



# Keyless Entry for a Secure Smart Lock

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# Basic Description

- Motor mounted to single cylinder deadbolt
- Deadbolt mounted to small door frame to simulated actual door
- Multiple ways to unlock the door
- Monitoring the doors state change (when it is unlocked/locked)



# Motivation

- Moving home towards smart system
- Increasing access to home
- Being able to monitor entry/exit
- Not having to worry about being locked out of home



# Goals and Objectives

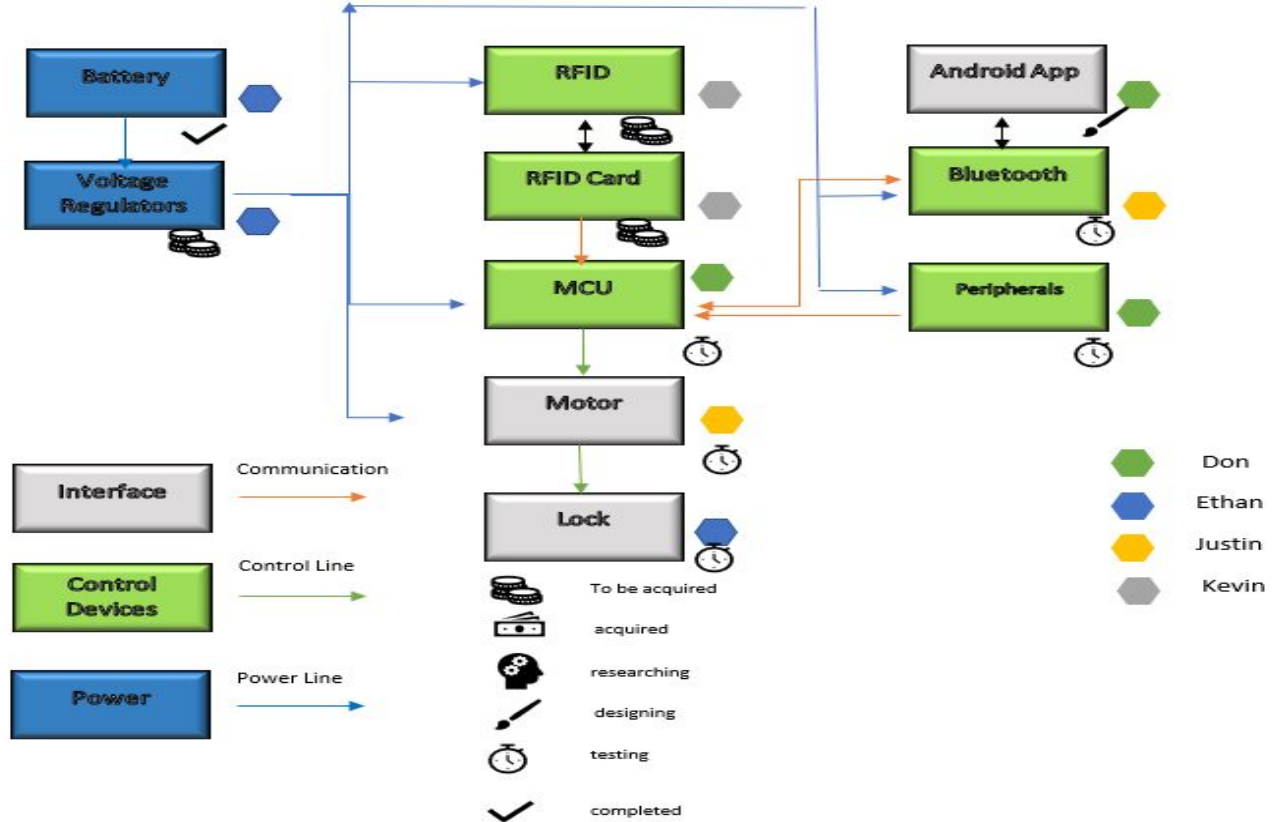
- Power efficient
- Multiple ways to unlock the door
- Monitor when the door is unlocked/locked through App
- Remotely grant access to the home
- Easy to use interface
- Keep developmental costs low



