Pill^3

Senior Design Project: Group 16

DESIGN GOAL

“Create a device to aid people who forget to take their medicine”

- Simple to set up and use
- Have IOT connectivity
- An affordable option

Our Team

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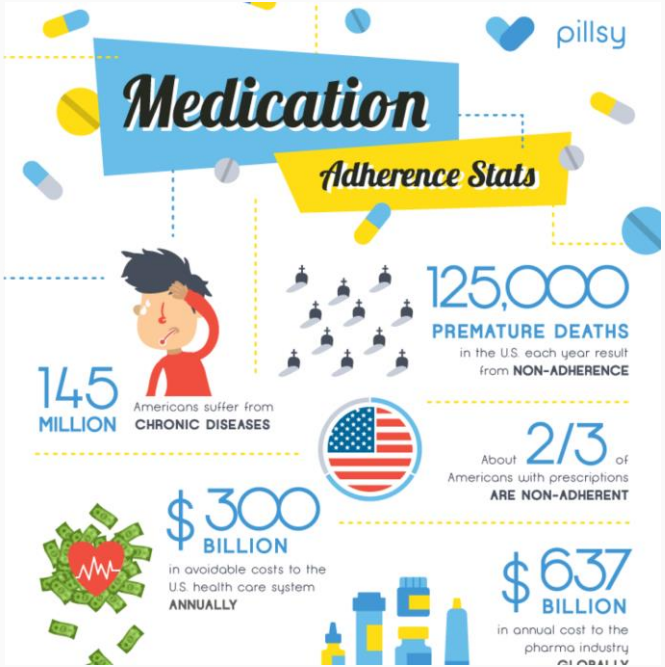


PROJECT MOTIVATION

Prescription non-adherence, both intentional and unintentional, is one of the biggest issues within the American medical community.

- Contributes thousands of tons to medical waste
- Results in additional spending on medication or procedures
- May lead to otherwise avoidable life-threatening illness and injury

The issue of non-adherence has affected the daily lives of all of our group members in different ways.

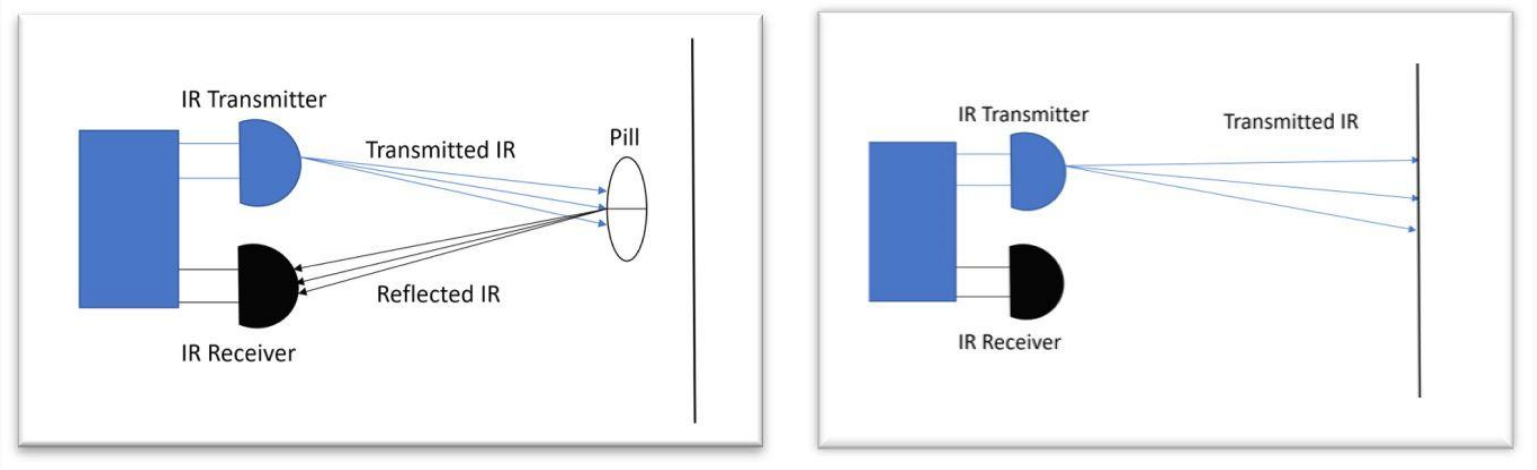
OVERALL DESIGN

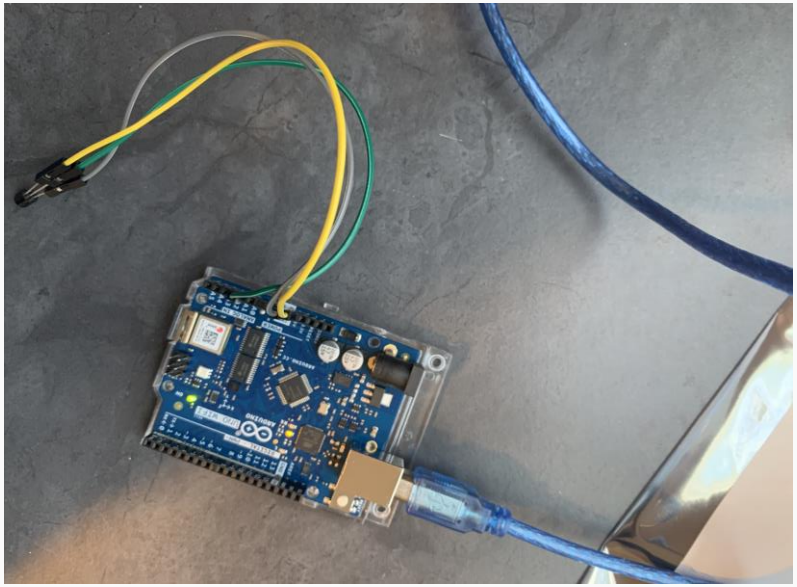
The original Pill^3 dispenser design consisted of three main subsystems.

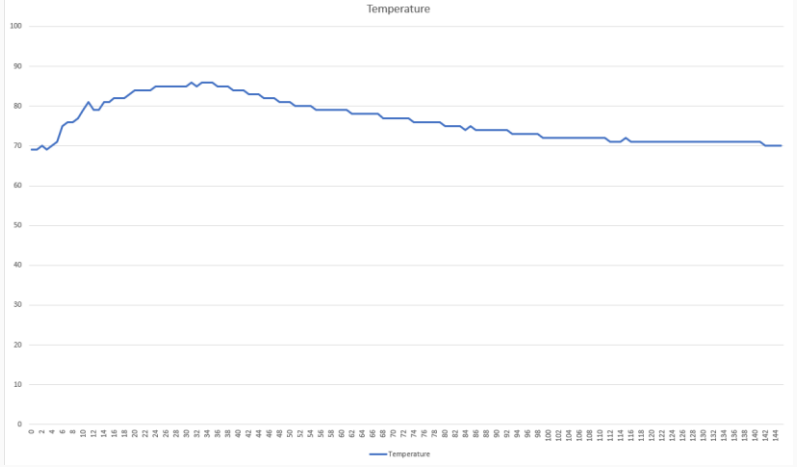
- First Subsystem: Pill storage chambers
  - Pill tracking
  - Pill distribution
  - Size sorting
- Second Subsystem: Device status sensors
  - Temperature
  - Clock
- Third Subsystem: User notifications
  - Audio
  - Visual
  - Smartphone App

IR SENSORS

Simple infrared emitter and receiver sensor packages were used to measure object movement. Through this, we were able to track when pills passed a certain point on the distribution line and subtract them from the total stored amount. Using this method, one sensor would be able to detect pills of any size using the same metric.







