Home Health Monitoring System

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Abstract

The idea behind the senior design project through EE-498 and 499 is to demonstrate the ability to design, model, and eventually create a prototype of the chosen team project. Throughout this project, the team develops a further understanding of teamwork regarding communication and delegation. The idea behind this project is to develop a home health monitoring system controller that has the ability to connect multiple subsystems to approach different aspects of a client's needs. This was done by designing the systems hub around the goal of creating a modular system that would fit around a client's flexible needs. The design process consisted of creating a design table that would display all design decisions made throughout the process of creating the system. To ensure the best choices were made throughout the design process, each decision table was created to display and ultimately choose the best decision for each part of the design process. In each decision table, numerous weighted engineering characteristics were used to calculate the chosen option. These decision tables were compiled to create the design table used to create the prototype.

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Introduction

This report will outline and document the design methods and decisions made throughout the entire semester in the first semester of senior design. The project will demonstrate basic knowledge and understanding of both hardware and software systems as well as the capabilities of working in a virtual team environment. The goal of this first semester was to complete the entire design process in order to focus on the implementation next semester so that the group might arrive with a successful final senior design product at graduation. The communication abilities and knowledge of required tool sets were tested and displayed through the semester.

For the purpose of this project, the semester began with defining the problem: How can one monitor their partially dependent family member while the user is away from their home? Although there are many options that someone could choose to pursue such as a nursing home or a live-in nurse, these can be extremely expensive. Not only does the price of care create a ginormous burden on the family members, the additional factors of Covid-19 now come into play. Family members are now limited to either extremely limited and controlled visiting hours or in some cases visitors are no longer allowed to visit nursing homes to see their loved ones. In a time of desperation and near world-wide terror, being restricted from seeing family members can have a huge impact on the moral in elderly people - this can/could have a direct impact on the persons health.

Like mentioned in the previous paragraph, the competition that comes with monitoring loved ones are in-home nurses, nursing homes, and current in-home “smart” monitoring systems. So why not choose one of these options? To begin: in-home nurses can be extremely expensive, costing up to ninety dollars an hour, and in many cases have minimum hours each day. Over-night and whole day personal care can easily get out of hand when it comes to pricing and in many families, this is not a feasible option. Next, in the United States of America, the average nursing home or assisted living facility can cost upwards of $4,000 a month. Over the course of five years, this will cost the family $240,000.

So, what is the solution here? Develop a home health monitoring system hub that can connect multiple subsystems to approach different aspects of a client’s needs. The system would have the ability for a user to add on any type of subsystem/sensor that they desired as the system would be designed around the concept of modularity. This means that the system would be designed in such a way that the subsystems would be divided into their own independently created systems that will have the ability to be created, modified, replaced, or exchanged with other subsystems. The subsystems added would have the ability to measure everyday aspects of an individual’s health from information like their movement throughout the house to how many times they have used the restroom or even taken a shower. The limits to what aspects of the user’s day to day life that is monitored by the home health monitoring system is limited only to the user’s imagination – and of course knowledge of hardware.

To begin with the project, stakeholders as well as the lines that needed to be drawn regarding the scope of the project were discussed. This discussion was then taken and revised to create the problem statement that was used to brainstorm the initial top-level diagram. After multiple revisions, the final diagram can be seen in [Figure 1] and [Figure 2] below.

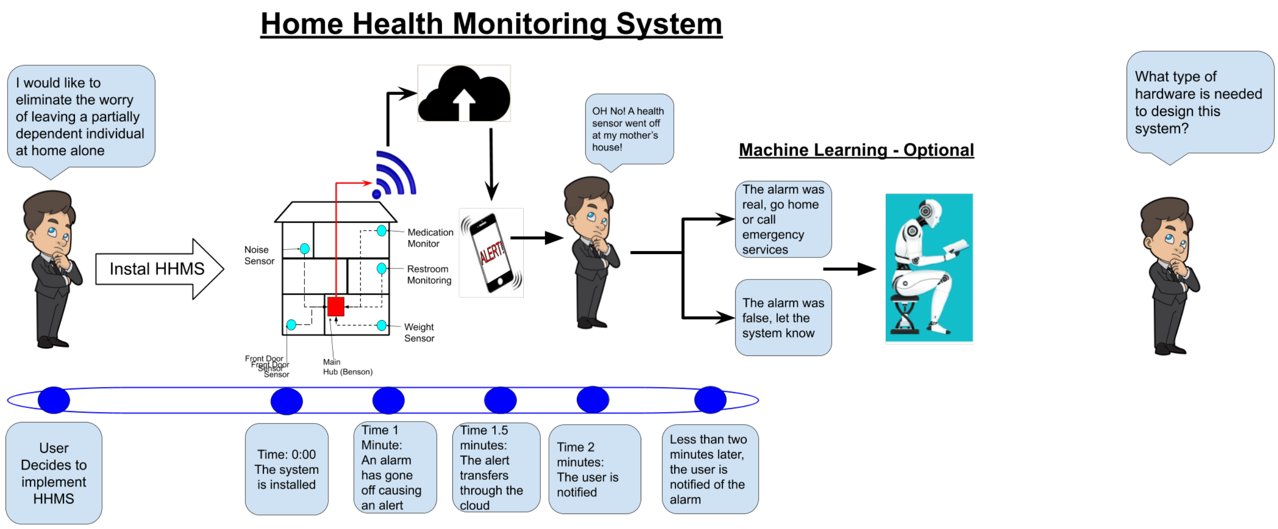


Figure 1: Top Level Diagram

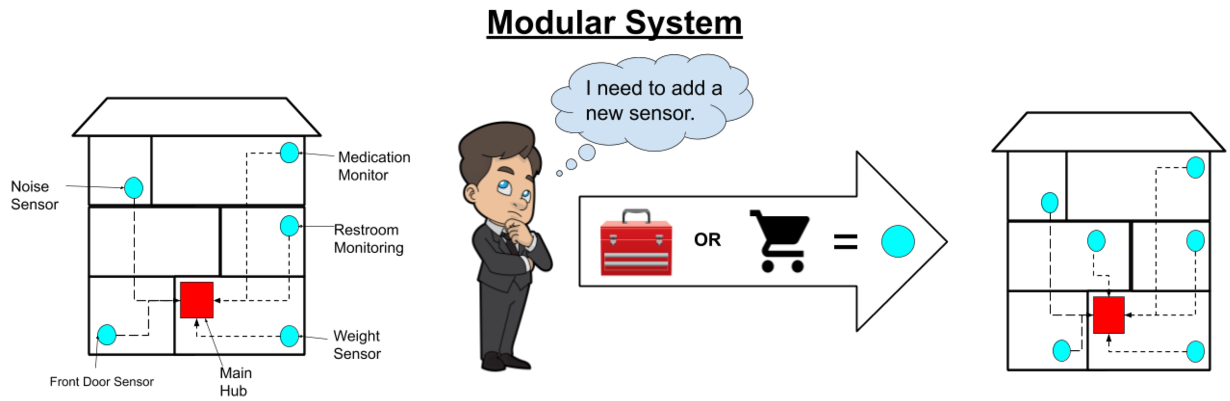


Figure 2: Top Level Diagram Part 2

Background

Existing Solutions

Project Description

In order to address the aforementioned problems, the team proposes an open-source home health monitoring system with an API to encourage extensibility to third-party devices. The system, initialized as **HHMS**, seeks to create and focus on a framework moreover than a single implementation, allowing relatively simple additions to the system without necessitating a recreation of the multi-step communication setups and data processing.

The project thusly focuses on establishing this framework and its API, allowing near any device to integrate with the system given it adheres to the protocols set by the system.

Sample

While the framework is the main focus, it is dificult to show that a framework exists without a working solution, and indeed multiple. If the system only demonstrated a single communicating device, it would hardly justify or prove the extensibility. Hence several sensor sub-systems will be set-up to work with the framework as an example of its capability and proof-of-concept.

Capabilities

- **Data Acquisition and Communication**: the user shall be able to read the data from their sensor subsystems, as well as communicate back to them in order to set their properties.
- **Data Processing**: data shall be processed according to set rules in order to indicate discrepencies with expected behavior.