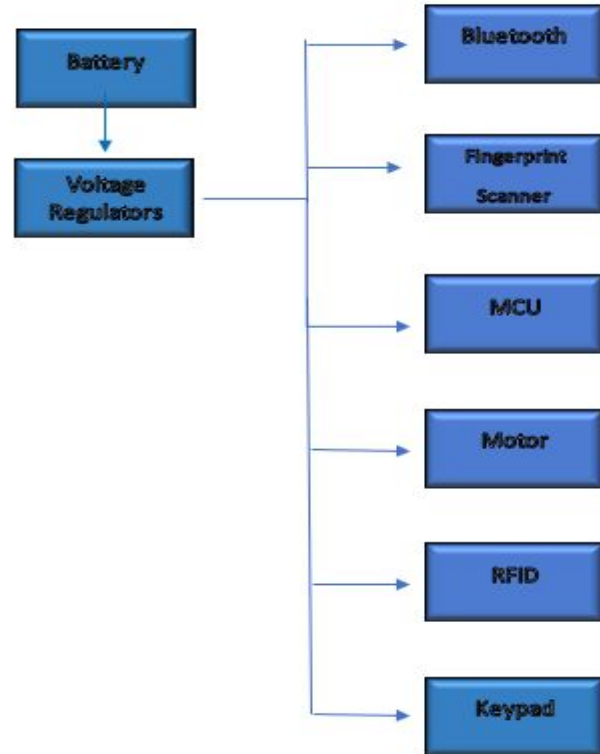
# Specifications

Classification	Description	Value and Units
Performance, Functionality, and Operation	Able to be updated with new operating code	
Environmental	Operating temperature range	15°F-130°F
Environmental	Water resistant	
Economic	Relatively inexpensive to create	<\$100
Energy	Long lasting battery life	Approximately 1 year
Environmental	Recyclable batteries	4x AA
Health and Safety	Safety measures against hacking (i.e. strong password requirements)	
Usability and Maintainability	Simplistic to use.	1 fingerprint sensor, RFID Card, Bluetooth Application
Usability and Maintainability	Functions when battery is dead	Manual unlock/lock
Usability and Maintainability	Easy battery replacement	3-minute replacement time
Manufacturability and Reliability	Reliable Lock/Unlock toggles. (low percentage of error)	<1%

# Block Diagram



# Power Diagram





# Comparison of Power Supply

Type	Voltage (DC)	mAh	Pros	Cons	Cost
<b>AC Adapter</b>	5V	Lifetime	<ul style="list-style-type: none"><li>-Constant power</li><li>-Less maintenance</li></ul>	<ul style="list-style-type: none"><li>-Requires a power cord to be routed to PCB</li><li>-Bulky</li></ul>	\$28
<b>AA Battery</b>	1.5Vx4=6V	2000-3000	<ul style="list-style-type: none"><li>-Readily available</li><li>-Affordable</li><li>-Compact</li><li>-High Capacity</li></ul>	<ul style="list-style-type: none"><li>-Needs replacement overtime</li><li>-Susceptible to corrosion</li></ul>	\$5 for 4
<b>9V Battery</b>	9V	500	<ul style="list-style-type: none"><li>-Higher voltage</li><li>-Compact</li><li>-Cheap</li></ul>	<ul style="list-style-type: none"><li>-Low Capacity</li><li>-Needs replacement overtime</li><li>-Susceptible to corrosion</li></ul>	\$8 for 2



## Required Power of Essential Devices

Device	Voltage	Current
<b>MCU</b>	5V	50mA
<b>Servo</b>	6-7.4V	4.8A (stall current)
<b>RFID</b>	3-5V	55mA (idle: 4.4mA)
<b>Bluetooth</b>	1.8-5.5V	1.7mA (active) 1.3 $\mu$ A (sleep)
<b>Fingerprint Sensor</b>	3.3-5V	<40mA