TEMPERATURE SENSOR

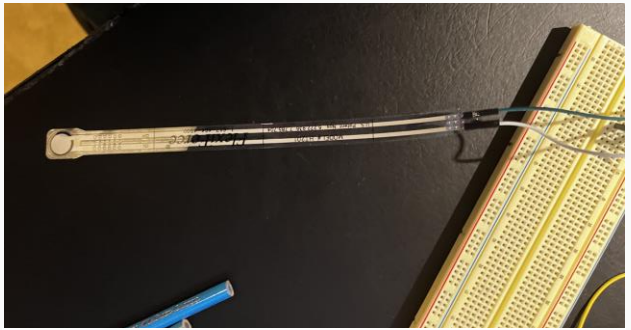
A LMT85LP temperature sensor was used to ensure that the device is operating at safe temperature levels. The overall temperature of the device was almost measured to ensure that the medicine was stored at an appropriate level.

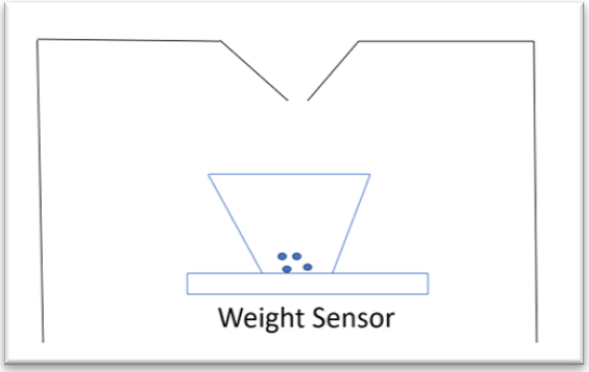
This sensor acts as a variable resistor through which changes in voltage can be linked to changes in temperature. From there the information can be applied to either maintain the temperature or alert the user to a potential issue.

PRESSURE SENSOR

The Flexiforce pressure sensor was used to determine if there is a container positioned below the dispenser for the medicine to be deposited into. This helps to prevent the device from dispensing too many pills or spilling the dispensed pills onto a random surface.

The sensor is adjustable to work with any common household dish or cup, although it does come with a specified receptacle.



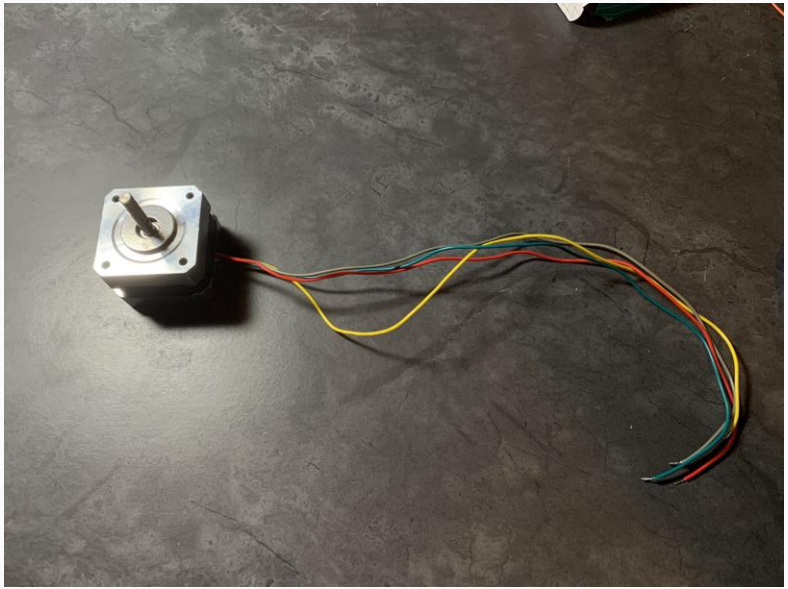


STEPPER MOTORS

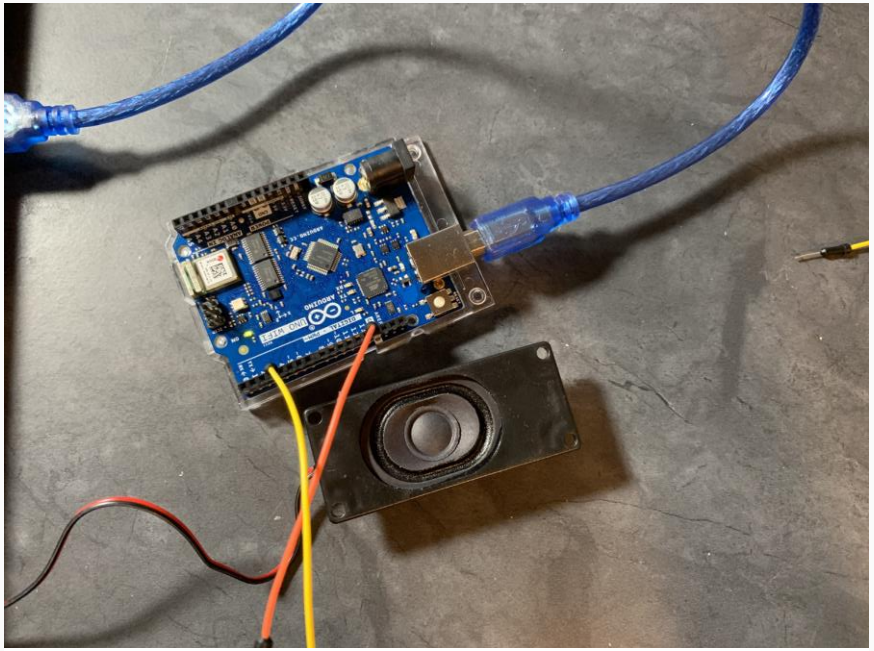
For what we wanted to achieve, a stepper motor was the most sensible choice as it had a full range of rotation and could start and stop more accurately than DC motors of the same power requirements. This specific adafruit stepper motor was chosen as it combines the right amount of precision and strength needed to control the pill distribution device.