Machine Learning

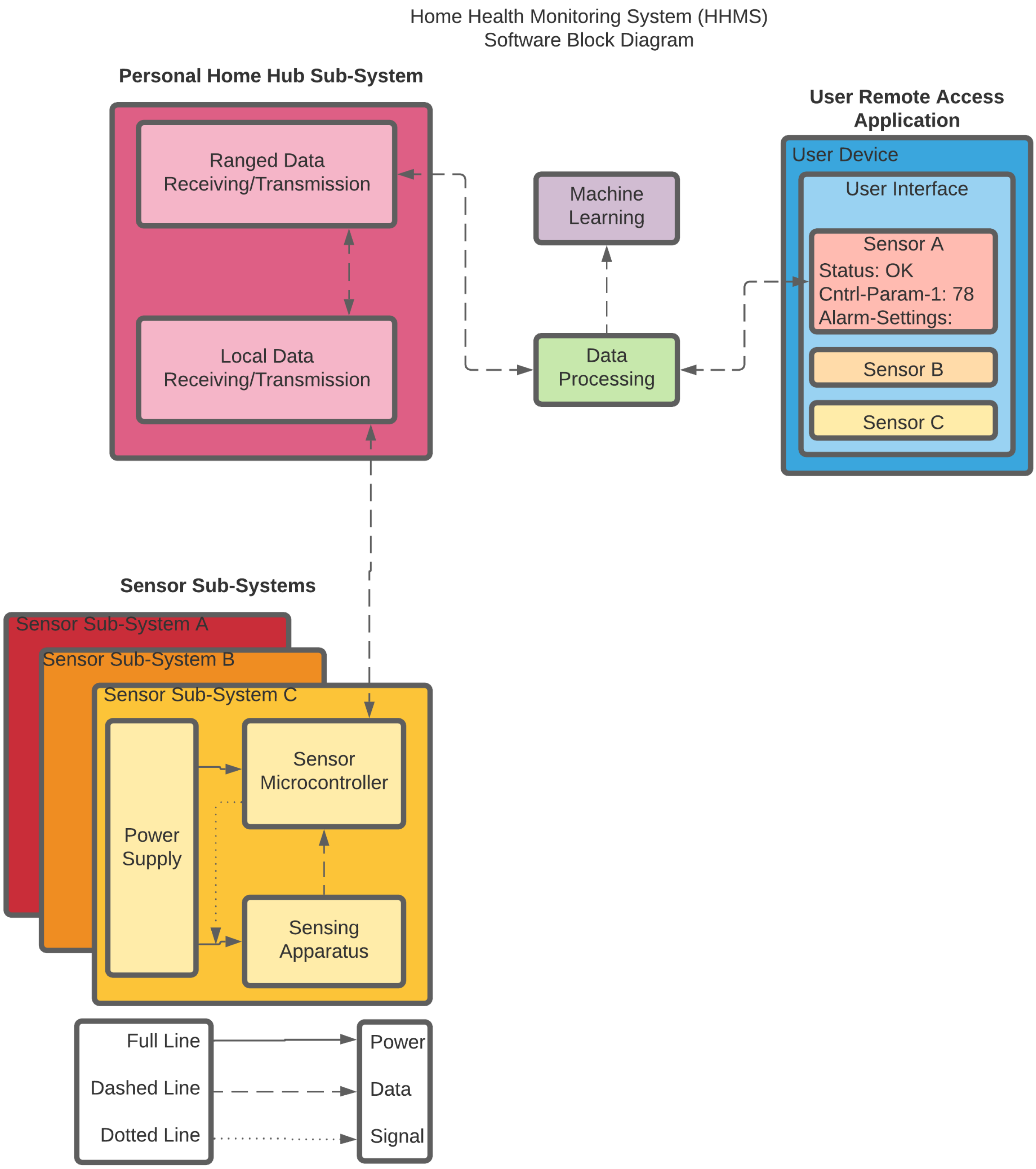
In order to further aid the efforts of the caretaker, behavior anomaly recognition should be implemented in order to detect irregular patterns or sharp steps in established patterns. The implementation will allow short-term recognition of emergencies (e.g. falls) as well as unhealthy longer-term patterns (such as a sudden drop in weight over a few days).

Dictionary

- Partially-Dependent Individual (PD): the stakeholder who will be monitored and cared for by the Caretaker
- Caretaker: a primary stakeholder, uses HHMS to monitor their PDs
- Data-Acquisition Hub (DA or DAH): the component that resides in the user's home to acquire and transmit data (as well as potentially more). Previously synonymous with "Hub" and at times "Microprocessor"
- Sensor Subsystems (SS): a setup that allows communication of sensor data to the DAH. Synonymous in the context of the DAH as a Slave, and at times synonymous with Microcontroller.
  - We additionally need a term that refers to the abstract collection of devices that can be enslaved to the DAH as mapped by software, undecided on this.
  - Do not confuse with sensors, which may comprise the entirety of the SS or be merely a component. The SS wraps the sensor. Likewise, the SS wraps the Microcontroller and/or Microprocessor, which is why it may be inappropriate to call it as such.

Design Process

After establishing the main project goals, design began with the overarching view of the project and brainstorming solutions via conceptual block diagrams, as d



An early conceptual diagram for the outline of the software systems.

To this end, there is already a necessary separation in the software – data-steams of the connected devices and metadata used by the system to interpret the data-streams – as well as hardware – sensor component and system wrapping microcontrollers. Additionally, due to the emphasization on a DIY and simple extensible set-up, user communication through the system is inherent to the design.

After the broad design was established, the individual components and implementation details were established in decision tables using a calculated Figure of Merit system. These decisions were then processed into the design table that outlines the final component-level decisions. Due to the inexperience of team Engies, this system is crucial in order to determine the proper materials for the project and develop the parts list without merely relying on the limited scope of products introduced in courses.

Methods

Decision Tables

The decision tables compile the research into the relevant specifications

								Input Types
Micro Controllers	Bluetooth	Wifi	USB 1.1	USB 2.0	USB 3.0	USB C	RS-232	HDMI Type A - Standard
Weights: 0-10; Values: Boolean	0	1	0	5	5	2	1	4
	Value:	Value:	Value:	Value:	Value:	Value:	Value:	Value:
Raspberry PI 4B 4GB	1	1	0	1	1	1	0	0
Raspberry PI 4B 8GB	1	1	0	1	1	1	0	0
Arduino NANO 33 IOT	1	1	0	1	0	0	0	0
Banana Pi M3	1	1	0	1	0	0	0	1
Odroid XU4	0	0	0	1	1	0	0	1
NanoPi NEO4	1	1	0	1	1	1	0	1
UDOO BOLT V8	1	1	0	0	1	1	0	1
UDOO X86 II ULTRA	1	1	0	0	1	0	0	1
ASUS Tinker Board	1	1	0	1	0	0	0	1
Onion Omega2+	0	1	0	1	0	0	0	0
Orange Pi 4B	1	1	0	1	1	0	0	1
NanoPC-T3 Plus	1	1	0	1	0	0	0	1
Le Potato - AML-S905X-CC	0	0	0	1	0	0	0	1
Orange Pi Zero Plus2	1	1	0	0	0	0	0	1
Raspberry Pi Zero W	1	1	0	1	0	0	0	0
Intel® NUC Board NUC7i3DNBE	1	1	0	1	1	0	0	1

Decision Table 1

Microprocessors	Bluetooth	Wifi	USB 1.1	USB 2.0	USB 3.0	USB C	HDMI Type A - Standard	HDMI Type C - Mini
Weight: 0-10	10	7	1	5	5	2	1	4
Values: Boolean								
Raspberry PI 4B 4GB	1	1	0	1	1	1	0	0
Raspberry PI 4B 8GB	1	1	0	1	1	1	0	0
Arduino NANO 33 IOT	1	1	0	1	0	0	0	0
Banana Pi M3	1	1	0	1	0	0	0	1
Odroid XU4	0	0	0	1	1	0	0	1
NanoPi NEO4	1	1	0	1	1	1	0	1
UDOO BOLT V8	1	1	0	0	1	1	0	1
UDOO X86 II ULTRA	1	1	0	0	1	0	0	1
ASUS Tinker Board	1	1	0	1	0	0	0	1
Onion Omega2+	0	1	0	1	0	0	0	0
Orange Pi 4B	1	1	0	1	1	0	0	1
NanoPC-T3 Plus	1	1	0	1	0	0	0	1
Le Potato - AML-S905X-CC	0	0	0	1	0	0	0	1
Orange Pi Zero Plus2	1	1	0	0	0	0	0	1
Raspberry Pi Zero	1	1	0	1	0	0	0	1
Intel® NUC Board NUC7i3DNBE	1	1	0	1	1	0	1	0

Decision Table 2

Design Tables

To ease with the design process, a design table was created to document and display each design decision that was made throughout the semester. The table shown below in [Figure 3] shows each decision that was made from the weighted tables as well as the problem statement, approach, and necessary equipment in order to create the home health monitoring system. The design table was then used to create the parts list towards the end of the report.

For each item in the design table a sub table was created to show the decision processes and to choose the best option based on the desired engineering characteristics and weights. Every support table lists each possible option that was found through extensive research and then the engineering characteristics that were chosen to help narrow down the most logical choice.

Problem Statement	Approach	Solution	Features	Approach	Hardware Needed	Price (USD)	Link
How can one monitor their partially dependant family member while the user is away from their home?	Develop a home health monitoring system hub that has the ability to connect multiple subsystems to approach different aspects of a client's needs	Hub(Benson)	Data Processing	Use the hub as a transport to relay the data to an offsite software to process the data			
			Computer/Controller	Raspberry PI 4B 8GB	Rasberry Pi 4B 8Gb	75	https://www.pishop.us/product/raspberry-pi-4-model-b-8gb/?src=raspberrypi
			Input	WiFi			
				Bluetooth			
				USB 2.0			
				USB 3.0			
				USB C			
				HDMI Type D - Micro			
				Ethernet			
			Output	Wifi			
			Hub Case Material	Store Bought Case	Raspberry Pi 4 Case, Red/White	5	https://www.pishop.us/product/raspberry-pi-4-case-red-white/
			Case Cooling Fan/Heatsink	Store Bought Fan for Case	Case Fan & Heatsink For Raspberry Pi 4 Case	5	https://www.pishop.us/product/case-fan-heatsink-for-raspberry-pi-4-case/?src=raspberrypi
			Temporary Data Storage (Hub)	64GB Storage	Class 10 microSD card - 64GB	14	https://www.amazon.com/SanDisk-Extreme-microSD-UHS-I-Adapter/dp/B07FCMBLV6/ref=sr_1_4?dchild=1&keywords=micro+sd+card+64gb+class+10&qid=1603739377&sr=8-4
			Temporary Data Storage (SubSystems)	32GB Storage	Class 10 microSD card - 32GB	7	https://www.amazon.com/SanDisk-Ultra-microSDXC-Memory-Adapter/dp/B073JWXGNT/ref=sr_1_3?dchild=1&keywords=micro+sd+card+32gb+class+10&qid=1603739324&sr=8-3
			Power Supply	Wired	USB-C Power Supply	8	https://www.pishop.us/product/usb-c-power-supply-5-1v-3-0a-black-ul-listed/
		Subsystems	Magnetic Contact Switch Sensor	Monitor movement in the house	Magnetic Alarm Contact Switch	$27	https://www.amazon.com/Gikfun-
				Monitor if a person has gone to the restroom			https://www.amazon.com/MEUFE
				Monitor exterior doors			
			Button For User Input	Has the person taken their medication?	Small Static Button	$33	https://www.newark.com/alc
				Did the person take a shower or bath?			dev=c&hvdvcmdl=&hvlocint=&hvlo
				Has the person had a meal?			
			Light Level Sensor	Insure that lights have not been left one throughout the home	Photoresistor Photo Light Sensitive Resistor Light Dependent Resistor	$38	botics.com/shop/tmp36-temperat
				Make sure the user is moving throughout the day (lights turning off and on)			https://www.amazon.com/MEUFE
			Temperature Sensor	Monitor the temperature throughout the house	TMP36 Temperature Sensor	$29	https://www.amazon.com/gp/pro
		Client Interface	Log Interface	dot Net Core	dot Net Core		
			Alert Types	Email			