# Voltage Regulators

5V Regulators	LD117		KA278R05C	
<b>Input Voltage</b>	7V (max)		35V (max)	
<b>Output Voltage</b>	4.9-5.1V		4.88-5.12V	
<b>Quiescent Current</b>	5-10mA		10ma	
<b>Output Current</b>	800-1300mA		2A (max)	
<b>Dropout Voltage</b>	Io=100mA	1-1.1V	Io=1A	0.5V
	Io=500mA	1.05-1.15V		
	Io=800mA	1.10-1.2V		
<b>Price</b>	\$0.15		\$1.17	

3.3V Regulators	LP2986		MAX1651	
<b>Input Voltage</b>	16V (max)		3-16V	
<b>Output Voltage</b>	3.3V		3.17-3.43V	
<b>Quiescent Current</b>	850µA		100µA (max)	
<b>Output Current</b>	350mA (max)		1A (max)	
<b>Dropout Voltage</b>	Io=1mA	7mV	Io=500mA	300mv
	Io=50mA	225mV		
	Io=150mA	500mV		
<b>Price</b>	\$0.15		\$2.13	



# Motor Comparisons

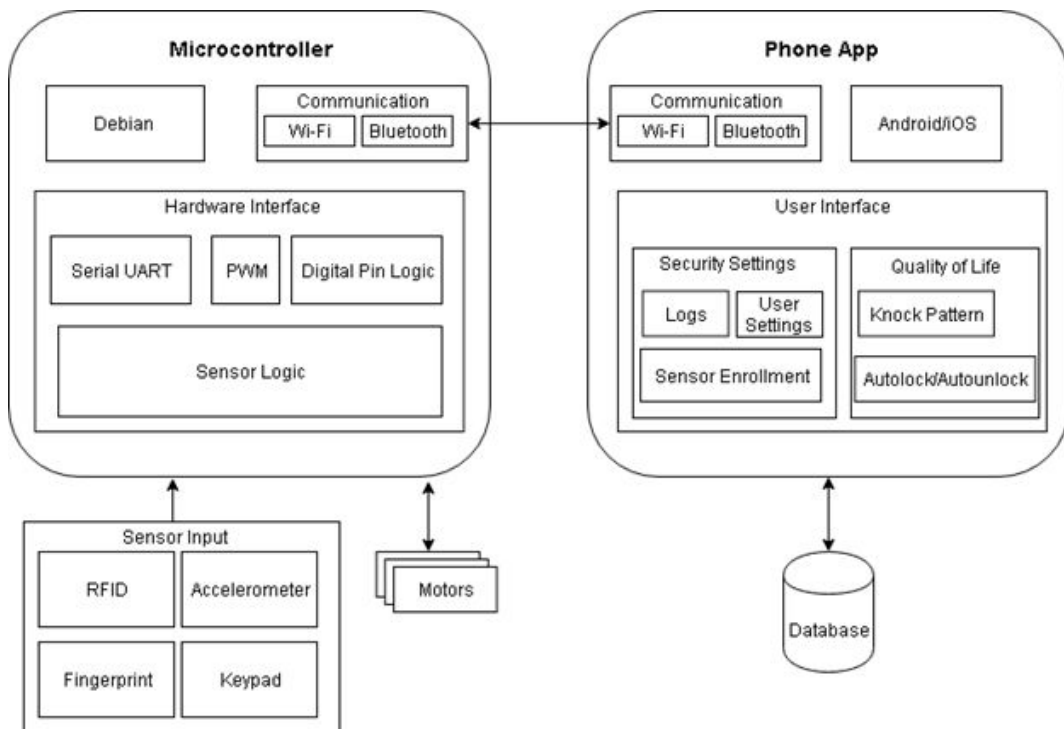
Type	Servo	Stepper	DC
<b>Voltage</b>	6-7.4V	2.9V	6-12V
<b>Stall Torque (oz/cm)</b>	402	18.41	285.04
<b>Max Travel (deg)</b>	198	1.8 (increments)	-
<b>Current Drain</b>	4.8A (stall) 300mA (no load) 9mA (idle)	0.7A (per phase)	360mA (stall) 30mA (no load)
<b>Motor Driver Needed?</b>	No	Yes	Yes
<b>Price</b>	NA	\$12.99	\$19.90