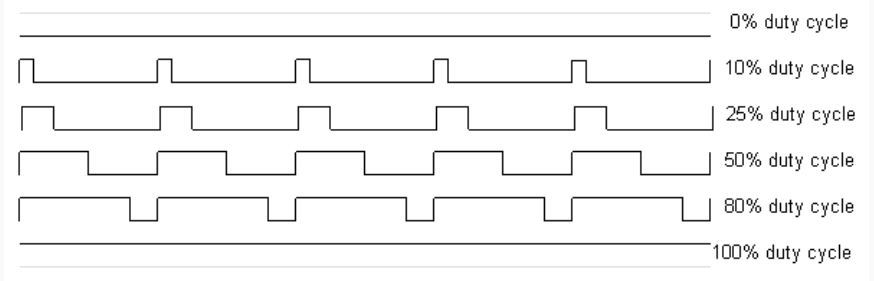
Adafruit NEMA-17 stepper motor specifications

- 0.2 Nm of torque
- 360 degrees of rotation
- 1.8 degrees of accuracy



SPEAKER

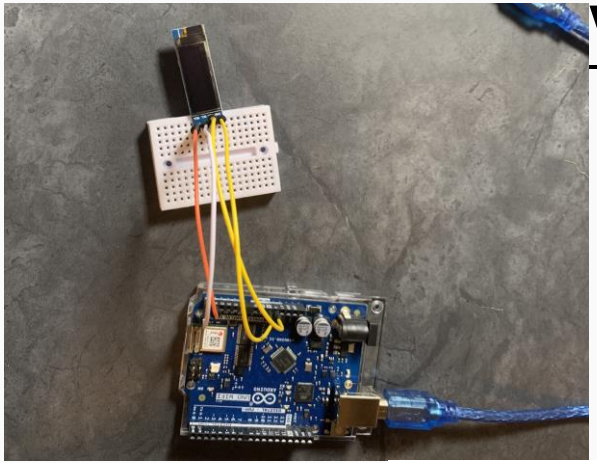




The speaker used was simple to implement and customize, and allowed for the user to have auditory alerts that can be heard from several rooms away. We decided to forego an audio driver in favor of driving the speaker with a pulse width modulator voltage. Changes in voltage and duty cycle translate to changes in pitch and volume of the tone produced

DISPLAY

The tertiary user alert system implemented into the Pill^3 was a 0.91” OLED screen. It can both indicate that a prescription is ready and display information about the system at a glance without needing to communicate with the smartphone application. It will typically display general system and environmental information like the time and temperature.

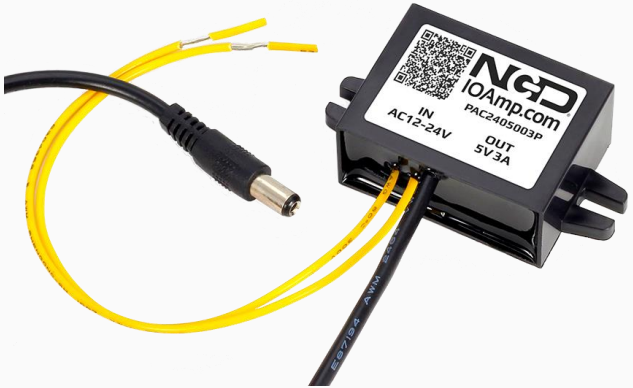


POWER SUPPLY

When comparing different types of power sources we can see that AC power from a wall outlet…

- Long lifecycle
- Great energy storage
- Low cost
- Versatility
- Does not need replacement
- Is more reliable than solar energy
- Provides constant power
- Provides more interior room in the design of the device

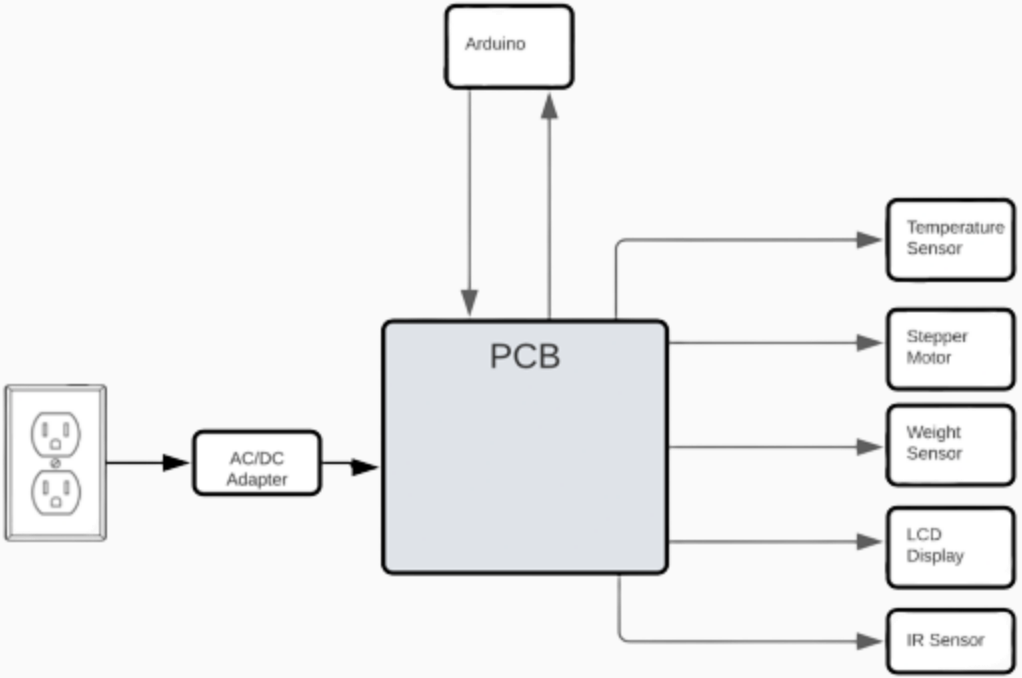
However…
For our device to function, we need to have an outlet available.
Cords can also cause unneeded messes to occur



POWER DISTRIBUTION

Hardware	Voltage Requirement
Arduino UNO Wi-Fi REV2	12 V
Adafruit NEMA-17 Motor	12 V
Obstacle avoidance IR Sensor	3.3 V - 5 V
FlexiForce Weight Sensor	5 V
MakerFocus Display	3.3 V - 5 V
LMT85LP Temp. Sensor	3.3 V - 5 V

OUR DESIGN


Arduino
PCB
AC/DC
Adapter
Temperature
Sensor
Stepper
Motor
Weight
Sensor
LCD
Display
IR Sensor