Figure 3: Design Table

Many of the decision tables revolved around the systems hub/controller. The first table that was created to help ease the decision on which microcontroller to implement, the output and input types of each microcontroller were added to the support tables seen below in [Figure 4] and [Figure 5]. The given outputs would be needed to connect to the systems data processing controller – meaning the outputs must be compatible with Wi-Fi.

Output Types										
Microprocessors	Bluetooth	Wifi	USB 1.1	USB 2.0	USB 3.0	USB C	HDMI Type A - Standard	HDMI Type C - Mini	HDMI Type D - Micro	RESULTS
Weight: 0-10	10	10	1	5	5	2	1	2	3	
Values: Boolean										
Raspberry PI 4B 4GB	1	1	0	1	1	1	0	0	0	32
Raspberry PI 4B 8GB	1	1	0	1	1	1	0	0	0	32
Arduino NANO 33 IOT	1	1	0	1	0	0	0	0	0	25
Banana Pi M3	1	1	0	1	0	0	0	1	0	27
Odroid XU4	0	0	0	1	1	0	0	1	0	12
NanoPi NEO4	1	1	0	1	1	1	0	1	0	34
UDOO BOLT V8	1	1	0	0	1	1	0	1	0	29
UDOO X86 II ULTRA	1	1	0	0	1	0	0	1	0	27
ASUS Tinker Board	1	1	0	1	0	0	0	1	0	27
Onion Omega2+	0	1	0	1	0	0	0	0	0	15
Orange Pi 4B	1	1	0	1	1	0	0	1	0	32
NanoPC-T3 Plus	1	1	0	1	0	0	0	1	0	27
Le Potato - AML-S905X-CC	0	0	0	1	0	0	0	1	0	7
Orange Pi Zero Plus2	1	1	0	0	0	0	0	1	0	22
Raspberry Pi Zero	1	1	0	1	0	0	0	1	0	27
Intel® NUC Board NUC7i3DNBE	1	1	0	1	1	0	1	0	0	31

Figure 4: Microprocessor Output Types

Input Types												
Micro Controllers	Bluetooth	Wifi	USB 1.1	USB 2.0	USB 3.0	USB C	RS-232	HDMI Type A - Standard	HDMI Type C - Mini	HDMI Type D - Micro	Ethernet	Audio Jack - 4 Pole 3.5mm
Weights: 0-10; Values: Boolean	0	1	0	5	5	2	1	4	2	3	10	1
	Value:	Value:	Value:	Value:	Value:	Value:	Value:	Value:	Value:	Value:	Value:	Value:
Raspberry PI 4B 4GB	1	1	0	1	1	1	0	0	0	1	1	0
Raspberry PI 4B 8GB	1	1	0	1	1	1	0	0	0	1	1	0
Arduino NANO 33 IOT	1	1	0	1	0	0	0	0	0	0	0	0
Banana PI M3	1	1	0	1	0	0	0	1	0	0	1	1
Odroid XU4	0	0	0	1	1	0	0	1	0	0	1	0
NanoPI NEO4	1	1	0	1	1	1	0	1	0	0	1	0
UDOO BOLT V8	1	1	0	0	1	1	0	1	0	0	1	0
UDOO X86 II ULTRA	1	1	0	0	1	0	0	1	0	0	1	0
ASUS Tinker Board	1	1	0	1	0	0	0	1	0	0	1	0
Onion Omega2+	0	1	0	1	0	0	0	0	0	0	0	0
Orange PI 4B	1	1	0	1	1	0	0	1	0	0	1	0
NanoPC-T3 Plus	1	1	0	1	0	0	0	1	0	0	1	1
Le Potato - AML-S905X-CC	0	0	0	1	0	0	0	1	0	0	1	1
Orange PI Zero Plus2	1	1	0	0	0	0	0	1	0	0	0	0
Raspberry PI Zero W	1	1	0	1	0	0	0	0	1	0	0	0
Intel® NUC Board NUC7I3DNBE	1	1	0	1	1	0	0	1	0	0	1	0

Figure 5: Microprocessor Input Types

In both the input and output support tables for the microprocessor above, the Raspberry Pi 4B 8Gb was the obvious answer but before we could be sure that this was the decision that needed to be made for the final design, a support table regarding the speed and power of each microprocessor needed to be created. This table can be seen below in [Figure 6].

Microprocessors					
Microprocessors	Processor Name	Processor Speed	Number of Cores	Onboard Ram	Integrated GPU
		Weight:	Weight:	Weight:	Weight:
		10	7	7	3
		Value in GHz:	Value:	Value in GB:	Value: 1: yes 0:no
Raspberry PI 4B 4GB	Cortex-A72	1.5	4	4	1
Raspberry PI 4B 8GB	Cortex-A72	1.5	4	8	1
Arduino NANO 33 IOT	SAMD21 Cortex®-M0+	0.048	1	0.000032	0
Banana Pi M3	Allwinner A83T ARM Cortex-A7	1.8	8	2	
Odroid XU4	Samsung Exynos5422 Cortex-A15 and Cortex-A7 Octa core	2/1.4	8	2	0
NanoPi NEO4	Rockchip RK3399 64-bit Dual Core Cortex-A72 + Quad Core Cortex-A53	2/1.5	2/4	1	1
UDOO BOLT V8	AMD Ryzen™ Embedded V1605B Quad Core	2.0/3.6	4	up to 32	1
UDOO X86 II ULTRA	Intel Pentium N3710	2.56	4	8	1
ASUS Tinker Board	Rockchip Quad-Core RK3288	1.8	4	2	1
Onion Omega2+	MT7688 SoC	0.58	1	0.128	0
Orange Pi 4B	Rockchip RK3399	2	6	4	1
NanoPC-T3 Plus	Samsung S5P6818	1.4	8	2	0
Le Potato - AML-S905X-CC	ARM Cortex-A53	1.512	4	2	1
Orange Pi Zero Plus2	Cortex-A53	1.2	4	0.512	1
Raspberry Pi Zero W	BCM 2835 SOC	1	1	0.512	0
Intel® NUC Board NUC7i3DNBE	Intel® Core™ i3-7100U	2.4	2	up to 32	1

Figure 6: Microprocessor Support Table

The next decision that needed to be made regarding the hub/controller can be seen in [Figure 7]. The material the case that will hold the controller needed to be determined. After creating the table and beginning to fill out the engineering characteristics for each option, it was obvious due to the convenience and the extremely low price, that a store-bought case was the best option.

Hub Case Material									
Material	Price	Durability	Availability	Production Speed	Lifespan	Replacement	Weight	Size	Link
	10	5	10	5	3	7	6	8	
	Value:	Value: 1-4	Value: 0 or 1	Value: 1-4	Value: 1-4	Value:	Value:	Value:	
3d print Plastic	$30	3	1	4	2				
Aluminum	$60	3	1		3				https://www.digikey.c
Steel	$75	4	1		4				
Plexi Glass	$40	1	0	1	1				
Wood	$15	4	0	1	4				
Store Bought	$7	4	1	4	4				https://www.pishop.

Figure 7: Microprocessor Case Material Table

After choosing the previous decisions found in the support tables above, the amount of temporary data storage for the hub/controller needed to be determined. The reason for the storage is in the situation of a power outage inside the house. In this case the controller of the system would not be able to immediately relay data to the data processor and without a temporary storage, the data would be lost. Thus, the need for onboard storage. The most important part of this table came when determining the amount of storage needed. To do this, guesstimates were made in order to determine file size from each sensor type to then calculate the amount the system would need. The results can be seen below in [Figure 8].