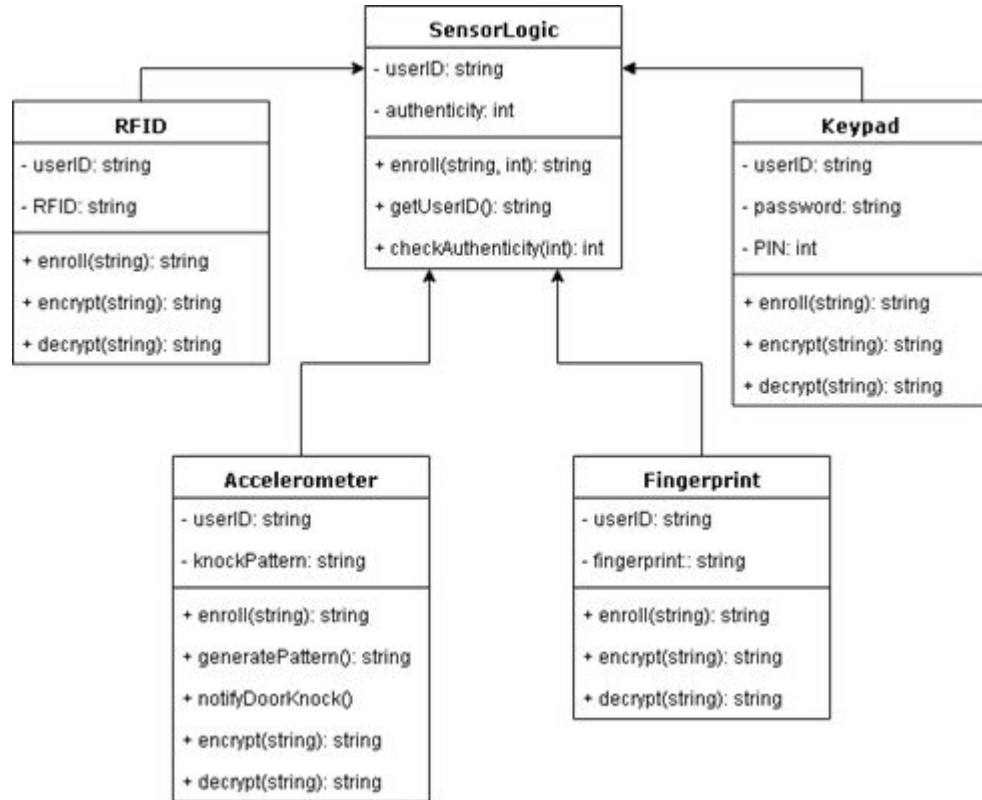
# Software Design

- Hardware Interface
  - Sensor Logic
    - Sensor Input
- Software Interface
  - Sensor Enrollment
  - Quality of Life
- Database

# Software Design



# Sensor Logic



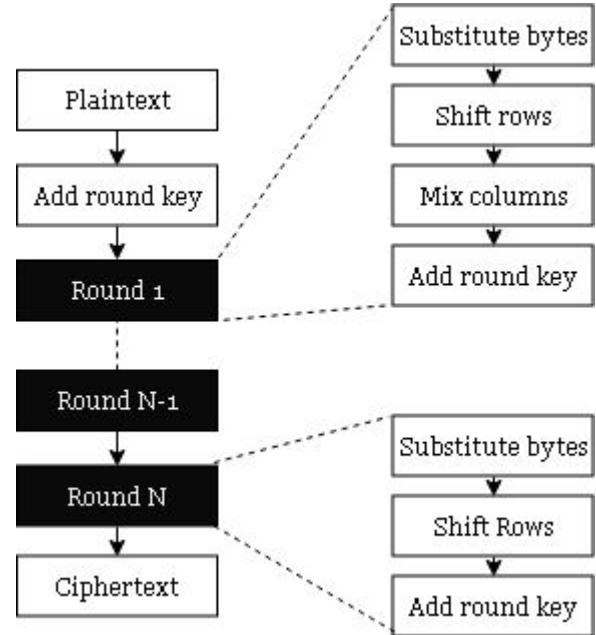


# Federal Information Processing Standard (FIPS)

- FIPS is a U.S. government computer security standard used to approve cryptographic modules.
  - Encryption
  - Hashing
  - Random Number Generation (RNG)
    - Digital Secure Standard (FIPS 186-4)
    - Cryptographically Secure Random Number Generators (CSRNG)

