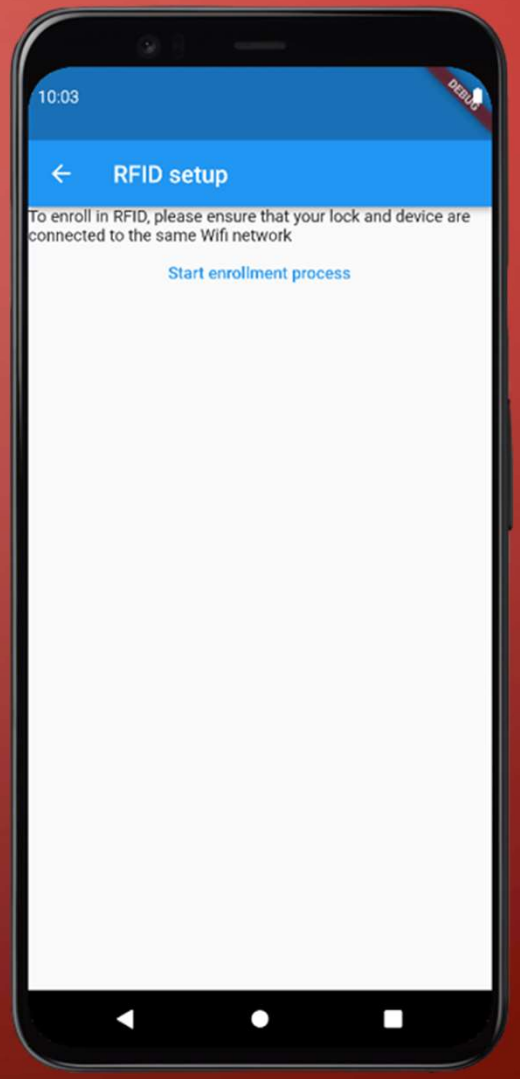
CONFIGURE RFID



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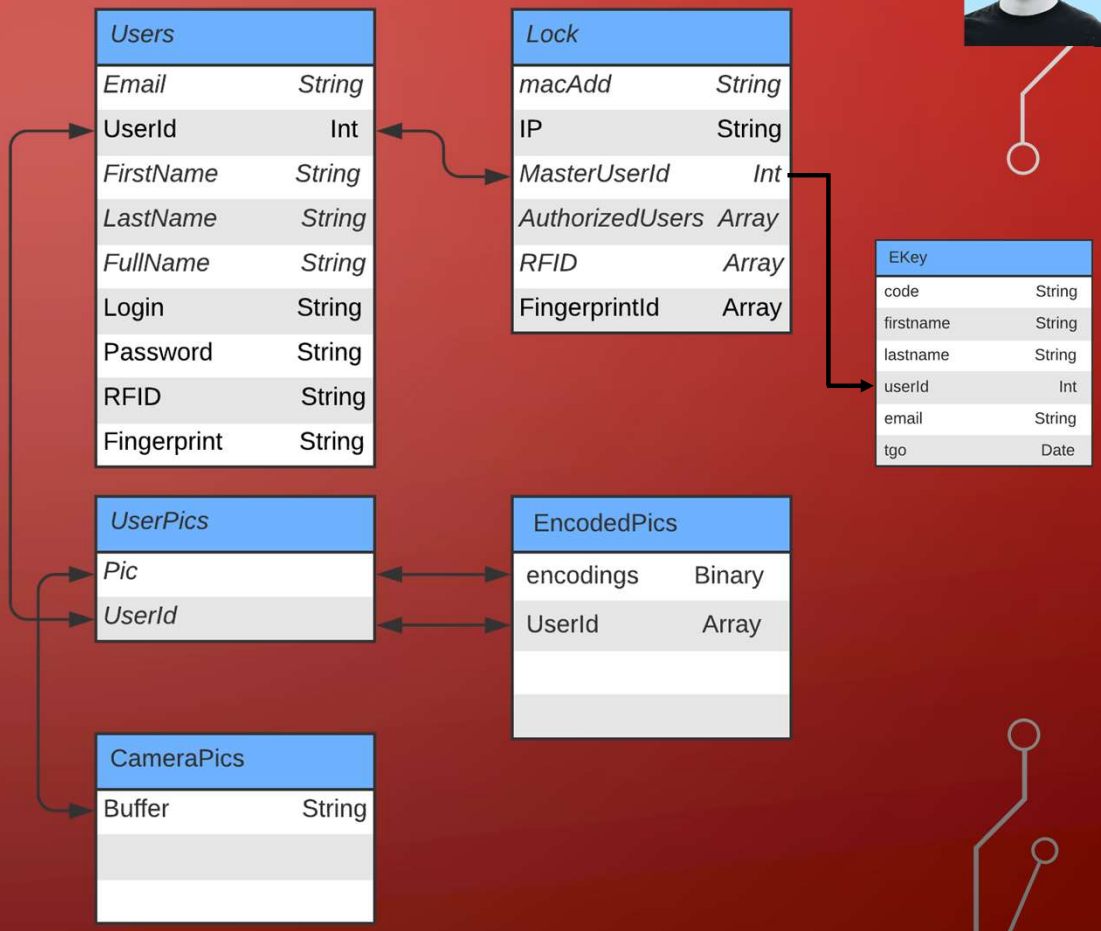
DATABASE

The database will be need to store all biometric information to allow for the comparisons to be made during authentication. We chose MongoDB, a NoSQL database program, as our database.



Kenneth McDonald

MAJOR COMPONENT SELECTION

MCU PART COMPARISON

Matthew Navarro

	ATmega328p	ATmega4809	MSP430FR6989
Price	~ $2.82	~$3.08	~$10.00 to $11.00
CPU	8-bit AVR, RISC, 16 MIPS @ 16MHz	8-bit AVR, RISC, 20 MHz	16-bit, RISC, 16 MHz
ADC	8-channel 10-bit	16-channel 10-bit	12-bit SAR
Flash Memory	32KB	48KB	N/A
SRAM	2KB internal	6KB	2KB
EEPROM	2 KB	256 Bytes	N/A
FRAM	N/A	N/A	128KB non-volatile
I2C	Yes	Yes	Yes
SPI	Yes	Yes	Yes
UART	Yes	Yes	Yes
Registers	32 8-bit registers	32 8-bit registers	16 16-bit registers
I/O Pins	23	41	83

Kenneth McDonald

MCU SELECTION (ATMEGA328P)

The main purpose for the microcontroller will be used to communicate sensor data with the Wi-Fi module.