Temp Data Storage Types Hub						
Storage Types	Capacity	Speed	Price	Physical Size	Life span	Link
	Weight:	Weight:	Weight:	Weight:	Weight:	
	10	7	10	4	10	
Yes = 1, No = 0	Value: in GB	Value: mb/s	Value: $	Value: 0 - 4	Value:	
Class 10 microSD card - 16GB	16	100	10	0		https://www.ama
Class 10 microSD card - 32GB	32	98	9	0		https://www.ama
Class 10 microSD card - 64GB	64	160	15	0		https://www.am
Class 10 microSD card - 128GB	128	160	24	0		https://www.ama
Class 10 microSD card - 256GB	256	100	48	0		https://www.ama
Class 10 microSD card - 512GB	512	90	100	0		https://www.ama
1TB Flashdrive/Thumbdrive	1000	85	34	2		https://www.ama

Figure 8: Data-Acquisition Temporary Storage Size Table

To continue in the design process, the support tables for the subsystems needed to be created. This consisted of a temporary data storage size and the microcontroller chosen for the design. These two tables can be seen below in [Figure 9] and [Figure 10].

The microcontroller chosen is the ESP32 board. This board was chosen based on speed and output connection types which consist of both the required Bluetooth and Wi-Fi. The other engineering characteristics that were used to determine the microcontroller decided for this design can be seen in the table below. Another important aspect of the chosen board was the number of input/output analog and digital pins that the board was compatible with.

Microcontrollers									
Microcontrollers	Cost	Physical Size	Bluetooth	Wifi	Clock Speed	Flash Memory	Digital I/O Pins	Analog I/O Pins	Coding Languages
	in USD	in mm	Weight:	Weight:	Weight:	Weight:	Weight:	Weight:	Weight:
			10	7	7	10	10	10	10
			Value (0=no, 1=yes):	Value (0=no, 1=yes):	Value in MHz:	Value in KB:	Value:	Value:	Value:
Arduino UNO WIFI Rev 2	35.84	53.4 x 68.6	1	1	16	48	14	6	Arduino
Arduino YÚN Rev 2	46.90		0	1	16	32	20	12	Arduino
Canaduino WEMOS D1 R32	7.66		1	1	240	4	20	6	
Teensy 4.0	29.17	17.78 x 35.56	0	0	600	2048	40	14	
Digi Stump Oak	10.95	23.4 x 30	0	1	80	4096	11	1	
SparkFun RedBoard Artemis Nano	14.95	23.14 x 50.04	1	0	48	1024	17	8	
Raspberry Pi Zero	5.00	30 x 65	0	0	1000	0	40	0	
ESP-12E NODEMCU	4 for 16.99	25.6 x 48.55	0	1	80	4096	11	1	Arduino
HiLetgo ESP-WROOM-32	10.99	25.4 x 48.26	1	1	240	4096	32	0	Arduino
MSP-EXP430FR2355	15.59		0	0	24		44	12	

Figure 9: Microcontroller Type Table

To complete the design process for the subsystem's boards, the Microprocessor support table ([Figure 10]) was created to determine the necessary storage types that would be required. Like mentioned above in the controller/hub storage, the data storage would only be needed in emergency situations where power was lost to the sensor. With the calculations made in the hub, the subsystem data size was also chosen.

Temp Data Storage Types Subsystems						
Storage Types	Capacity	Speed	Price	Physical Size	Life span	Link
	10	7	10	4	10	
Yes = 1, No = 0	Value: GB	Value: mb/s	Value: $	Value: 0 - 4	Value: years	
Class 10 microSD card - 16GB	16	100	10	0	10	https://www.a
Class 10 microSD card - 32GB	32	98	9	0	10	https://www.
Class 10 microSD card - 64GB	64	160	15	0	10	https://www.a
Class 10 microSD card - 128GB	128	160	24	0	10	https://www.a
Class 10 microSD card - 256GB	256	100	48	0	10	https://www.a
Class 10 microSD card - 512GB	512	90	100	0	10	https://www.a
1TB Flashdrive/Thumbdrive	1000	85	34	2	10	https://www.a

Figure 10: Sensor Subsystem Buffer Storage Table

Input Table

Output Table

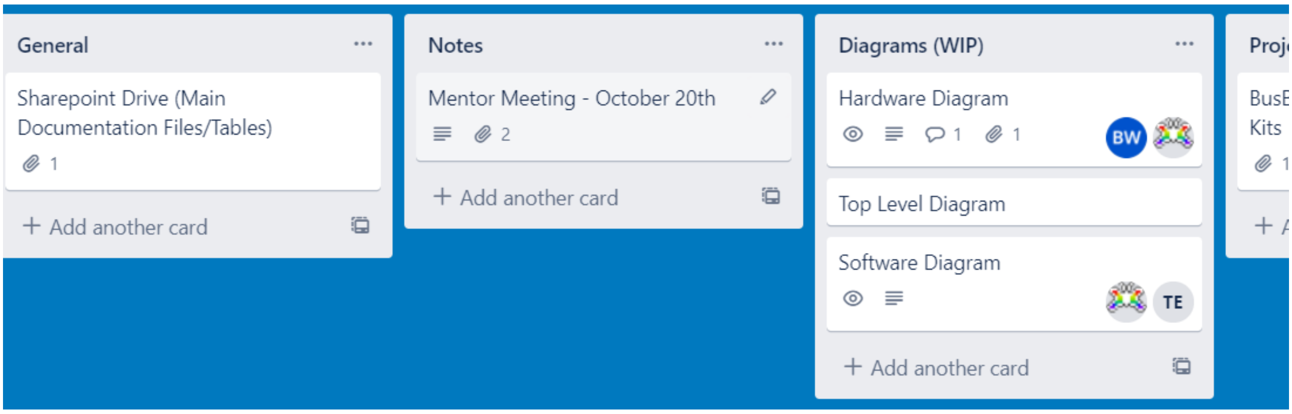
Output Table		
Parameters	**Expected Results**	**Measured Results**
Data Rates		TBD
Bluetooth	3 MB/s	
Wi-Fi	25 MB/s	
USB	18 MB/s	
Cloud upload	20 MB/s	
Battery Life		
Subsystems - Door Sensor	400 Hours	
Subsystems - Weight Scale	400 Hours	
Subsystems - Light Sensor	200 Hours	
Subsystems - Temperature Sensor	100 Hours	
Hub	0 Hours (Wired)	
Software		
Expected file size of the string sent from the subsystems to the hub - Door Sensor	Format of String: Opened - Date - Time - Sensor ID 40 KB	
Expected file size sent from the subsystems to the hub - Button sensor. Sending a 1 when it's been pressed, storing for a week	20 KB	
Expected file size sent from the subsystems to the hub - Temperature Sensor. Potential hourly log of room temp.	100 KB	
Expected file size sent from the subsystems to the hub - Light Sensor. Potential hourly log to check if a light is on, sending 1 if on, 0 if off	20 KB	

Figure 11: Output Table

The Output Table, shown above in [Figure 11], for the project is a list of potential tests and their expected results, with the measured results table to be filled in in the next semester for EE499 after extensive testing on the project has been performed. With this output table, the expected tests are to be done involving the data transfer rates, such as transferring data from the system to the hub via Bluetooth or Wi-Fi. To allow for a battery backup, testing for the battery lives for some of the different subsystems will be performed to make sure the battery back-up will be adequate for the project. And for the software aspect of the project, the file sizes of the data logs will be tested, expecting the files stored in the data acquisition hub, or the temporary storage of the subsystem itself in case of a power outage. The data filled in the expected column of the table was gathered by researching common data rate, battery lives, and based on the size of the strings generated for the activity logs, allowing for some overhead in the file size.

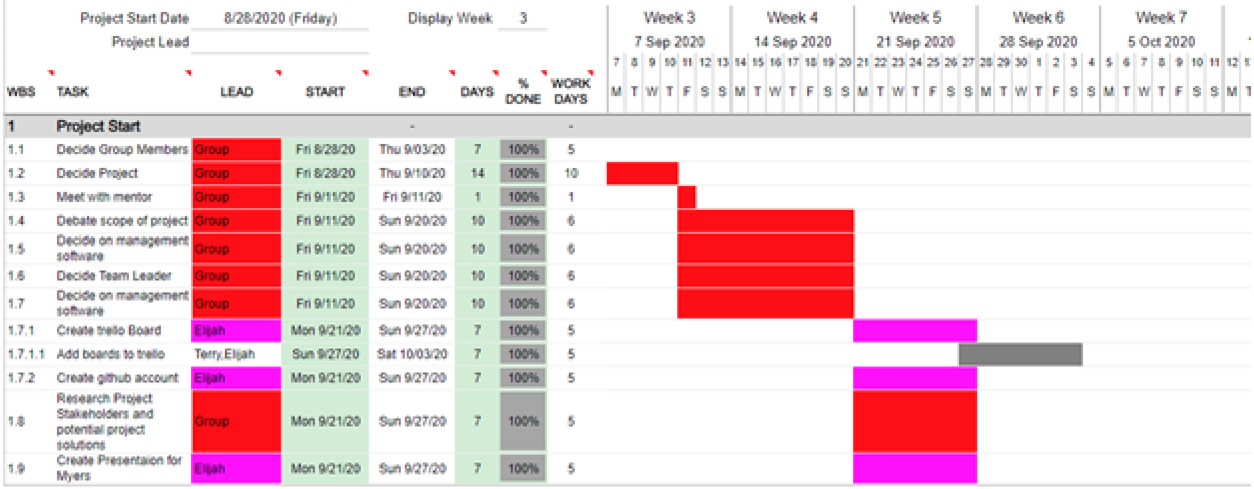
Timeline

To help with the organization of the project, a Gantt Chart for the Fall 2020 semester for EE498 was created. By giving each team member a color as well as a color for group activities, the work of the group can be visually organized and compiled in an easy-to-read manner, showing who's assigned to the given tasks with each task having a specific timeline in order to complete it. The figures below show the different tasks assigned over the course of the semester to each team member, or the group if need be.[1]



A Kanban-style PM.