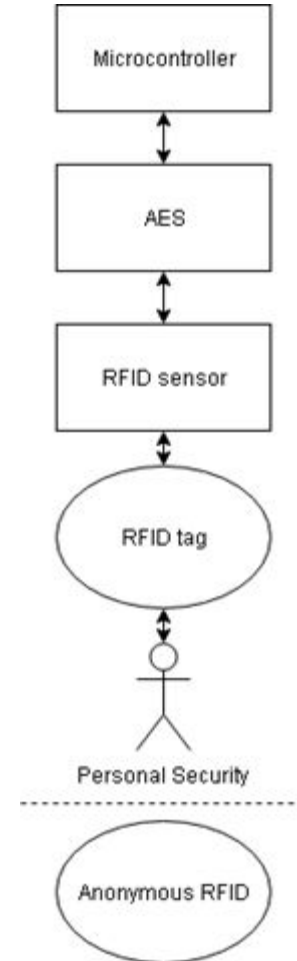
# Advanced Encryption Standard (AES)

- Also known as, Rijndael.
  - Winner of the AES competition.
- Used by the U.S. Government.
  - Fast
  - Simple
- Alternatives
  - Twofish- More complex
  - Serpent- Slower
    - Rijndael- 10 rounds
    - Serpent- 32 rounds



# Encryption Implementation

- Secure Communication
  - Ciphertext instead of Plaintext
- Personal Security
  - User is responsible for keeping tag secure.
  - Authentication can be recalibrated.



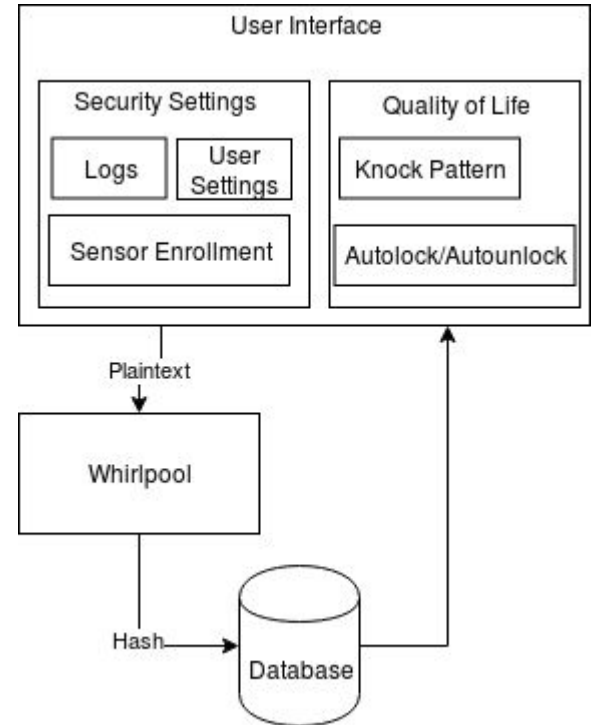


# Hashing Algorithm

<b>Algorithm</b>	MD5	SHA-256	Whirlpool
<b>Output Size</b>	128 bits	256 bits	512 bits
<b>Rounds</b>	64	64	10
<b>Notes</b>	Collision vulnerable	NSA	Based off of AES

# Hash Implementation

- Hash sensitive data into database.
  - Sensor data, User Settings
- Hashes are irreversible
  - Hackers can't determine the data from the hash.
  - Hash Comparison