CHALLENGES FACED FOR POWER SUPPLY

Our original design was to make our own AC/DC converter this however would

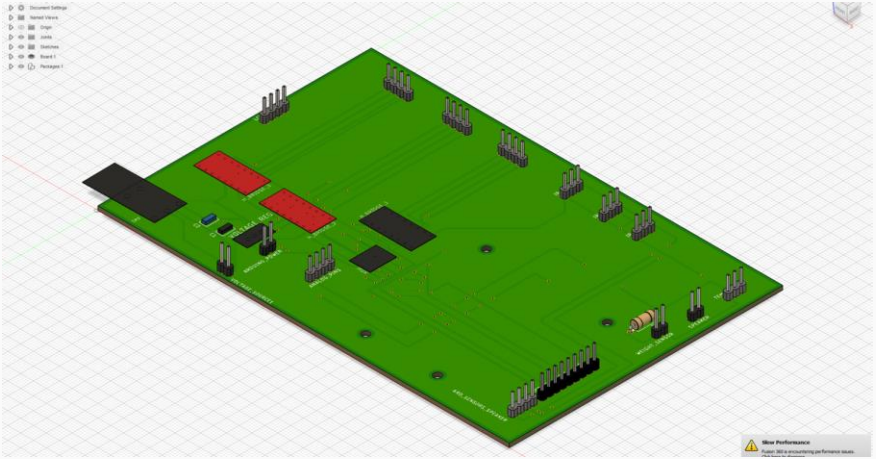
- Make us be more prone to error
- Increase our cost
- Make the design more difficult

By using our current design, we eliminate all these issues and can primary focus on the functionalities of the Pill[3]

PCB DESIGN

During the overall design of the Pill^3 certain components were incorporated in the PCB board that will be used for the project. Throughout the development of the board certain decisions were made:

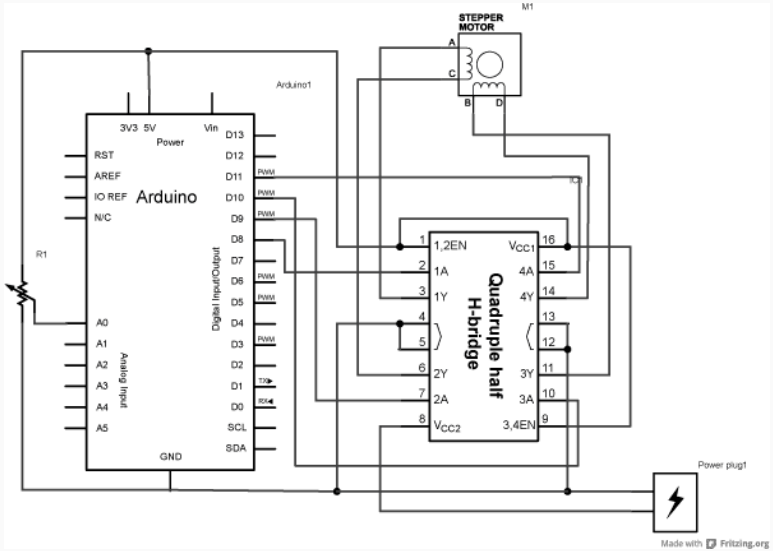
- Software
- Components
- Vendors
- MCU
- Voltage Regulators
    - Efficiency vs Functionality



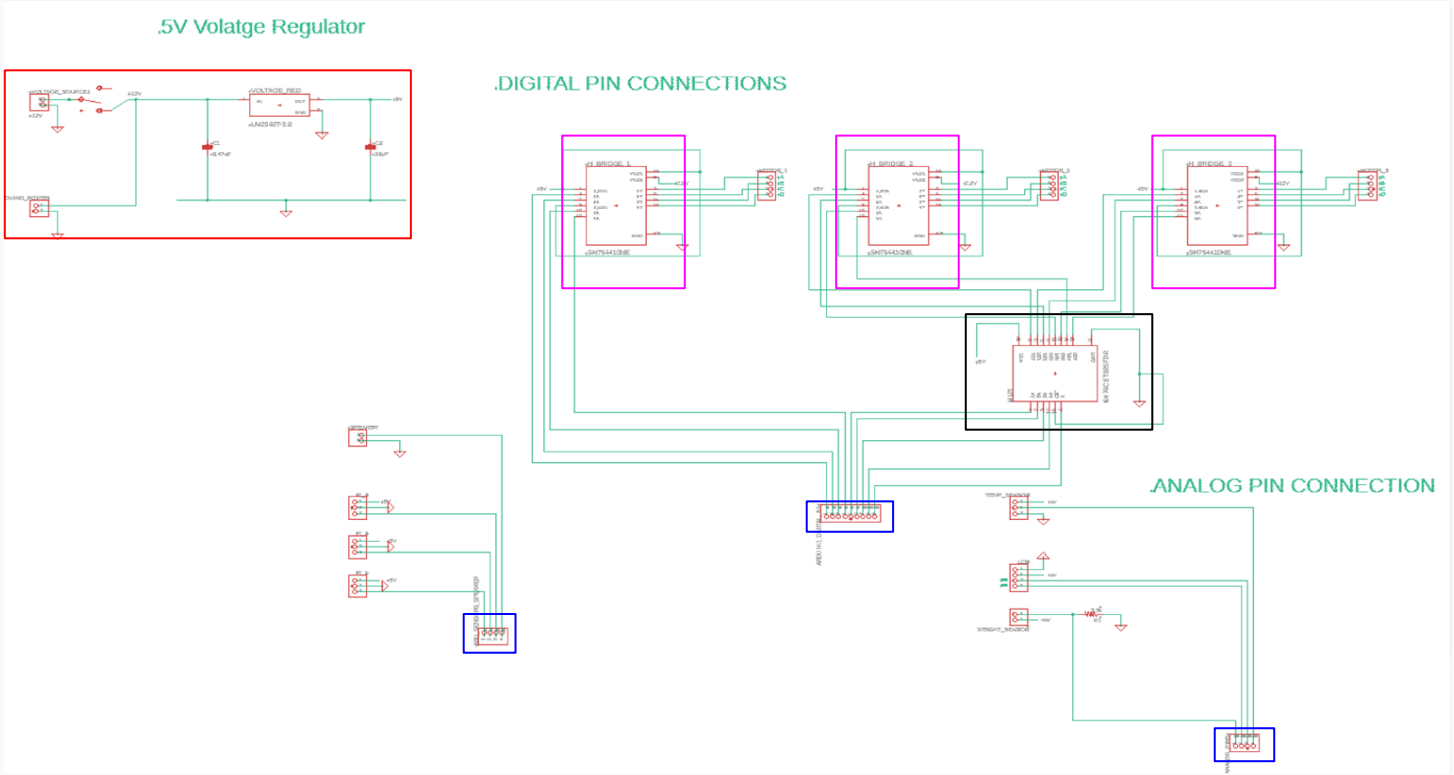
PCB DESIGN CHALLENGES

Originally for the PCB design we had various ideas on how to incorporate certain components, however, in the process of making the PCB we encounter certain issues that lead us to incorporate more components that were not predicted at the early stages of the design. Some of these challenges faced during the design were:

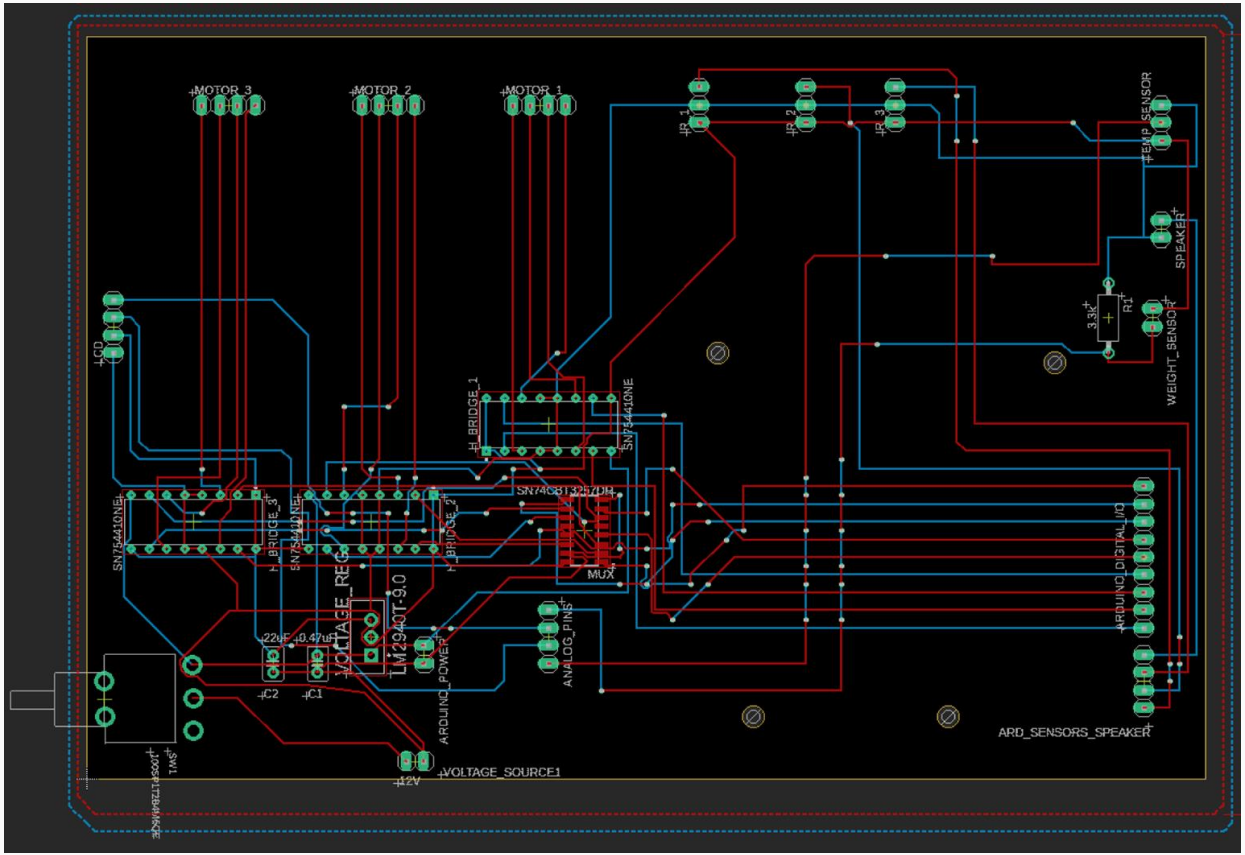
- Component Shortage
- Multiplexer/Demultiplexer
- Quadruple H-Bridge
- AC/DC Voltage



PCB SCHEMATIC



PCB BOARD


MOTOR_3
MOTOR_2
MOTOR_1
IR_1
IR_2
IR_3
TEMP_SENSOR
SPEAKER
3.3k
R1
WEIGHT_SENSOR
LCD
H_BRIDGE_1
SN754410NE
SN74CBT3257DR
MUX
H_BRIDGE_3
H_BRIDGE_4
H_BRIDGE_2
VOLTAGE_REG
LM2940T-9.0
22uF
0.47uF
C2
C1
ARDUINO_POWER
ANALOG_PINS
ARDUINO_DIGITAL_I/O
ARD_SENSORS_SPEAKER
12V
VOLTAGE_SOURCE1
TMS

WHY A MOBILE APPLICATION?

For a platform, it needs to be as accessible as possible. Using a mobile device allows easy notifications and on-the-go management of the system.

Not using a mobile application requires the user to have to be around either a computer or the actual device. This is not optimal and we would have to use a text message to notify the user or not notify them at all.

Platform	Requires Internet	Requires Backend	Notifications	Support	Modularity
Native Screen	No	No	Around device	2/5	Not very modular
Web Application	Yes	Yes	Around PC	5/5	Very modular
Desktop Application	Yes	Yes	Around PC	3/5	Somewhat modular
Mobile Application	Yes	Yes	Everywhere	4/5	Very modular

WHAT PLATFORM ON MOBILE?

	Frontend Framework/ Language	Android	iOS	Hot-reloading	Ease of Use	Support
Native to Android or iOS	Java/Kotlin	Yes	No	No	3/5	3/5
	Swift	No	Yes	No	4/5	3/5
Up to preference	React Native	Yes	Yes	Yes	5/5	5/5
	Flutter	Yes	Yes	Yes	5/5	3/5

Our software lead has used React Native and React in multiple projects so it made the most sense to use React. Javascript is also an industry-standard compared to Dart- which Flutter uses.

GOOGLE FIREBASE CLOUD DATABASE

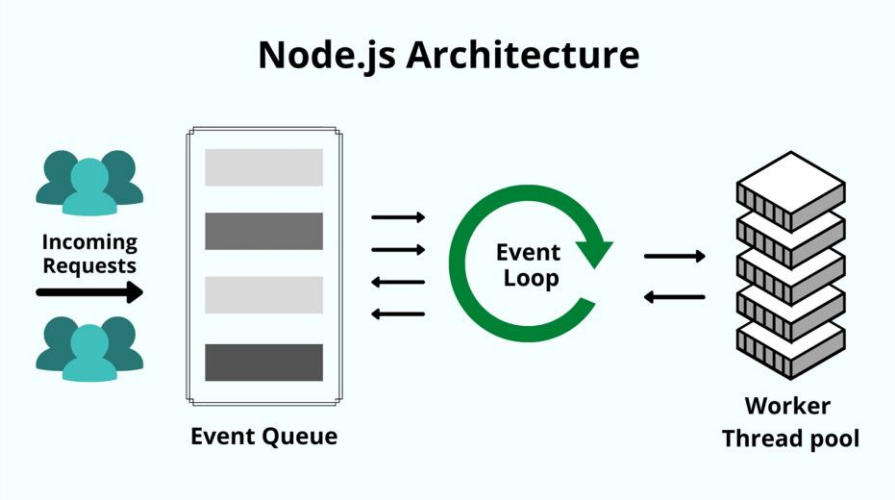
Our software lead has used Firebase and AWS before so it made sense to use either. AWS in general is more complicated and not really used as much for smaller projects due to its complexity.