Since most of the computation will be server-side we have chosen to go with the Atmega328p.

Advantages:

- Huge Open-Source support and Documentation, allows for simplicity in programming.
- Most single clock cycle execution with 131 powerful instructions
- 23 I/O Pins that can be used with our sensors which is a bit more than required for our Lock.
- Low priced around $2.82
- Can use SPI, UART, and I2C

Price	~ $2.82
CPU	8-bit AVR RISC CPU On-chip 2-cycle multiplier
Flash Memory	32 KB
SRAM	2 KB internal
Registers	32 8-bit general purpose working registers
I/O Pins	23

WI-FI MODULE COMPARISON

Matthew Navarro

	ESP8266	ESP32	CC3120
Price	~ $1.60	~$2.00	~$3.00
CPU	Tensilica L106 32-bit processor	Xtensa single-/dual-core 32-bit LX6 microprocessor	On-chip Arm network processor
RAM	< 50 kB RAM	520 KB SRAM	N/A
Other Memory	External Flash supports up to 16MB	448 KB ROM, Up to 16 MB of External Flash	Maximum supported serial flash size is 32 MB.
SPI	2	4	1
UART	2	3	1
Wi-Fi Protocol(s)	WPA/WPA2	N/A	WEP/WPA/WPA2/WPA 3
Pins	17	34	64
Bluetooth	No	Yes	No
I^2C	1	2	N/A
I^2S	1	2	N/A
Package Size	5mm x 5mm QFN	6mm x 6mm QFN	9mm x 9mm VQFN

Kenneth McDonald

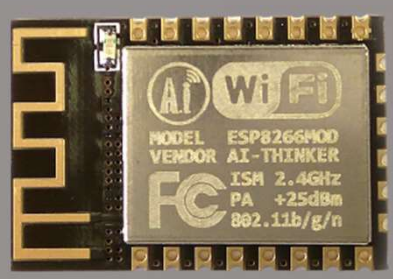
WI-FI MODULE (ESP8266)

The Wi-Fi module will be used to communicate sensor data from the microcontroller to the server and will be used to send the signal to unlock the door.

We were looking at the ESP8266, ESP32 and the CC3120. Since we do not need too much processing power on the Wi-Fi chip itself, we ultimately went with the ESP8266.

Advantages:

- Lowest Price
- Lowest Power Consumption
- Smallest Size
- Communicates through UART
- Can complete HTTP requests



Price	$1.60
CPU	Tensilica L106 32-bit processor
RAM	< 50 KB
Other Memory	16 MB External Flash
Operating Current	~ 80 mA
I/O Pins	17
Size	5mm x 5mm

Matthew Navarro

CAMERA COMPARISON

	OV2640	OV7670	OV5642
Price	~ $1 - $5	~$5 - $10	~$30
Operating Voltage	1.2-3.3V	1.8-3.3V	1.8 – 3.3V
Image Sizes	UXGA, SXGA, SVGA, any size scaling down to 40x30	VGA, CIF, any size scaling down from CIF to 40x30	5 Megapixel, any arbitrary size scaling down from 5 MP
Operation Modes	Video and Photo	Photo	Video and Photo
Image Transfer Rates	60fps (CIF), 30fps (SVGA), 15fps(UXGA, SXGA)	30fps (VGA)	15fps (5MP), 30fps (1080p)
Image Quality Controls	Color Saturation, Gamma, Sharpness, Lens Correction, White Pixel Cancelling, Noise Canceling, 50/60 Hz Luminance Detection	Color Saturation, Hue, Gamma, Sharpness, Anti-Blooming	Color Saturation, Hue, Gamma, Sharpness, Lens Correction, Defective Pixel Canceling, Noise Cancelling
Automatic Image Control Functions	AEC, AGC, AWB, ABF, ABLC	AEC, AGC, AWB, ABF, ABLC	AEC, AGC, AWB, ABF, ABLC
LED and Flash Mode	Yes	Yes	Yes

Kenneth McDonald

CAMERA (OV2640)

The main purpose for the camera module is to take images of guests at the door and store in the database to later be used for facial recognition.

We have decided to go with the ESP32-CAM module that uses the OV2640 for image processing and uploading.

Advantages:

- Lowest price
- Allows for Facial Recognition in terms of the Image Quality.
- Other comparable features were identical across camera's we looked at.

Price	~$1 - $5
Image Sizes	UXGA, SXGA, SVGA, any size scaling down to 40x30
Image Transfer Rates	60fps(CIF), 30fps(SVGA), 15fps(UXGA,SXGA)
Image Quality Controls	Color Saturation, Gamma, Sharpness, Lens Correction, Noise and White Pixel Cancelling, 50/60 Hz luminance Detection
Operating Modes	Video and Photo

Matthew Navarro

FINGERPRINT SENSOR COMPARISON

	AS608	ID809
Price	~ $20	~$17
Communication Method	UART	UART
Storage Capacity (Fingerprints)	~240	~80
Size	15mm x 17mm	Diameter: 21mm
DPI Resolution	500	508
Search Time	< 220 ms	300-400 ms

Kenneth McDonald

FINGERPRINT SENSOR (AS608)

The fingerprint sensor will be used as another tier of security for the lock.

We were looking at optical and capacitive fingerprint sensors and ultimately decided on the AS608 optical fingerprint sensor.

Advantages over other sensors:

- 3x the storage size for fingerprints
- Faster Search Time
- Rectangular shape will allow for better placement on the enclosure.

Price	~$1 - $5
Communication Method	UART
Storage Capacity	240 fingerprints
Search Time	< 220 ms
Size	15mm x 17mm

Matthew Navarro

PIR SENSOR COMPARISON

	DIYmall	Stemedu	DaFuRui
Price	$10.49	$10.49	$11.99
Operating Voltage	4.5V-20V	4.5V-20V	2.7V - 12V
Quiescent Current	<50uA	<50uA	Not Stated
Interface Type	Uses triggers and digital pins	Uses triggers and digital pins	Uses triggers and digitial pins
Delay Time	0.3- 200 seconds	0.5-200 seconds	2 seconds
Range	Adjustable	Adjustable	3-5 meters
Block Time	2.5 seconds	2.5 seconds	2 seconds
Number of Pieces	5	5	5

Kenneth McDonald

PIR SENSOR (HC-SR501)

The PIR sensor will be used to sense when a person approaches the door and to transition the system from low-power mode to normal operation.