However, due to the EE498 requirements, the project was switched to Gantt-style task management.



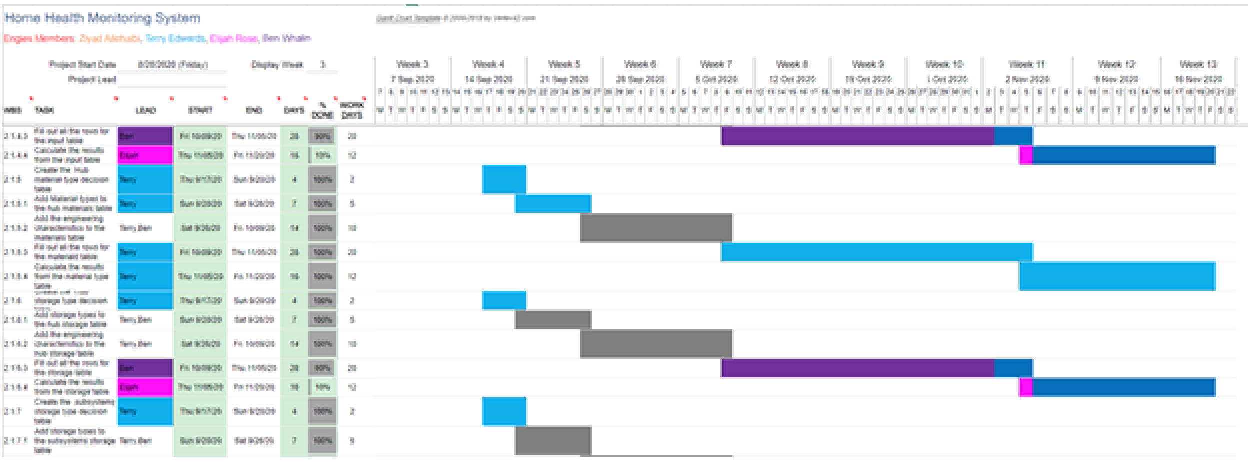
Project Start Date 8/28/2020 (Friday) Display Week 3
Project Lead

WBS	TASK	LEAD	START	END	DAYS	% DONE	WORK DAYS
1	**Project Start**			-			-
1.1	Decide Group Members	Group	Fri 8/28/20	Thu 9/03/20	7	100%	5
1.2	Decide Project	Group	Fri 8/28/20	Thu 9/10/20	14	100%	10
1.3	Meet with mentor	Group	Fri 9/11/20	Fri 9/11/20	1	100%	1
1.4	Debate scope of project	Group	Fri 9/11/20	Sun 9/20/20	10	100%	6
1.5	Decide on management software	Group	Fri 9/11/20	Sun 9/20/20	10	100%	6
1.6	Decide Team Leader	Group	Fri 9/11/20	Sun 9/20/20	10	100%	6
1.7	Decide on management software	Group	Fri 9/11/20	Sun 9/20/20	10	100%	6
1.7.1	Create trello Board	Elijah	Mon 9/21/20	Sun 9/27/20	7	100%	5
1.7.1.1	Add boards to trello	Terry,Elijah	Sun 9/27/20	Sat 10/03/20	7	100%	5
1.7.2	Create github account	Elijah	Mon 9/21/20	Sun 9/27/20	7	100%	5
1.8	Research Project Stakeholders and potential project solutions	Group	Mon 9/21/20	Sun 9/27/20	7	100%	5
1.9	Create Presentaion for Myers	Elijah	Mon 9/21/20	Sun 9/27/20	7	100%	5

Gantt Chart: Initialization

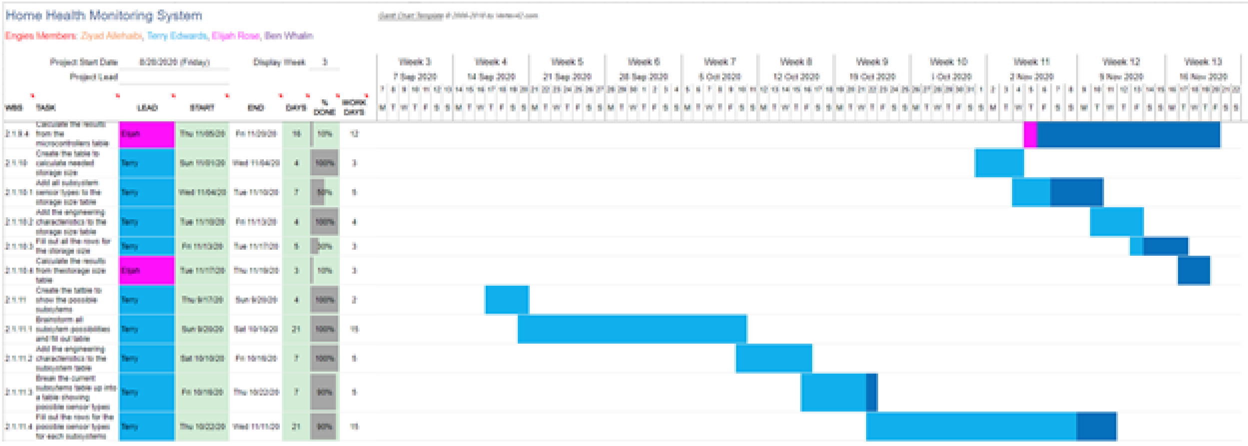
[1] A Kanban-style project organization and task management structure was attempted as well via *Trello*.

Gantt Chart: Design 1

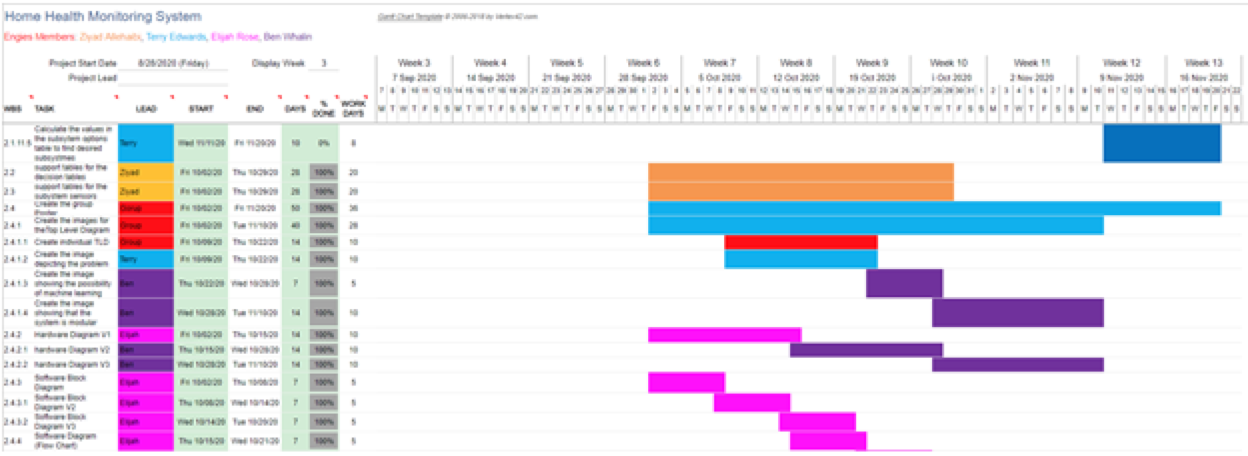


Gantt Chart: Design 2

Gantt Chart: Design 3

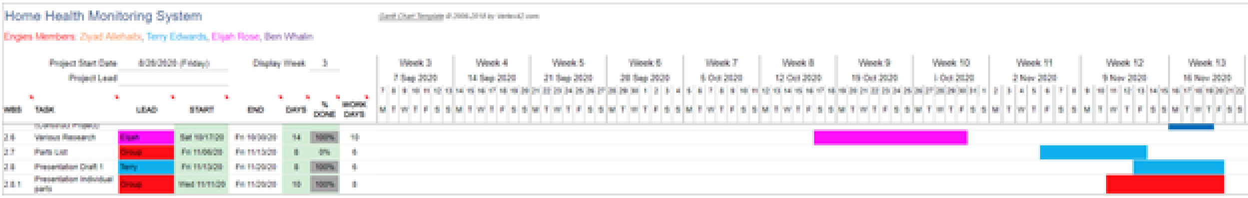


Gantt Chart: Design 4



Gantt Chart: Design 5

Gantt Chart: Design 6



Gantt Chart: Design 7

The project began in August 2020 towards the beginning of EE498 and the project will conclude in April of 2021 in EE499. Throughout the Fall 2020 semester, the project was selected, researched, and designed with each member of the group given certain tasks to complete, with group members helping each other out to try and complete the various tasks on time if need be. The implementation of the project's design will begin in the Spring 2021 semester beginning at the end of January.