# Oracle Cloud Database

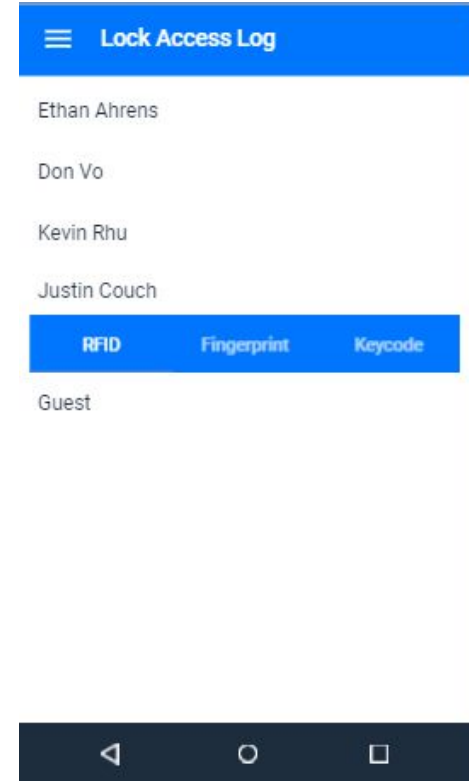
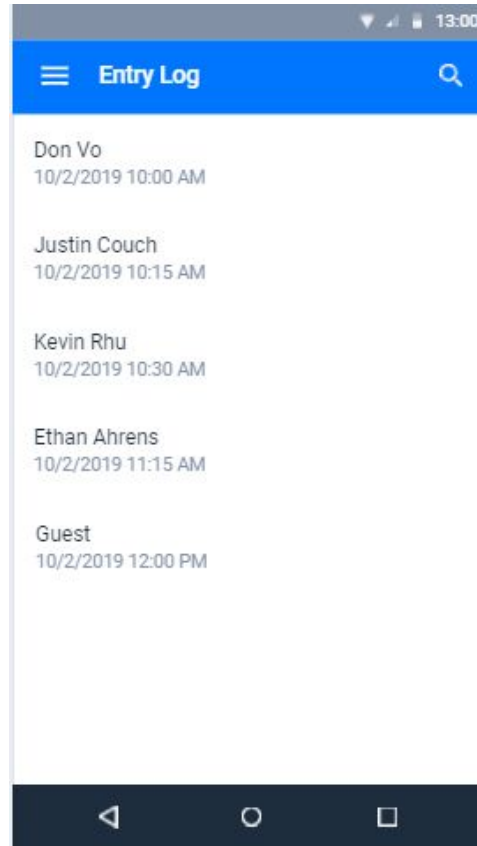
- Oracle Cloud Database
  - Wi-Fi compatibility
  - Multiple security features
- Alternatives
  - Amazon Web Services
  - Amazon Relational Database Service
- Amazon Alexa





# Application Layout and Features

- Entry Log
- Lock Access Log
- Lock Access Control
- Virtual Keys

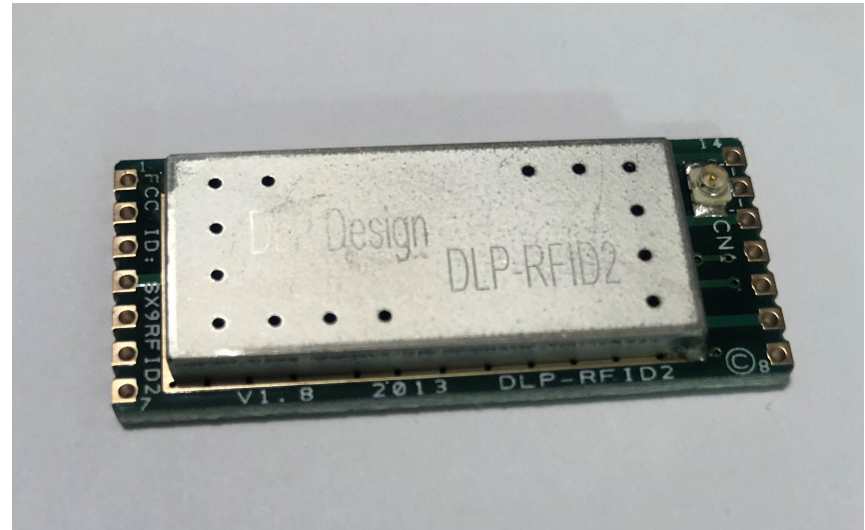


# RFID Sensor

- Choice: DLP-RFID2
- High Frequency RFID
- Operating Voltage: 3-5V
- USB and TTL interface
- Price Point