We were deciding between and HC-SR501 PIR sensor and a AM312 PIR sensor and ultimately went with the DIYmall HC-SR501 PIR sensor.

Advantages:

- Adjustable sensing range
- Adjustable delay time
- Lowest Price
- More documentation than other sensors

Price	~$5
Quiescent Current	< 50 uA
Delay Time	0.3-200 seconds
Range	Adjustable
Block Time	2.5 seconds

Matthew Navarro

DISPLAY COMPARISON

	16x2 LCD	OLED	20x4 LCD
Price	$7	$9	$8
MPU	4-bit, 8-bit	4-bit, 8-bit	8-bit
Backlight	LED	Self-illuminated	LED
Response Time	~1ms	~.01 ms	~1ms
Size	80x36x13.5(mm)	38x12 (mm)	97x59x12 (mm)

Kenneth McDonald

DISPLAY (OLED)

The display will be used to provide visual instructions to a person at the door.

We were deciding between an LCD display and an OLED display and ultimately went with the OLED. The OLED is about $2 more than the traditional display but the advantages of the OLED make the price difference worth it.

Advantages:

- Response time > LCD
- Power Consumption < LCD
- Every pixel on the screen can be used
- Small size

Price	~$6
Resolution	128 x 31
Backlight	Self - Illuminated
Response Time	~ .01 ms
Size	.91 inch

Matthew Navarro

RFID COMPARISON

	MiHappy	SunFounder
Price	$10.80	$6.99
Input Voltage	3.3V	3.3V
Operating Current	13-26mA	13-26mA
Interface Type	SPI	SPI
Read Range	0~60 mm	0~35 mm
Operating Frequency	13.56 MHz	13.56 MHz
Number of Pieces	1	1

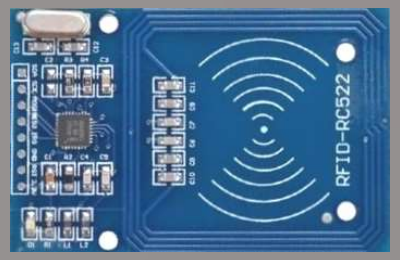
Kenneth McDonald

RFID (MFRC522)

The purpose of the RFID is to serve as another tier of security or as a backup key if necessary.

We decided to go with an RFID kit that is based on the widely used Phillips MFRC522 Chip.

Specifically, we decided to go with the MiHappy RFID kit. This kit is very similar to other RFID's using the same chip, but this specific kit has a farther read range than others.



Price	~ $10
Interface	SPI
Read Range	~ 0 – 60 mm
Operating Frequency	13.56 MHz
Input Voltage	3.3V

Matthew Navarro

LOCKING MECHANISM COMPARISON

	QWORK	TAKAHA	ATOPLEE
Price	$14.70	$35.00	$19.99
Solenoid Style	Latch(Pull)	Latch (Catch)	Cylinder (Pull)
Dimensions (mm)	17x27x15	47x10x105	55x42x27
Number of Pieces	4	1	2

Kenneth McDonald

LOCKING MECHANISM (ELECTRIC SOLENOID)

For our locking mechanism, we have decided to go with an electric solenoid due to its simplicity, size, and ease of integration with the rest of our components.

Specifically, we have chosen a latch style solenoid. When constructed we will be able to send a digital signal to the relay which will then supply power to the solenoid to unlock or lock the door.

Price	~ $3
Input Voltage	12V
Input Current	350mA
Solenoid Style	Latch
Size	17mm x27mm x 15mm