Data	Offers NoSQL	Free tier	Infrastructure Complication
Google Firebase	Yes	Yes	2/5
Amazon Web Services	Yes	Yes	5/5
Microsoft Azure	Yes	Yes	4/5
Heroku	Yes	Yes; but at a much lower scale	2/5

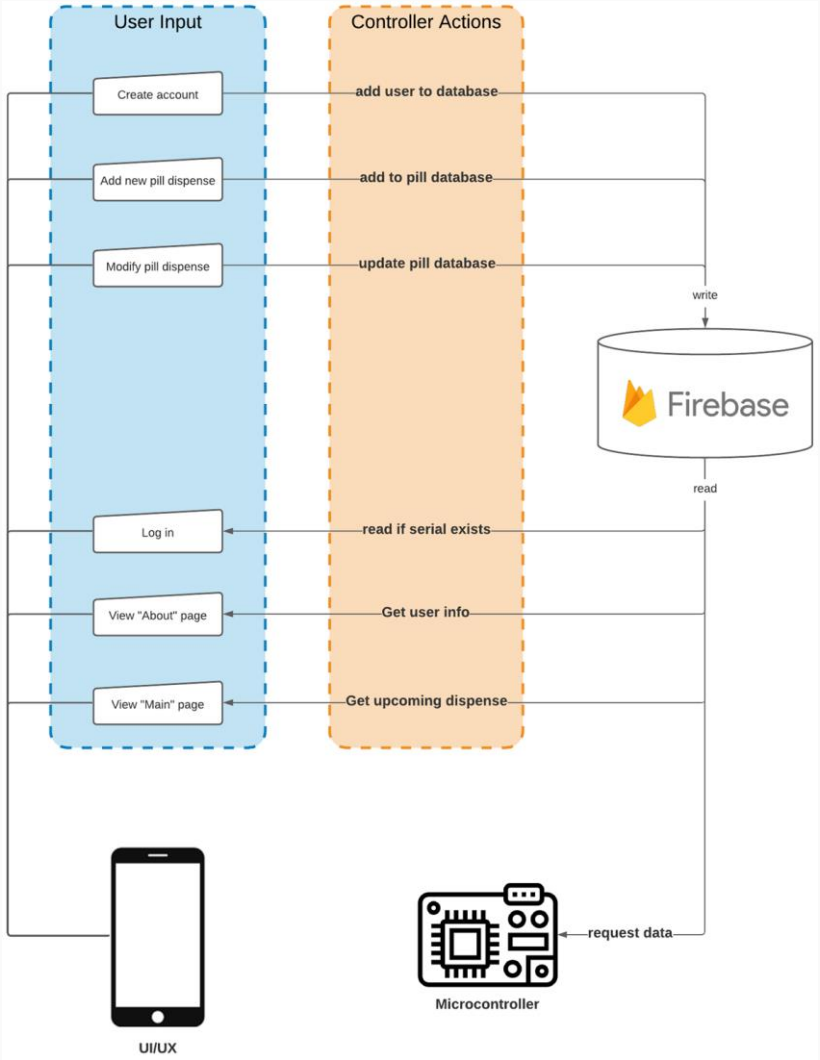
Another big factor is due to Firebase's NoSQL database, which stores data as JSON-like data in documents and collections. This is easier to manage for accounts and also offers basic security features such as encryption and authorization.

NODE.JS BACKEND SERVICE

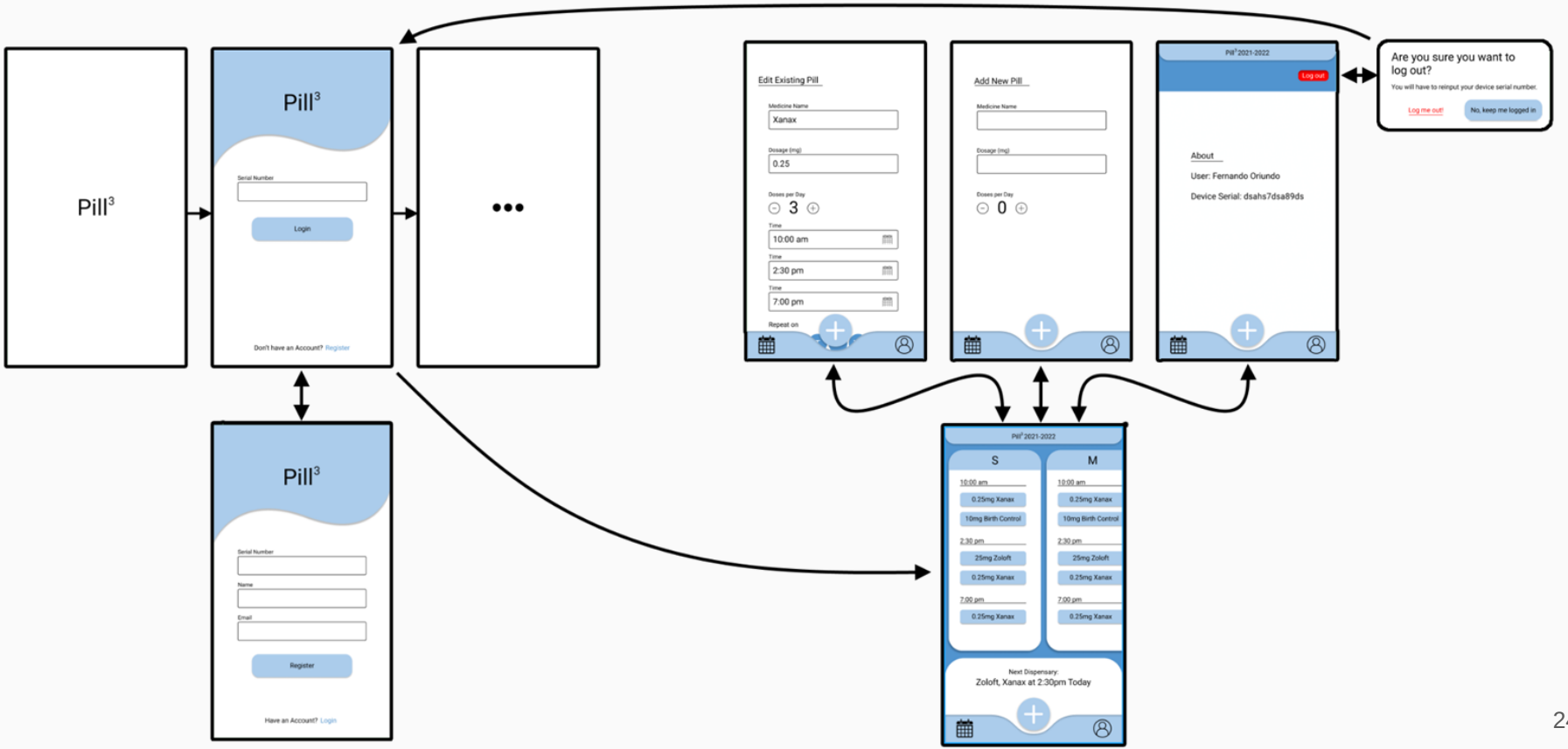
We are using Node.js as it is one of the easiest-to-use, most industry-wide, and has very little competition when it comes to asynchronous I/O in most applications. It is an event-driven architecture and makes communication from requests to data straightforward.