**Table 8: RFID Sensor Comparison**

Model	Vendor	Price	Pin Count
DLP-RFID2	Mouser/Digikey	\$34.95	14
RWD-QT-R2-ND	Digikey	\$40.37	24
RI-STU-MRD2	Digikey	\$92.40	30



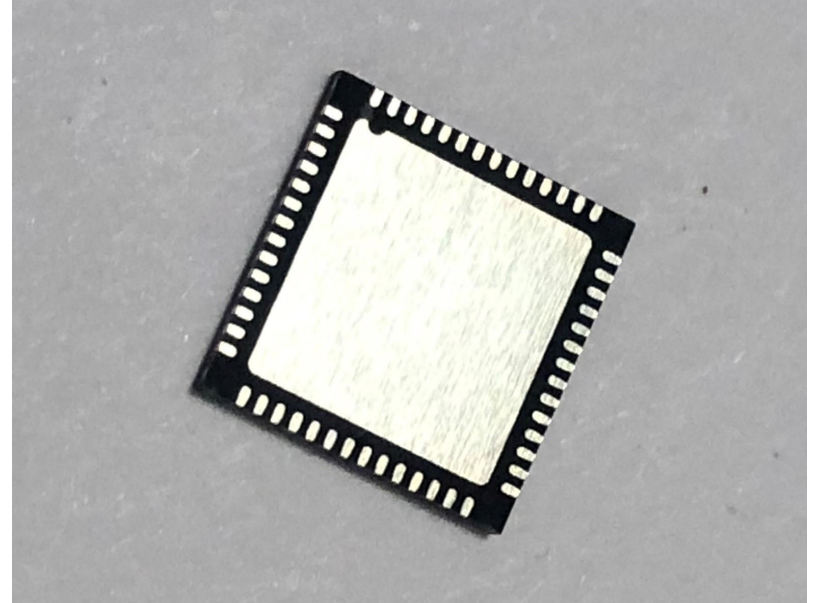


# PSoC Bluetooth

- Programmable System on Chip
- Have their own CPU Core
- Scalable & Reconfigurable
- Has separate memory spaces:
  - Paged SRAM for data
  - Flash Memory for instructions & fixed data.
  - Input/Output registers

# Bluetooth Choice

- Cypress PSoC 4100\_BLE
  - 256 KB of Flash Memory
  - Easily Programmable
  - Data rate of about 1 Mbps
  - BLE Device (low energy)
    - Operating Voltage of 1.8 V - 5.5 V
  - Range of 50 meters.
  - Very Small 7 mm x 7 mm x 0.55 mm





## Bluetooth (Cont...)

- The bluetooth device is set to be a part of our center unit.
- Most connections are to be done through it.
- Has up to 36 programmable pins.
- Gives us the ability to use phones as authenticator devices.
- Most power efficient choice and helps support our microcontroller device.



# Fingerprint Sensor Options

- **Capacitive Fingerprint Sensor**
  - Based on a complex pattern of electrical currents that forms the image of a fingerprint.
  - Durable.
  - Always require the actual fingerprint, so it won't work off a picture.
- **Optical Fingerprint Sensor**
  - Uses a camera to capture images.
  - Finite Resolution.
  - Easy to read images of fingerprints shows a weakness in security.
  - Expensive due to the camera.



# Fingerprint Sensor Choice

- We chose the capacitive fingerprint sensor sold by Waveshare.
  - Communicates in both USB or UART interface (UART is the main interface we will be working on)
  - Operating Voltage of 3.3V - 5V
  - Dynamic Current of 40 mA.
  - Dimensions of 45 mm x 30 mm for the module and 33.4 mm x 20 mm for the sensor.
  - Less than 0.1 % Rejection Rate

# Keypad Choice

- Sparkfun Basic Wired Keypad
  - 12 Key Keypad that contains 0-9 keys.
  - Keypress Resistance is between 10 and 150 ohms.
  - Relatively Cheap
  - Easy to implement to design.





# Keypad Modifications

- The keypad can be modified to only require one pin rather than two.
- This is done by adding resistors around the different keys in the keypad.
- Different values are read pertaining to different key values.
- This method allows us to save the use of a pin from our central unit.