Kenneth McDonald

POWER

Battery for PCB: AA 1.5V x 4
MT306 Step Up Boost: 5V – 12V
Input Voltage: 6 – 9V

Voltage	5V	5V	3.3V	3.3V	12V	5V	5V
Component	MCU	Camera	RFID	WIFI	Lock	PIR	Relay

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SCHEMATIC AND PCB

Kenneth
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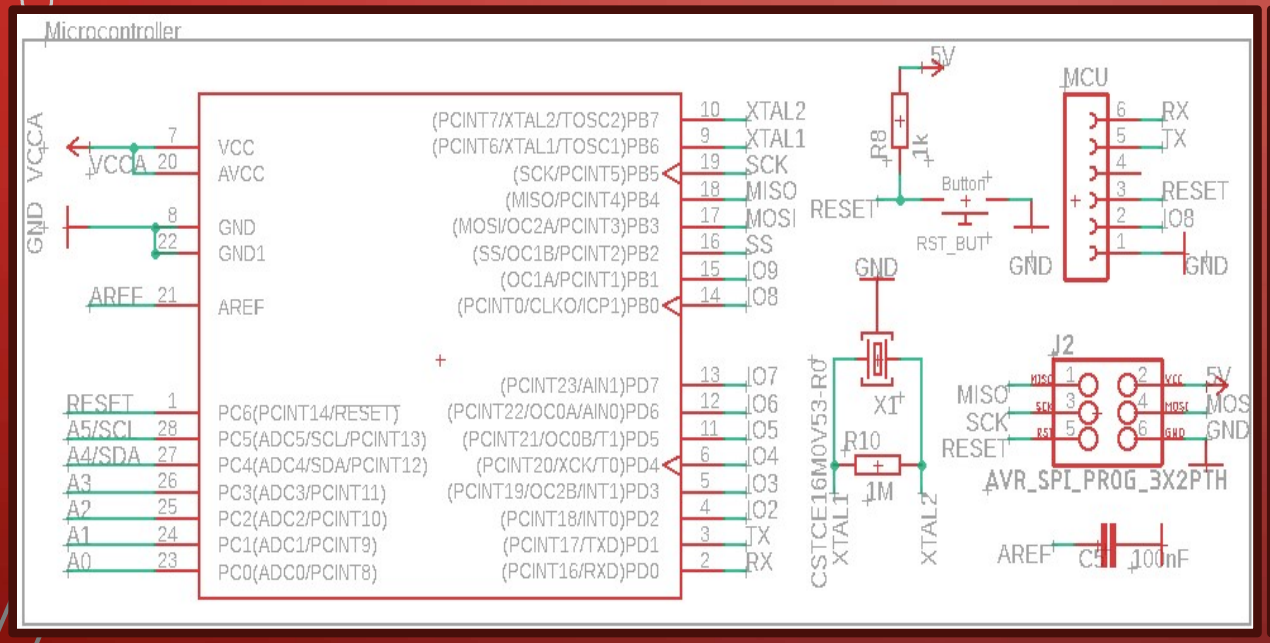
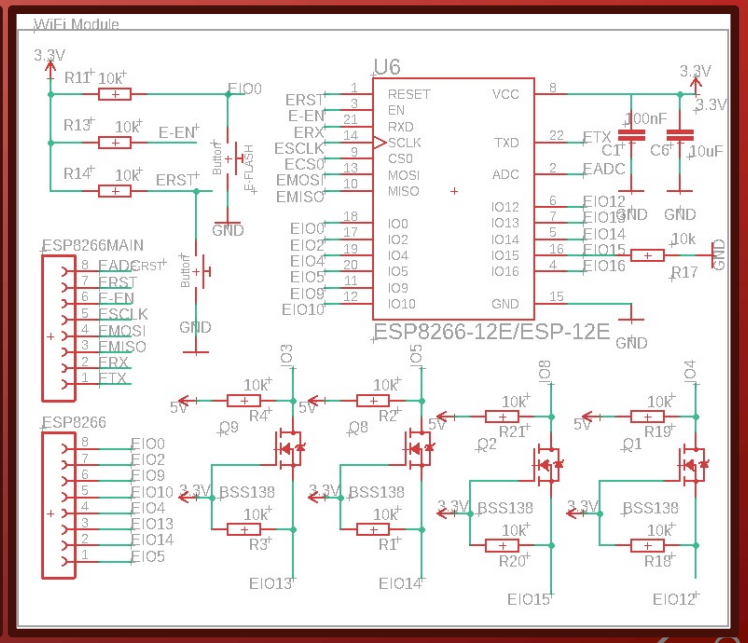
SCHEMATIC (MICROCONTROLLER AND WI-FI CHIP)





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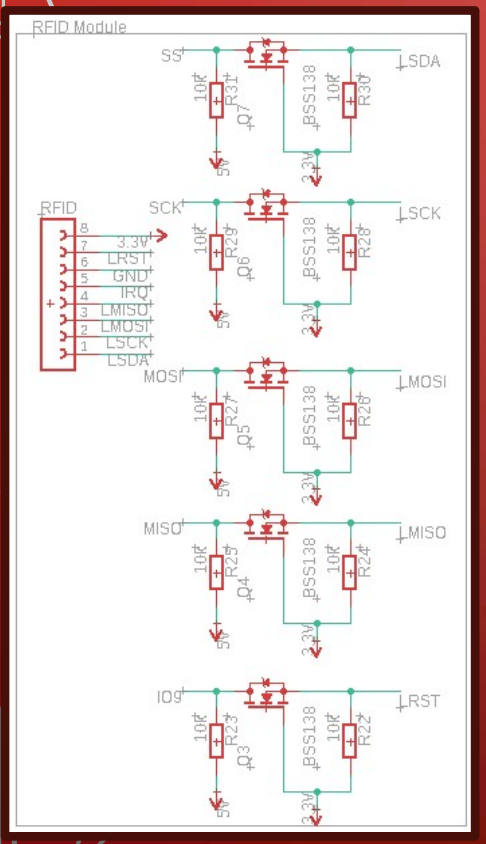
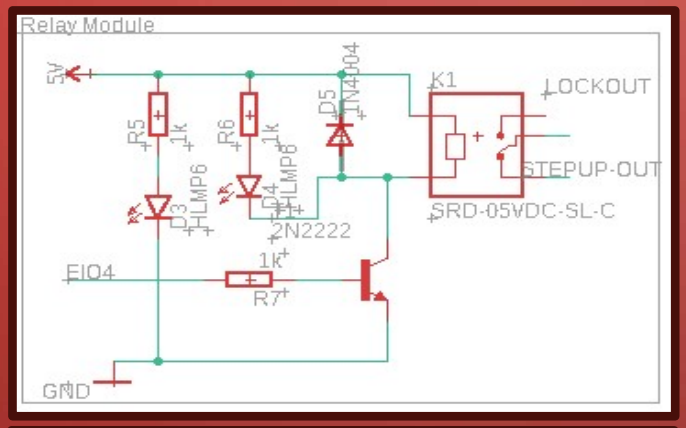
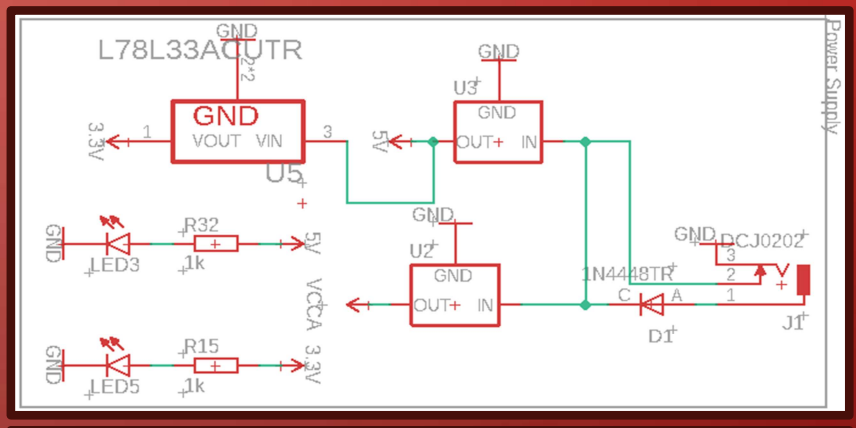
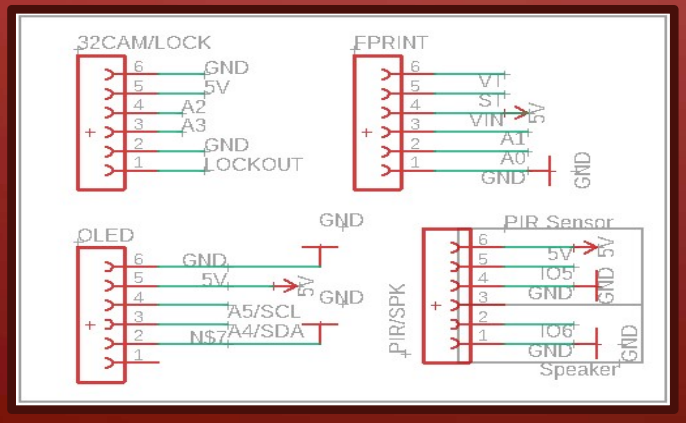
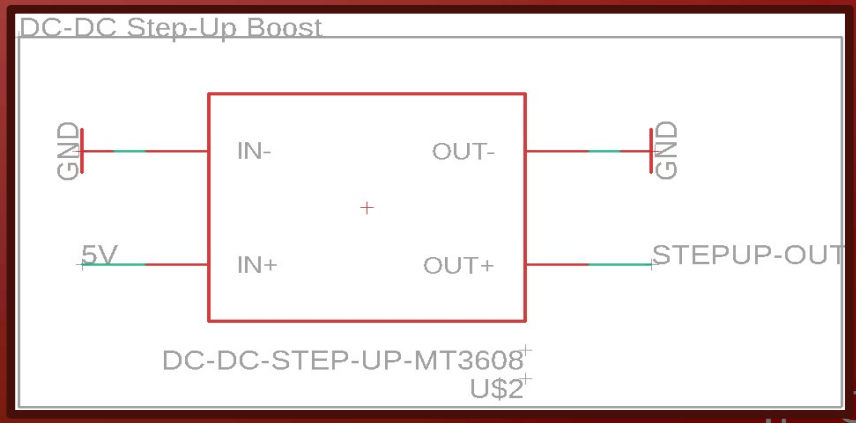
SCHEMATIC (SENSORS AND POWER MODULES)