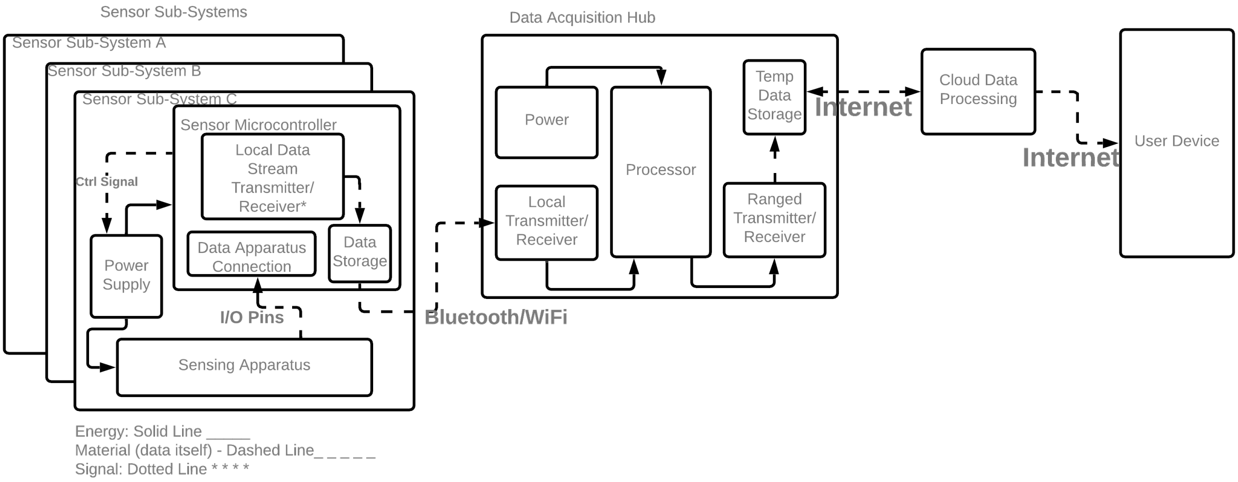
Subsystem Analysis

System Design

The following sections of show the respective hardware and software systems' designs, with the software simulations presented to give an idea of the look of the software aspect of the project. The hardware design will show the designs of the various hardware components of the project and the software design shows the expected flow of the project, that being the starting of the system and going through the ways the data is gathered and processed.

Hardware Design

The design of the hardware components hasn't been finalized for the project yet. While the specific components have all been decided upon, a concrete design for the entire system hasn't been decided upon. Though a final design will be decided upon and implemented in the Spring 2021 semester. While the design of the entire system is important, the software aspects of the system are more the focal point of the project since the project features a modular design, it's hardware design is more fluid and less concrete than other projects.

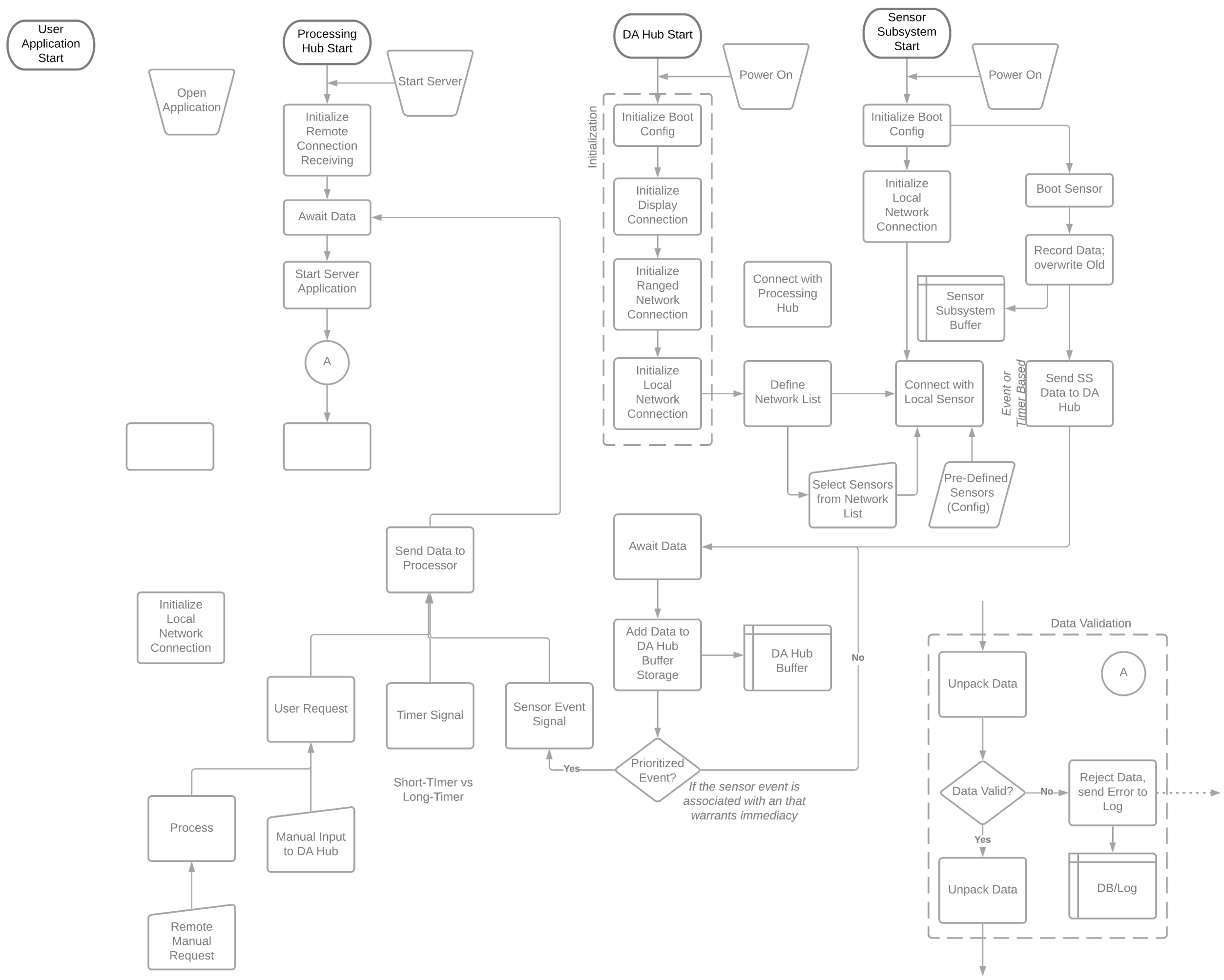


Hardware Block Diagram

Sensor Subsystem Analysis Each of the sensor subsystems consists of the Microcontroller, the power supply, and the sensing apparatus. The sensing apparatus is connected to the microcontroller via the GPIO pins on the microcontroller, with the microcontroller collected the data from the sensor and sending it via either Bluetooth or Wi-Fi to the Data Acquisition Hub to be logged in the storage for the Microprocessor and then transmitted and processed via the cloud to then be received by the user on their device.

Hardware Simulation

Software Design



Software Flowchart

Software Simulation

Cost Analysis

The budget that was given in senior design consisted of $200 per group member. This amounted to $800 for the entire project. Due to one of the goals of our design being that it would be affordable, the team desired to not use the entire budget for the baseline of our product. This meant that throughout the semester we kept this idea in mind and chose hardware options based off reliability and dependability and not price. At the end of the design, the total cost of the hub/controller alone came out to be $106.94 while the cost of the subsystem sensor package which includes six sensor systems, and a wearable watch came out to be $253.24. Combined, this makes our entire product $360.18, more than half of our budget.

Due to one of our team members being overseas for the semester and the fact that we are supposed to be social distancing, we opted in spending the remainder of our budget on purchasing extra subsystems and hub/controllers in order for each group member to be able to experiment and aide the process of implementing our design next semester. After figuring out the amount of subsystems and hubs that we could order while staying under our budget, we came to a price of $787.09. This price includes sixteen sensor subsystems and three sets of the hub/controller. The two sub parts tables and the total parts table can all be seen below.

Part Name	Status	Supplier	Part Number	Description	Price	Quantity	Subtotal	URL
Amazon								
SanDisk 64GB microSD Memory Card	Need to Order	Amazon	SDSQXA2-064G-GN6MA	Memory Card for Rasberry Pi	$13.99	1	$13.99	https://www.amazon.com/
PiShopUS								
Rasberry Pi 4B 8Gb	Need to Order	PiShopUS	8GB-9006	Raspberry Pi Development Board	$75.00	1	$75.00	https://www.pishop.us/pro
Raspberry Pi 4 Case, Red/White	Need to Order	PiShopUS	644824914916	Raspberry Pi Case	$5.00	1	$5.00	https://www.pishop.us/pro
Case Fan & Heatsink for Raspberry Pi 4 Case	Need to Order	PiShopUS	1411	Raspberry Pi Case Fan	$5.00	1	$5.00	https://www.pishop.us/pro
USB-C Power Supply, 5.1V 3.0A	Need to Order	PiShopUS	1203	Raspberry Pi Power Supply	$7.95	1	$7.95	https://www.pishop.us/pro
							$106.94	