BACKEND DESIGN



UI/UX DESIGN


Pill³
Pill³
Serial Number
Login
Don't have an Account? Register
Pill³
Serial Number
Name
Email
Register
Have an Account? Login
Edit Existing Pill
Medicine Name
Xanax
Dosage (mg)
0.25
Doses per Day
3
Time
10:00 am
Time
2:30 pm
Time
7:00 pm
Repeat on
Add New Pill
Medicine Name
Dosage (mg)
Doses per Day
0
Pill³ 2021-2022
Log out
About
User: Fernando Oriundo
Device Serial: dsahs7dsa89ds
Are you sure you want to log out?
You will have to reinput your device serial number.
Log me out!
No, keep me logged in
Pill³ 2021-2022
S
M
10:00 am
0.25mg Xanax
10mg Birth Control
2:30 pm
25mg Zoloft
0.25mg Xanax
7:00 pm
0.25mg Xanax
Next Dispensary:
Zoloft, Xanax at 2:30pm Today

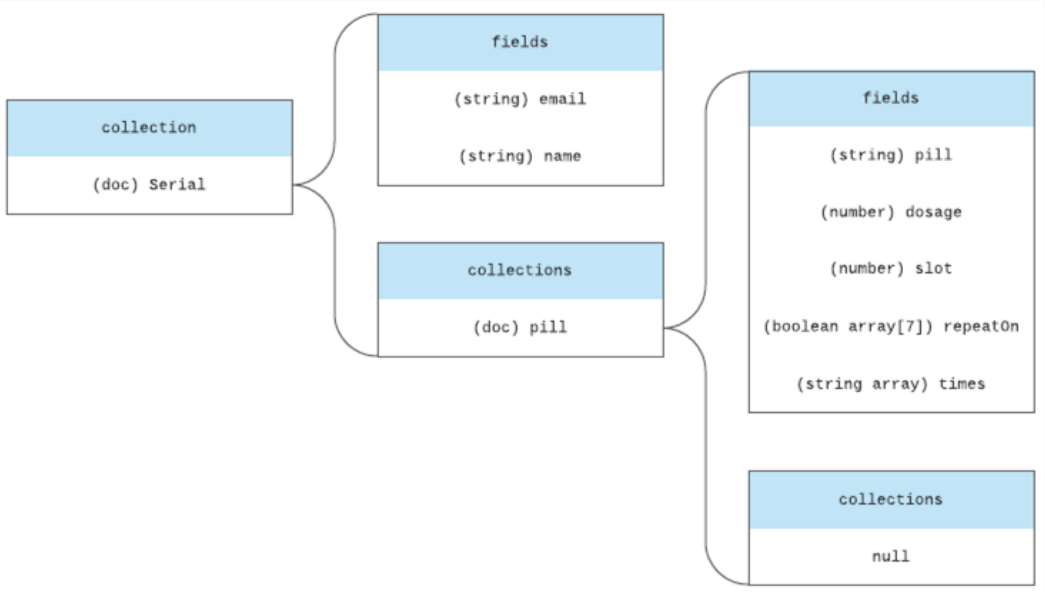
DASHBOARD


Tap to edit existing pills
Swipe to see other day's pill dispense schedule
See next dispense
Add new pill
S
M
Next Dispensary:
Zoloft, Xanax at 2:30pm Today

NOSQL DATABASE DESIGN

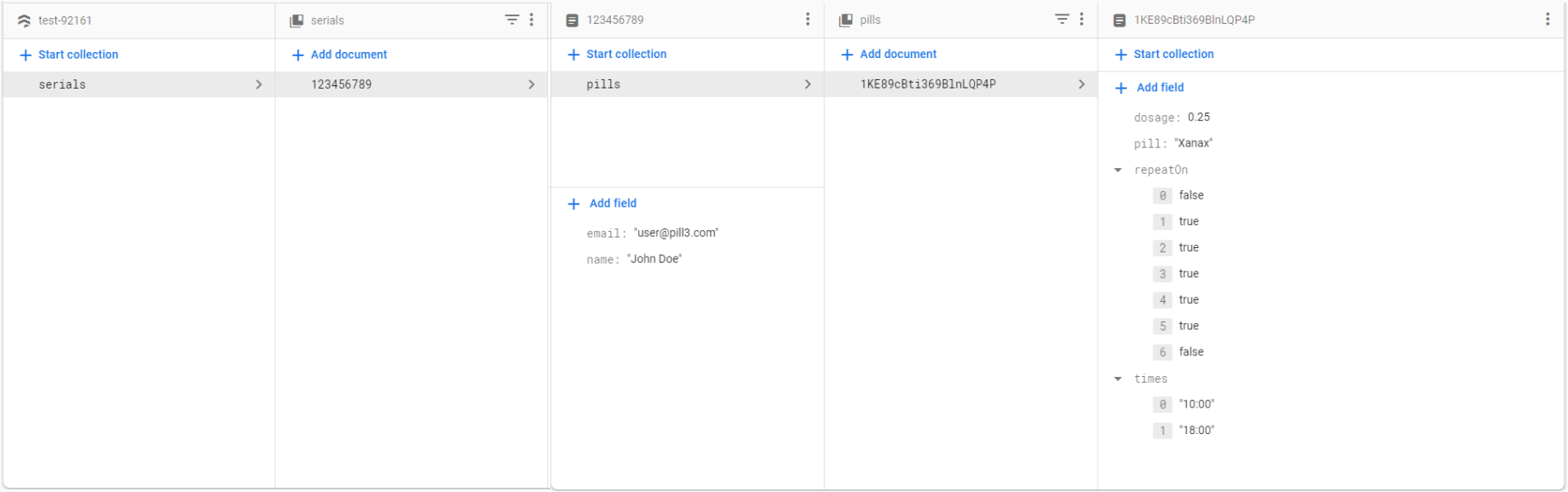
- Firebase uses a NoSQL database storage method which stores data as JSON objects.