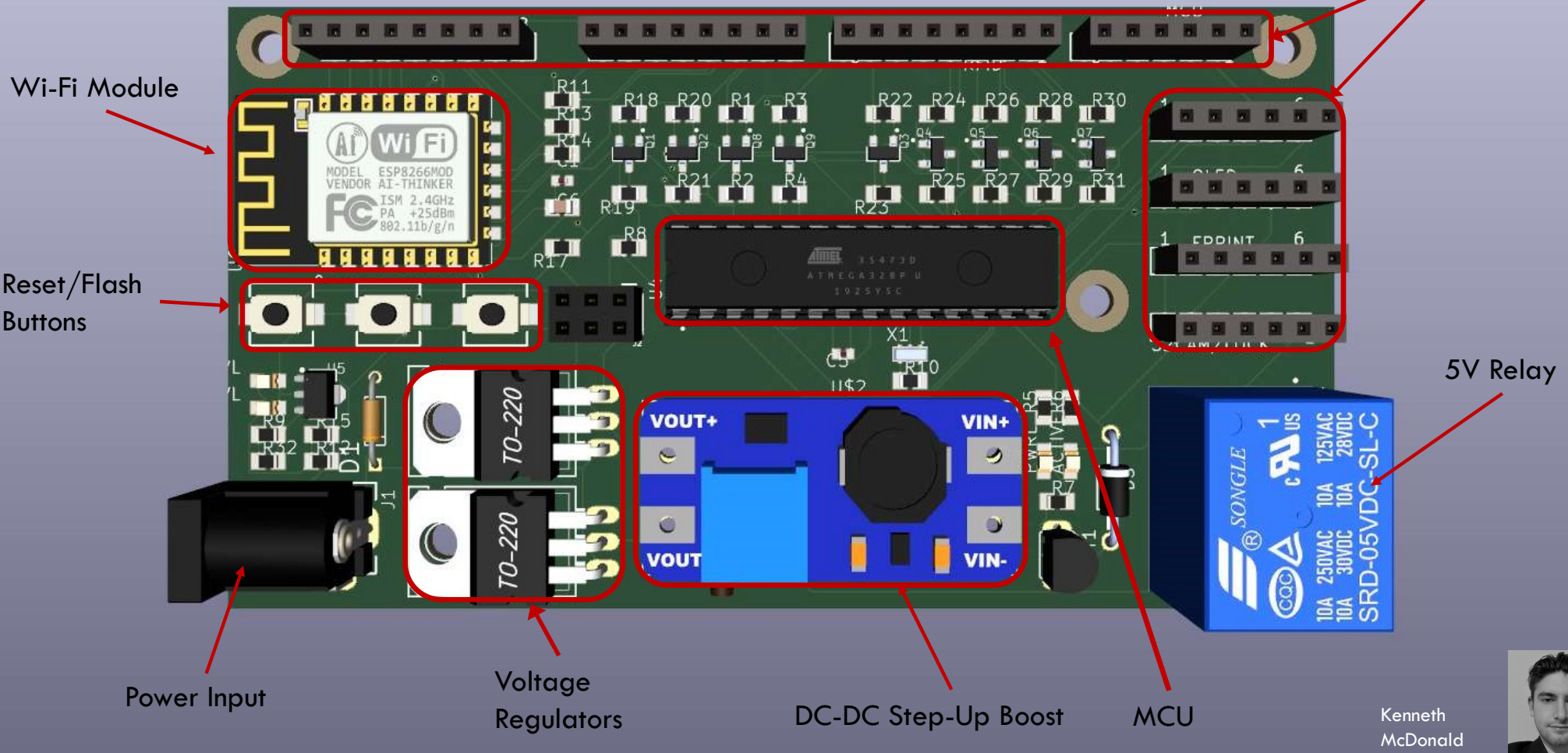








PCB LAYOUT



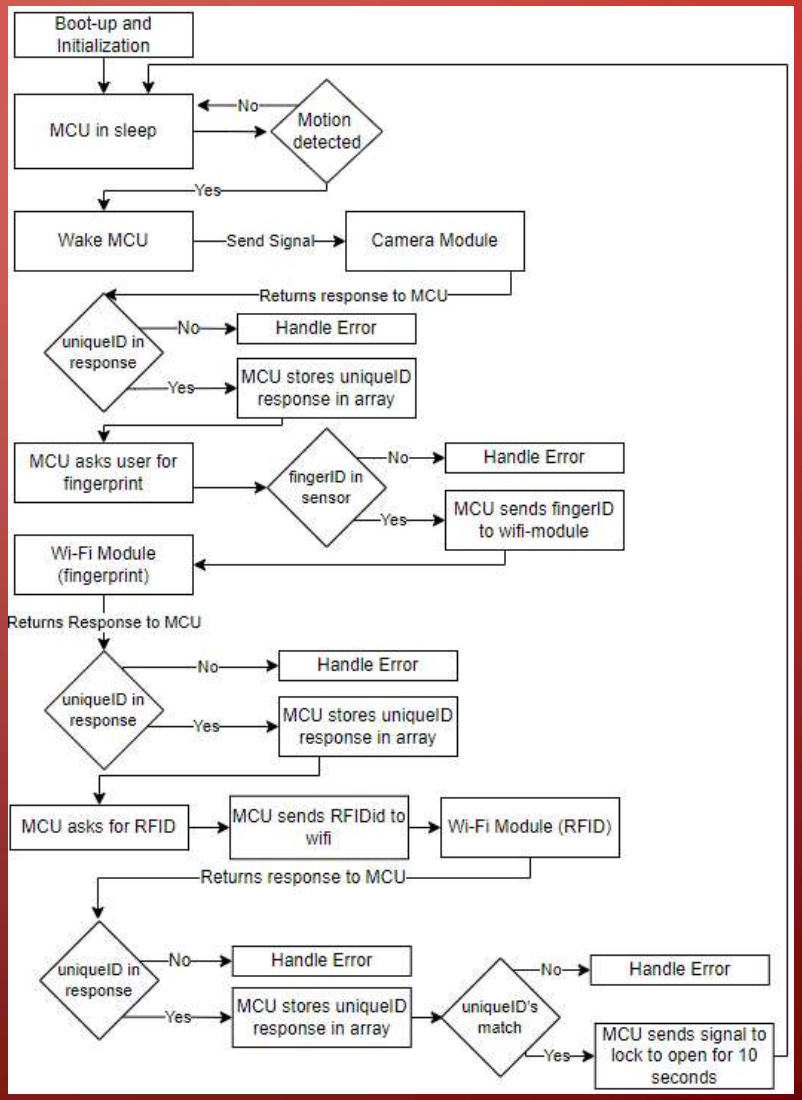
Kenneth McDonald

Gabriel
Couto

SOFTWARE FLOW FOR COMPONENTS

Gabriel Couto