Parts List for Hub/Controller

Part Name	Status	Supplier	Part Number	Description	Price	Quantity	Subtotal	URL
Amazon								
4PCS Breadboards Kit	Need to Order	Amazon	RQ-BK-002	Two large breadboards and two small	$9.99	2	$19.98	https://www.amaz
HiLetgo 200pcs/5x40pcs Breadboard Jumper Wires	Need to Order	Amazon	3-02-1141	Assortment of Wires	$6.99	1	$6.99	https://www.amaz
61 Values (Pack of 1095) 1% 0.25w Resistor Book kit	Need to Order	Amazon	EE902	Assortment of Resistors	$14.99	1	$29.98	https://www.amaz
Virtuabotix SD Card Reader/Writer for Arduino and other Microcontrolle	Need to Order	Amazon	SDREADWRITE_BO	SD Card Reader for ESP32 Board	$4.99	6	$29.94	https://www.amaz
SanDisk 32GB Ultra microSDHC	Need to Order	Amazon	SDSQUAR-032G-GN6MA	Micro SD Memory Card	$6.99	6	$41.94	https://www.amaz
MELIFE 2 Pack ESP32 ESP-32S Development Board	Need to Order	Amazon	B07Q576VWZ	with 3 Breadboards	$20.22	1	$20.22	https://www.ama
MELIFE 2 Pack ESP32 ESP-32S Development Board	Need to Order	Amazon	B07Q576VWZ	Pack of 2 ESP32 Development Boards	$14.99	2	$29.98	https://www.amaz
Gikfun MC-38 Wired Door Sensor Magnetic Switch	Need to Order	Amazon	3652995690	Two pack of door sensor	$7.29	1	$7.29	https://www.amaz
Cylewet 70Pcs Momentary Tactile Push Button	Need to Order	Amazon	CYT1115	35 Momentary Push Buttons	$8.99	1	$8.99	https://www.amaz
Elechip 10Pcs 18B20 DS18B20 TO-92 3 Pins Wire Digital Thermometer Ter	Need to Order	Amazon	1	Pack of 10 Temperature sensors	$9.99	1	$9.99	https://www.amaz
eBoot 30 Pieces Photoresistor Photo Light Sensitive	Need to Order	Amazon	EBOOT-RESISTOR-05	Pack of 30 Light Level Sensors	$4.95	1	$4.95	https://www.amaz
NodeMCU ESP8266 Programmable Development Board Built in 500mAh Battery with OLED Dispaly, Wristband and 3D Printing Case	Need to Order	Amazon	ZWQW16U53EUI2GO383O44	Wearable Watch from ESP32 board	$42.99	1	$42.99	https://www.ama
							$253.24	

Parts List for Hub/Controller

Part Name	Status	Supplier	Part Number	Description	Price	Quantity	Subtotal	URL
Amazon								
SanDisk 64GB microSD Memory Card	Need to Order	Amazon	SDSQXA2-064G-GN6MA	Memory Card for Rasberry Pi	$13.99	3	$41.97	https://www.ama
4PCS Breadboards Kit	Need to Order	Amazon	RQ-BK-002	Two large breadboards and two small	$9.99	3	$29.97	https://www.ama
HiLetgo 200pcs/5x40pcs Breadboard Jumper Wires	Need to Order	Amazon	3-02-1141	Assortment of Wires	$6.99	1	$6.99	https://www.ama
61 Values (Pack of 1095) 1% 0.25w Resistor Book kit	Need to Order	Amazon	EE902	Assortment of Resistors	$14.99	2	$29.98	https://www.ama
Virtuabotix SD Card Reader/Writer for Arduino and other Microcontroller	Need to Order	Amazon	SDREADWRITE_BO	SD Card Reader for ESP32 Board	$4.99	15	$74.85	https://www.am
SanDisk 32GB Ultra microSDHC	Need to Order	Amazon	SDSQUAR-032G-GN6MA	Micro SD Memory Card	$6.99	15	$104.85	https://www.ama
MELIFE 2 Pack ESP32 ESP-32S Development Board	Need to Order	Amazon	B07Q576VWZ	with 3 Breadboards	$20.22	4	$80.88	https://www.am
MELIFE 2 Pack ESP32 ESP-32S Development Board	Need to Order	Amazon	B07Q576VWZ	Pack of 2 ESP32 Development Boards	$14.99	4	$59.96	https://www.ama
Gikfun MC-38 Wired Door Sensor Magnetic Switch	Need to Order	Amazon	3652995690	Two pack of door sensor	$7.29	3	$21.87	https://www.ama
Cylewet 70Pcs Momentary Tactile Push Button	Need to Order	Amazon	CYT1115	35 Momentary Push Buttons	$8.99	1	$8.99	https://www.ama
Elechip 10Pcs 18B20 DS18B20 TO-92 3 Pins Wire Digital Thermometer Tem	Need to Order	Amazon	1	Pack of 10 Temperature sensors	$9.99	1	$9.99	https://www.ama
eBoot 30 Pieces Photoresistor Photo Light Sensitive	Need to Order	Amazon	EBOOT-RESISTOR-05	Pack of 30 Light Level Sensors	$4.95	1	$4.95	https://www.ama
NodeMCU ESP8266 Programmable Development Board Built in 500mAh Battery with OLED Dispaly, Wristband and 3D Printing Case	Need to Order	Amazon	ZWQW16U53EUI2GO383O44	Wearable Watch from ESP32 board	$42.99	1	$42.99	https://www.am
PiShopUS								
Rasberry Pi 4B 8Gb	Need to Order	PiShopUS	8GB-9006	Raspberry Pi Development Board	$75.00	3	$225.00	https://www.pish
Raspberry Pi 4 Case, Red/White	Need to Order	PiShopUS	644824914916	Raspberry Pi Case	$5.00	3	$15.00	https://www.pish
Case Fan & Heatsink for Raspberry Pi 4 Case	Need to Order	PiShopUS	1411	Raspberry Pi Case Fan	$5.00	3	$15.00	https://www.pish
USB-C Power Supply, 5.1V 3.0A	Need to Order	PiShopUS	1203	Raspberry Pi Power Supply	$7.95	3	$23.85	https://www.pish
							$797.09	

Parts List for Total Package

Individual Tasks

Ziyad Allehaibi

Terry Edwards

Excluding the work put into this document, my tasks for this semester (After the project was chosen and researched) consisted of creating the initial rough draft sketch of the top-level design image used in the design poster. This sketch was later recreated in google drawing before updated and improved upon by other group members. After the initial problem statement was decided on, the possible subsystems needed to be brainstormed. To do this I created the subsystems table and added the different things that could be possibly done regarding monitoring a loved one. To fill out this table, I interviewed multiple nurses and a respiratory therapist to get their opinion on aspects of the subsystems that I could not think of. After compiling all the findings and my own personal ideas, a table of roughly sixty different subsystems was created. This table was then broken down and colorized based on the type of physical sensor that could be used in each subsystem. After researching sensor types, I broke the original subsystem table up into the ten sensor types that we have today and then compiled and categorized the different subsystems that were brainstormed and displayed them in a new table. This table was then used to create a weighted decision table based on the chosen engineering characteristics to determine the subsystems that would be implemented into the final design. Alongside the work with the subsystems table, I also aided creating and filling out the design table. This consisted of making many decision tables that required individual engineering characteristics and weights. After completing the decision tables I then compiled all the results into the design table used in our presentation. Next, I took the design table and the subsystem table and created the parts list. I researched parts options to make sure there were no cheaper options and then added them to the parts list. To determine the best combination of parts amongst the group, I split the parts list into multiple tables that showed individual prices for the hub itself and a set of subsystem sensors. Afterwards I combined the two to create the current parts list. I then created the output table used in the presentation. I filled out the initial contents of the table and another student later added on to these. I also recreated the Gantt chart after the initial one made by another student was corrupted and no longer functioned. This consisted of going through the entire semester and deciding on potential tasks that would be necessary to produce our product. Finally, I created the initial copy of the presentation that was used while the other students came behind me and added their individual slides

Ben Whalin

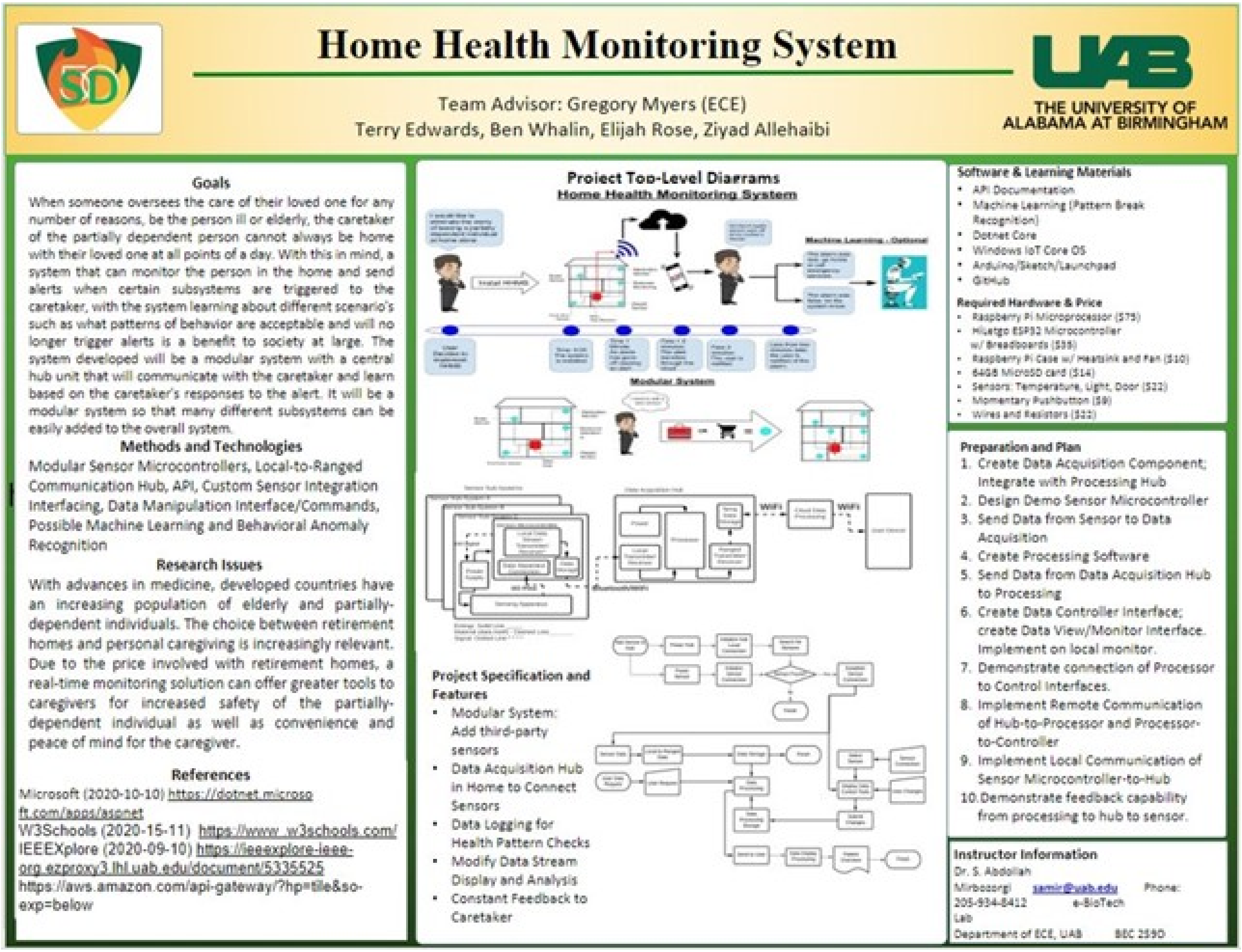
My tasks for the first semester one (EE498) included researching the potential Microcontrollers and Microprocessors that would be looked at and considered for use in the project. Throughout the semester, I helped work on the Design Table as well as the Decision Tables needed to help with the project. I created the Top-Level Diagram (TLD) used for the poster for the course as well as the Hardware Diagram that will be useful for helping create the project in EE499. I contributed to the PowerPoint Presentation by creating the slides used for the TLD, Hardware Diagram and the Poster as well as helping look over everyone's slides to help with ideas and proof-reading.