# Division of Labor

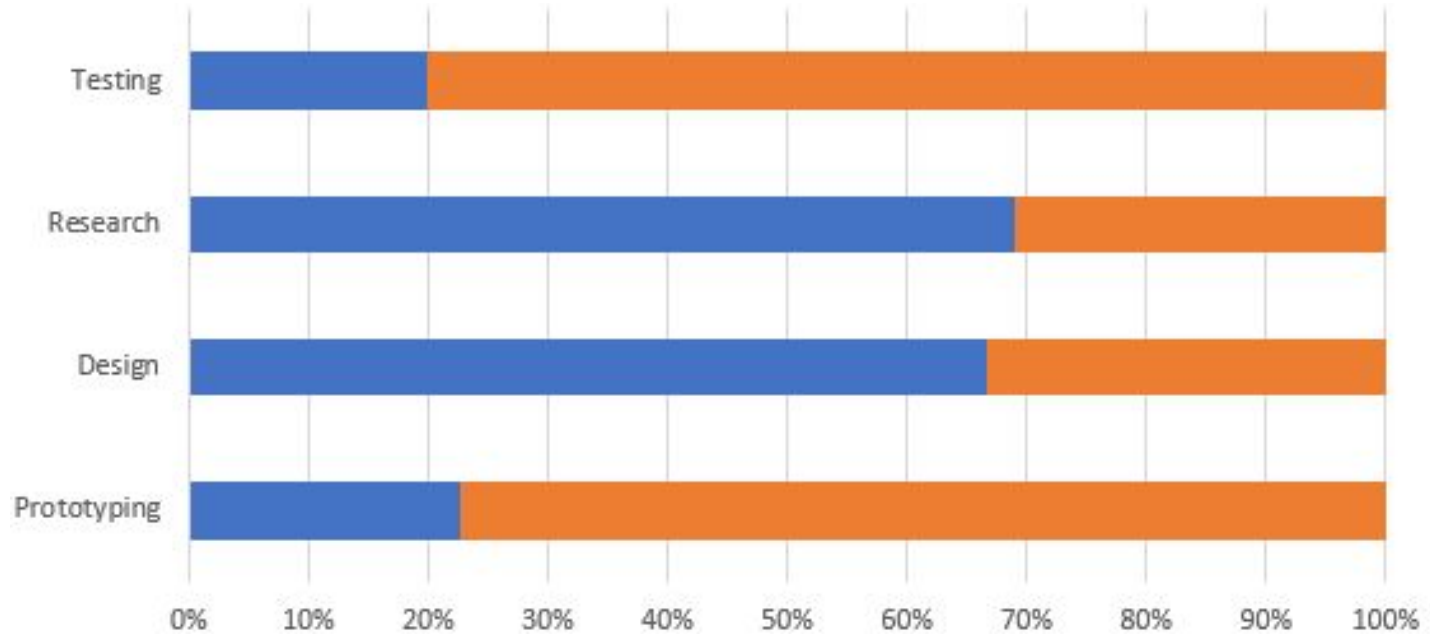
Name	Power	Motor	MCU	Bluetooth	RFID	Key pad	Fingerprint	Software	Hardware
Don			1	2	2	2	2	1	
Kevin				1	2	2	1	2	2
Ethan	1	1	2				2		1
Justin	2	2			1	1			2

Legend:

1-Primary Designer

2- Secondary Designer

# Progress Report





# Budget

HS-7950TH Servo Motor	N/A
DLP-RFID2-EDK RFID Sensor	\$34.95
Bluetooth Chip	\$1.28
Capacitive Fingerprint Sensor	\$38.99
COM-14662 Keypad	\$4.50
ARDUINO MEGA 2560 REV3	\$38.50
ESP8266 WiFi Chip	\$1.60
Linear Regulator	N/A
Total	\$119.82

# Issues

- Time Management
  - Balancing other classes, work and internships.
- Originally planned to use a beagleboard, but its compatibility with arduino proved to be an issue, so we switched boards.
- Little to no experience in:
  - 3D Printing
  - PCB Design





Questions?