MCU (NORMAL) FLOW DIAGRAM



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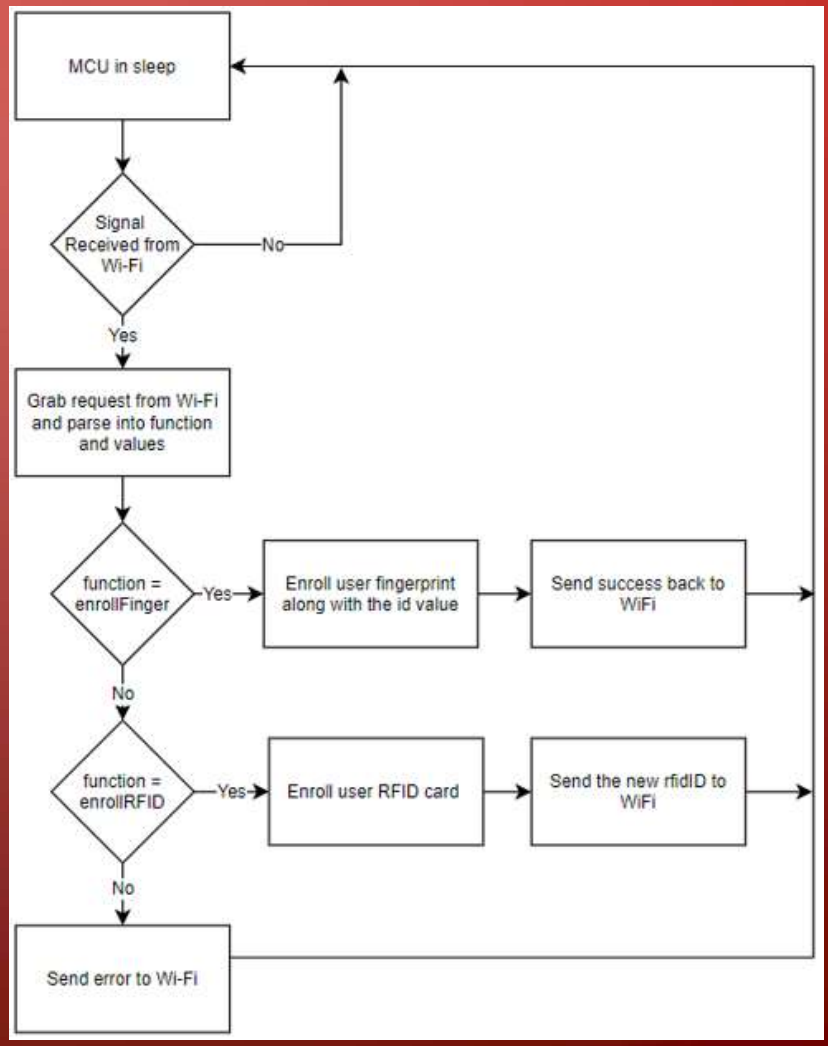
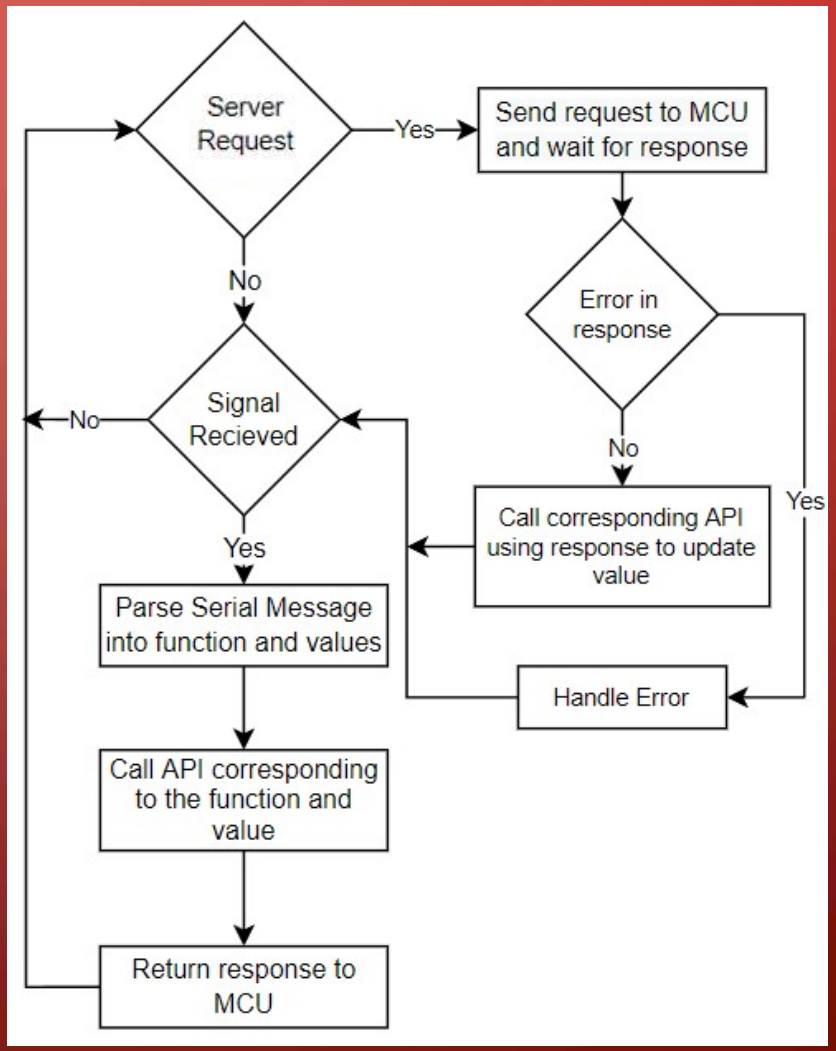
MCU (SETUP) FLOW DIAGRAM