- Device’s serial number
- User’s email
- User’s name
- Pill dispensing
  - What pill
  - What slot to dispense from
  - Dosage
  - When to dispense
    - What days to dispense
    - What times to dispense on each day



Firestore allows for *collections*, *documents*, and *fields*.
Collections contain *documents*.
Documents contain either *collections* (subsets) or *fields*.
Fields are composed of some **data type**

NOSQL DATABASE DESIGN *(CONT.)*



FRONTEND TESTING - WHY MANUAL?

Frontend Testing is wonderful; however, it can get complicated very fast. This begs the question if using a frontend testing framework is even worth it.

Testing Framework	Ease of Use	Support	Applicable	Readability
Jest	3/5	5/5	Yes	2/5
Detox	3/5	1/5	Yes	3/5
Manual	5/5	N/A	Yes	5/5

The choice of not including a frontend testing framework is mainly due to time- as it is unnecessary to frontend test something on such a small scale. If time permits, we can then decide on the best framework.

BACKEND TESTING - IS IT NEEDED?

Backend testing is extremely important. It allows a developer to easily and quickly see if everything is connected to the backend and to the cloud service (in this case, Firebase).

Jest is built-in to React Native, most industry-used, and most straightforward testing platform. Our software lead also already knows Jest and have used it in a multitude of projects with React Native. This allows for less time trying to learn a new framework and more time dedicated to improving the product.

Testing Framework	Ease of Use	Support	Applicable	Readability
Jest	5/5	5/5	Yes	5/5
Mocha	3/5	4/5	Yes	5/5
Jasmine	3/5	3/5	Yes	5/5

A lot of the time the backend testing framework is preference.

BUDGET

Quantity	Part	Manufacture	Manufacture Code	Price
1	Arduino Uno WiFi Rev.2	Arduino	ABX00021	$44.85
3	IR Sensor	Esooho	EK1254x5	$8.28
5	PCB	Jlcpcb	-	$82.00
3	Stepper Motor	Adafruit	XYU42STH34-0354A	$56.01
1	Speaker	Arduino	TPX00080	$7.99
1	Display	MakerFocus	SSD1306	$7.99
1	Temperature Sensor	Texas Instrument	LMT85LP	$1.60
1	AC/DC Converter	ALITOVE	CJ-1230	$9.99
1	DC Power Jack	DIKAVS	B074LK7G86	$10.99
1	Chassis Materials	Various	-	$128.77
			Total	$359.00

MILESTONE

	Hardware	Software
Week 1	Complete PCB design and start CDR	Finalize UI/UX diagram
Week 2	Get materials for chassis and finish CDR	Create UML class diagrams
Week 3	Start assembly of chassis	
Week 4	Test electrical components and continuation of chassis built	Set up programming environment
Week 5	Breadboard and PCB testing	Set up Firebase cloud environment ro connect to backend controller
Week 6	Solder all components to the PCB Board	Get backend controller working with writing to database

MILESTONE (CONT.)

	Hardware	Software
Week 7	Finish soldering	Get backend controller working with reading from database
Week 8	Finish built of chassis	Create basic frontend components components to connect to backend functions
Week 9	Test runs and polish device	Login authentication and login UI/UX
Week 10	Beautify interior and exterior	Create primary dashboard
Week 11	Beautify interior and exterior	Beautify & bug fixes
Week 12	Final test run and adding finishing touches	Beautify & bug fixes

PROGRES
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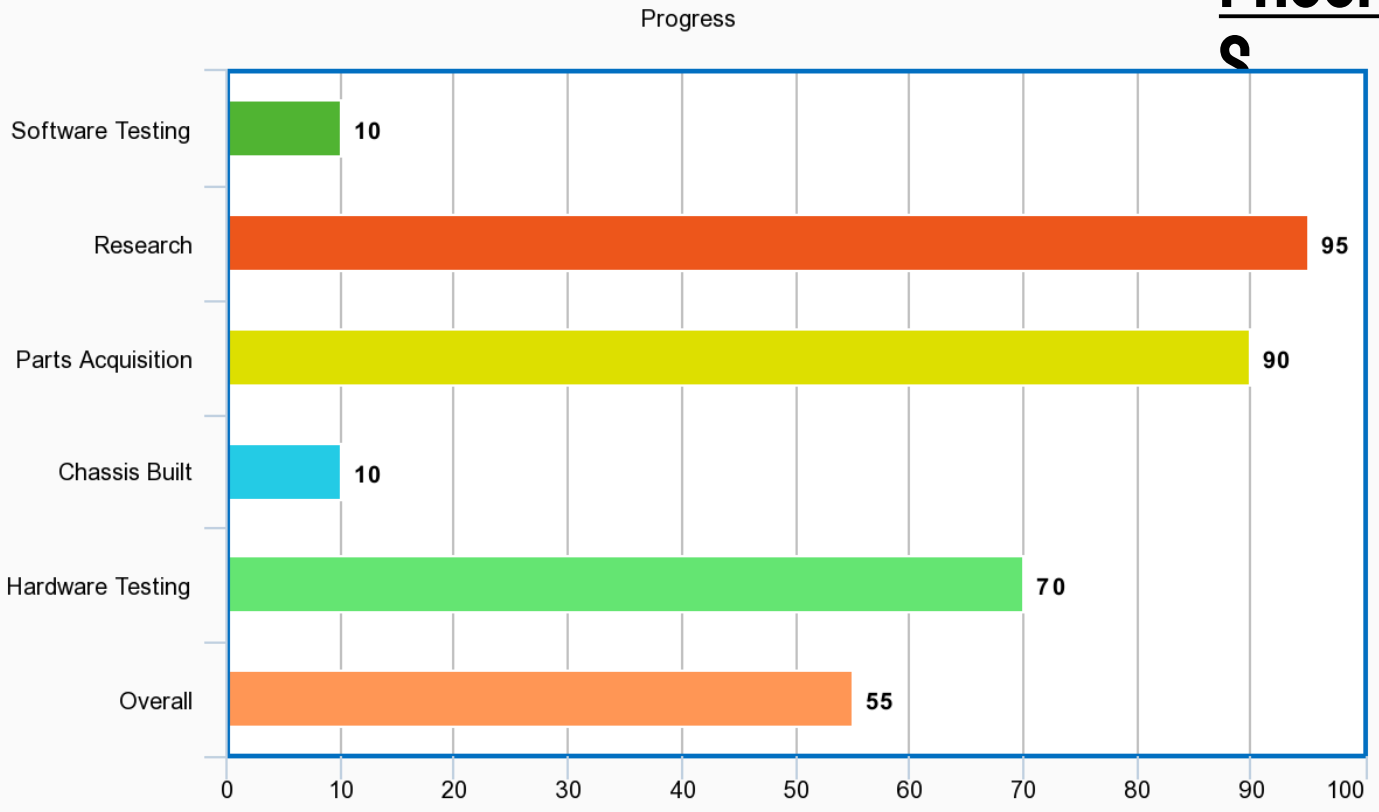

meta-chart.com

QUESTIONS?