Elijah Rose

Elijah focused primarily on the software design aspects of the project, along with the aid of Terry, as detailed in software simulation. He additionally contributed various other pieces and work to the team, such as the hardware diagram V1, separating the Data-Acquisition and Processing hub, etc.

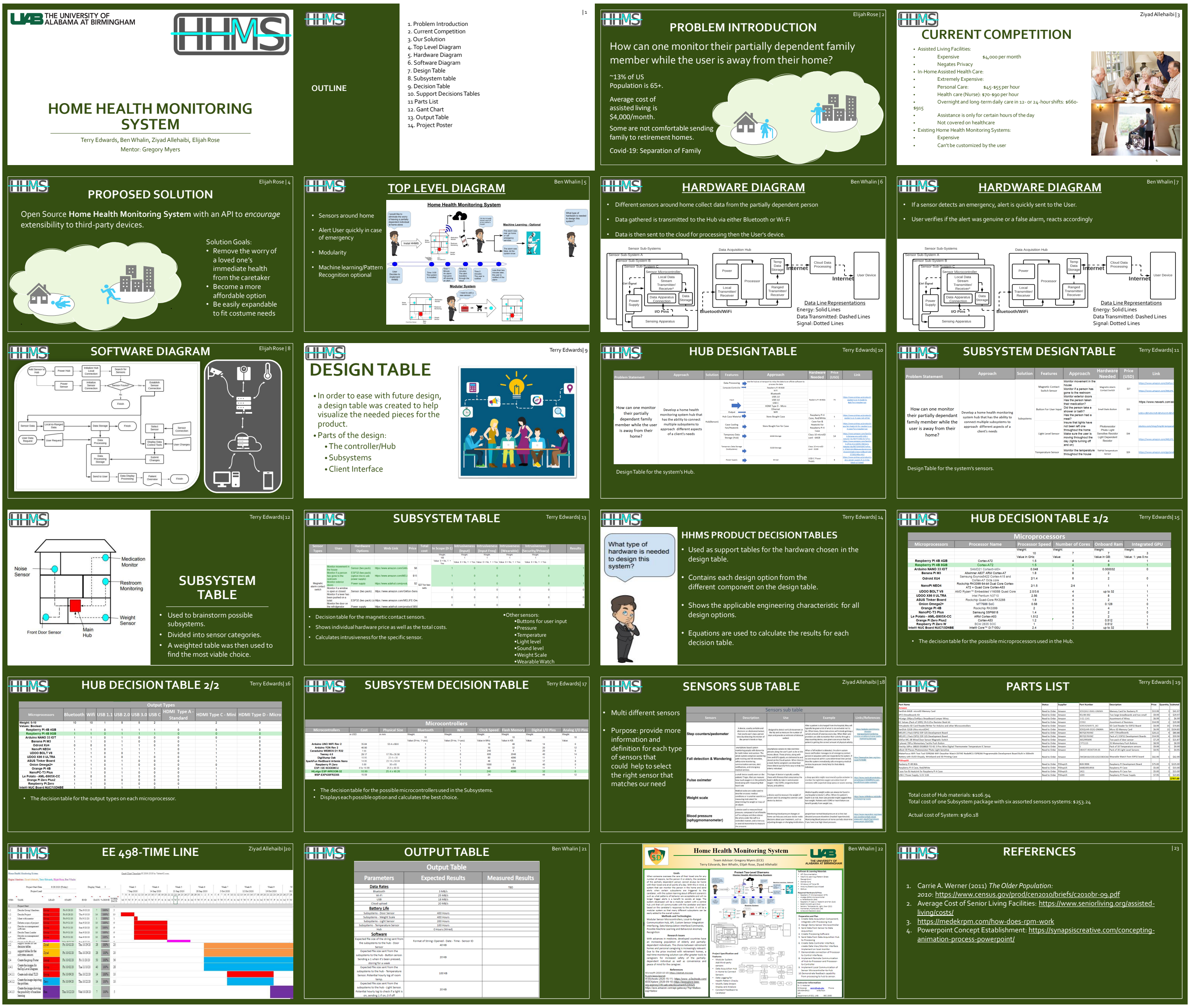
Appendix

Appendix A: Poster



HHMS Poster

Appendix B: Final Slides


HOME HEALTH MONITORING SYSTEM
Terry Edwards, Ben Whalin, Ziyad Allehaibi, Elijah Rose
Mentor: Gregory Myers
OUTLINE
1. Problem Introduction
2. Current Competition
3. Our Solution
4. Top Level Diagram
5. Hardware Diagram
6. Software Diagram
7. Design Table
8. Subsystem table
9. Decision Table
10. Support Decisions Tables
11 Parts List
12. Gant Chart
13. Output Table
14. Project Poster
PROBLEM INTRODUCTION
How can one monitor their partially dependent family member while the user is away from their home?
~13% of US Population is 65+.
Average cost of assisted living is $4,000/month.
Some are not comfortable sending family to retirement homes.
Covid-19: Separation of Family
CURRENT COMPETITION
PROPOSED SOLUTION
Open Source Home Health Monitoring System with an API to encourage extensibility to third-party devices.
Solution Goals:
Remove the worry of a loved one's immediate health from the caretaker
Become a more affordable option
Be easily expandable to fit costume needs
TOP LEVEL DIAGRAM
Sensors around home
Alert User quickly in case of emergency
Modularity
Machine learning/Pattern Recognition optional
HARDWARE DIAGRAM
Different sensors around home collect data from the partially dependent person
Data gathered is transmitted to the Hub via either Bluetooth or Wi-Fi
Data is then sent to the cloud for processing then the User's device.
HARDWARE DIAGRAM
If a sensor detects an emergency, alert is quickly sent to the User.
User verifies if the alert was genuine or a false alarm, reacts accordingly
SOFTWARE DIAGRAM
DESIGN TABLE
In order to ease with future design, a design table was created to help visualize the needed pieces for the product.
Parts of the design:
The controller/Hub
Subsystems
Client Interface
HUB DESIGN TABLE
Design Table for the system's Hub.
SUBSYSTEM DESIGN TABLE
Design Table for the system's sensors.
SUBSYSTEM TABLE
Used to brainstorm possible subsystems.
Divided into sensor categories.
A weighted table was then used to find the most viable choice.
SUBSYSTEM TABLE
Decision table for the magnetic contact sensors.
Shows individual hardware price as well as the total costs.
Calculates intrusiveness for the specific sensor.
HHMS PRODUCT DECISION TABLES
What type of hardware is needed to design this system?
Used as support tables for the hardware chosen in the design table.
Contains each design option from the different component on the design table.
Shows the applicable engineering characteristic for all design options.
Equations are used to calculate the results for each decision table.
HUB DECISION TABLE 1/2
The decision table for the possible microprocessors used in the Hub.
HUB DECISION TABLE 2/2
The decision table for the output types on each microprocessor.
SUBSYSTEM DECISION TABLE
The decision table for the possible microcontrollers used in the Subsystems.
Displays each possible option and calculates the best choice.
SENSORS SUB TABLE
Multi different sensors
Purpose: provide more information and definition for each type of sensors that could help to select the right sensor that matches our need
PARTS LIST
Total cost of Hub materials: $106.94
Total cost of one Subsystem package with six assorted sensors systems: $253.24
Actual cost of System: $360.18
EE 498-TIME LINE
OUTPUT TABLE
REFERENCES
1. Carrie A. Werner (2011) The Older Population: 2010: https://www.census.gov/prod/cen2010/briefs/c2010br-09.pdf
2. Average Cost of Senior Living Facilities: https://www.seniorliving.org/assisted-living/costs/
3. https://medekrpm.com/how-does-rpm-work
4. Powerpoint Concept Establishment: https://synapsiscreative.com/concepting-animation-process-powerpoint/


THANK YOU!
ANY QUESTIONS?