WI-FI MODULE FLOW DIAGRAM



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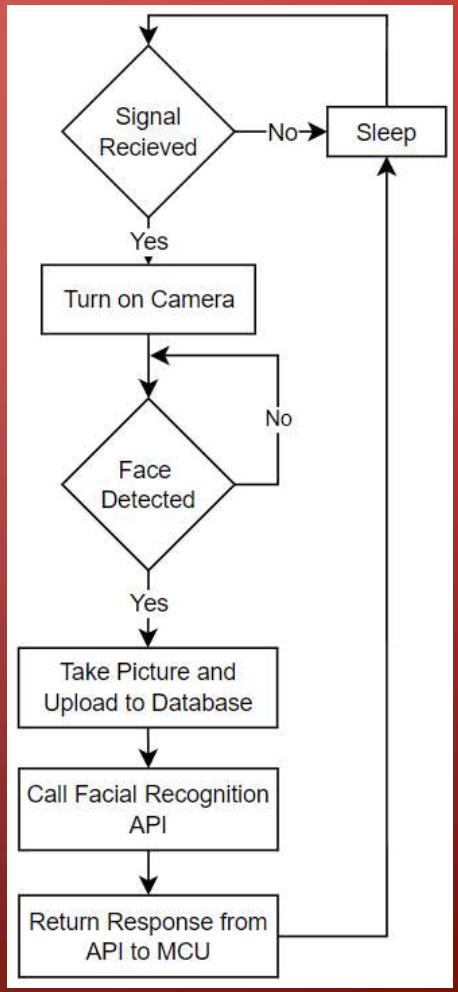
CAMERA MODULE FLOW DIAGRAM



ENCLOSURE AND 3D MODELS

Gabriel Couto

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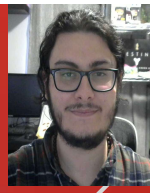
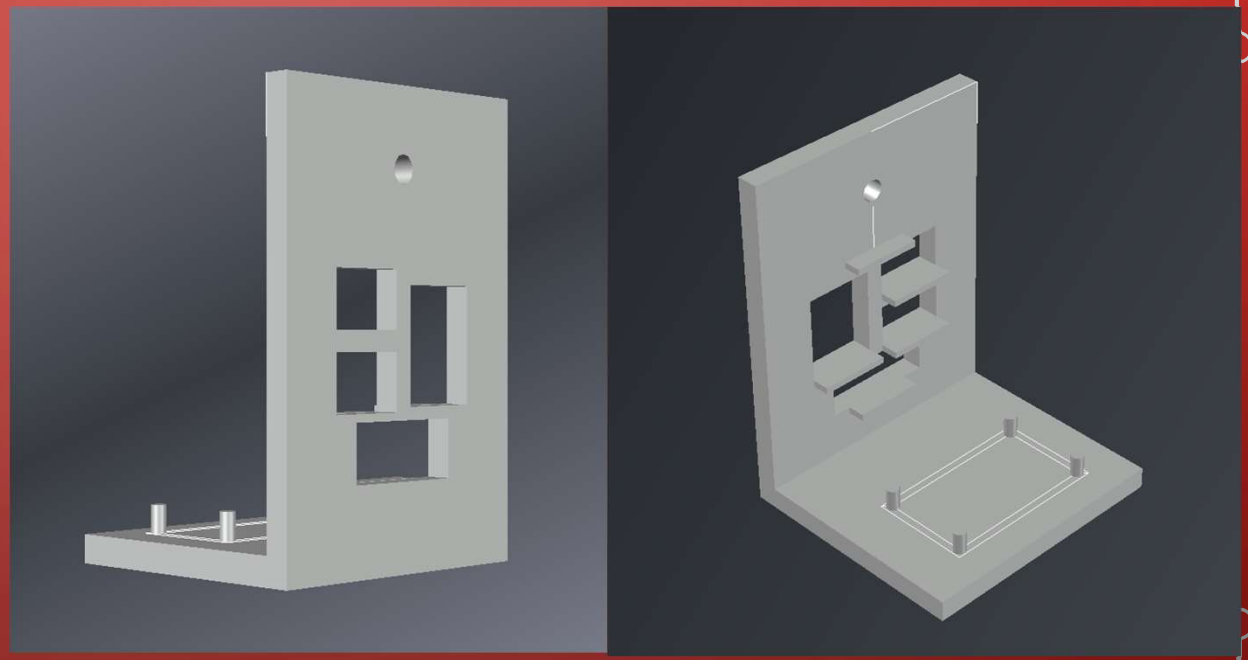


3D MODELS FOR ENCLOSURE



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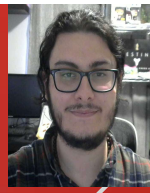
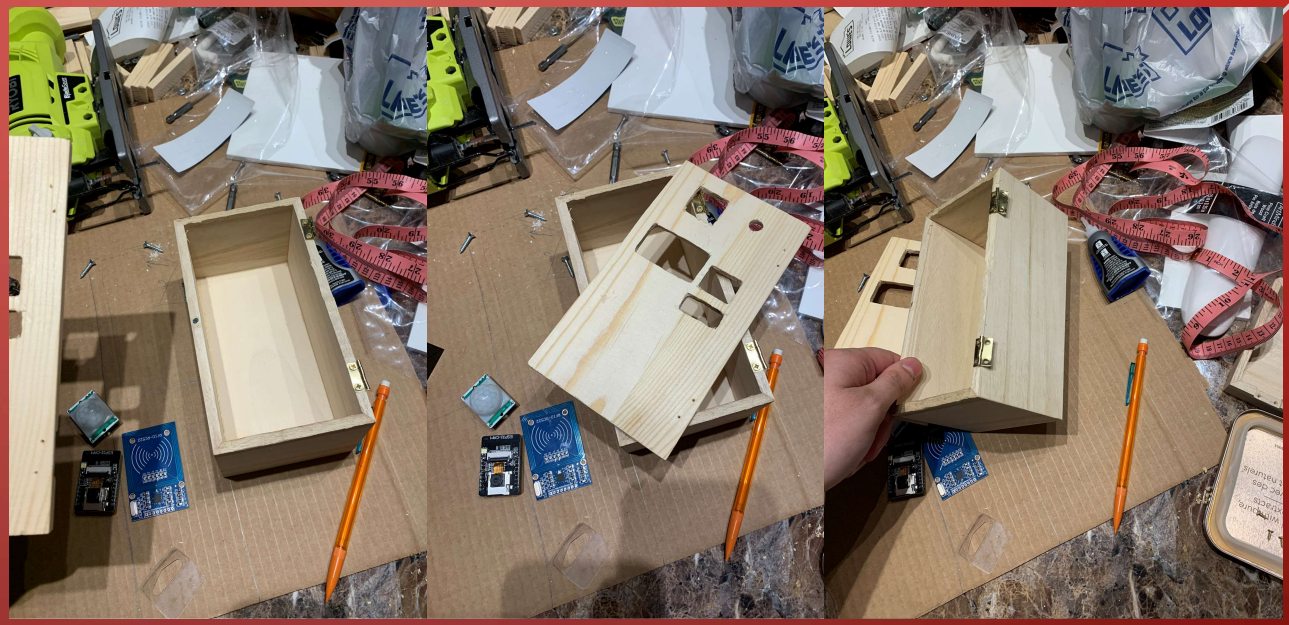


ENCLOSURE FINALIZED



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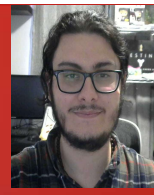
Couto



STANDARDS, CONSTRAINTS, AND DESIGN ISSUES

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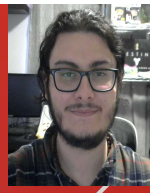

STANDARDS FOR CODING AND OTHER GUIDELINES

- Most modern codes have a detailed guideline that users to follow when coding and is what we will follow for coding in each language. A list of the guidelines we followed can be found on our Project Documentation Table 4.2.
- **SO/IEC 12207:2008 Systems and software engineering — Software life cycle processes-** This standard shows a flowchart of the development of software including development, maintenance, and operation. Along with mentioning how external software should be handled and integrated in the system.

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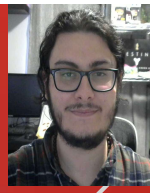

ECONOMIC CONSTRAINTS

The most pressing economic constraint will be the acquisition of parts that are not only cost effective but also designed for longevity.

The project is also self-financed so some parts may need to be found cheaper or to look for other alternatives for the system.

A general shortage of circuit boards in the United States which drastically lowers the number of boards that can be realistically used.

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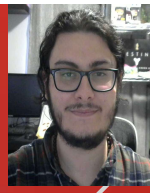

DESIGN ISSUES

Having Multiple Chips on a single board, may cause some minor inconveniences/complications when attempting to program them.

We need voltage regulators to ensure that all the components are getting their recommended voltage levels, this will ensure that components won't cause a surge in our system.

Two components with different voltage requirements may cause problems during transmission of data which required us to implement logic-level converters.

When uploading images to a database, we have decided to convert images to Base64 in order to overcome the issue of storage capacity when uploading a PNG or JPEG.

Matthew
Navarro

ADMINISTRATIVE CONTENT

Matthew Navarro

WORK DISTRIBUTION

P: Primary Focus
S: Secondary Focus

	Matthew Navarro	Kenneth McDonald	Eric Sayegh	Gabriel Couto
Backend	S ✓	S ✓	S ✓	P ✓
Frontend			P ✓	
API	P ✓	S ✓		S ✓
Database Management	P ✓		S ✓	
Software for Components		P ✓		S ✓
PCB Design		P ✓		

Matthew Navarro

BUDGET AND FINANCING

Item	Price (Estimated)	Quantity
Power Supply 9V (8 pack)	$11.87	1
Wi-Fi Module	$3.49	2
Camera	$10.82	2
Solenoid Lock	$14.70	2
Speaker	$12.00	2
Casing	$30.00	2
Fingerprint Scanner	$23.99	2
PCB	$130.00	2
Prototype Parts	$48.00	2
Display	$9.49	2
RFID	$10.80	2
PIR	$10.49	2
Total	$363.65	23

- The price estimate of $363.65 is still our running estimate for the project. This leaves our total for one lock to be $181.25.

- We still plan to split the project 4 ways, so we are currently spending $90.91 per member.

Matthew
Navarro

QUESTIONS?