PUMPED

The Smart Portable System for Weighing, Labeling, and Tracking Breast Milk

Group 15

Members:

Electrical Engineers:

Jimmie Rawls

Kevin Fernandez

Computer Engineers:

Agustin Rodriguez

Eric Hernandez

Project Sponsors:

VICTORIA RODRIGUEZ

MATTHEW ABERMAN

Mentors:

Dr. Lei Wei

Dr. Weeks

Reviewer Committee:

Mark Maddox	ECE	Adjunct Professor
Dr. Piotr Kulik	ECE	Assistant Professor
Dr. Azadeh Vosoughi	ECE	Professor

Chapter 2: Project Description

2.1 Motivation and Background

Taking care of a newborn is not for the weak, but that's why mothers are so strong. Mothers gladly give up their time and attention to make sure their newborn has everything they need. Perhaps one of the most important needs for a newborn is their mother's milk. Babies need constant feeding, and it is up to moms to have breastmilk ready for them when they need it. To keep up with this demand, mothers will painstakingly pump their milk at all hours of the day while also having to meticulously label each and every bag they pump. This process usually entails the mother having to write on the bags with a marker or pen to include information like the date and time the serving was produced, the volume of the serving, allergens, and any dietary considerations a serving may contain. Time is an important factor for pumped breast milk because milk that is pumped at night affects babies differently than milk that is pumped in the morning. Not only that, but mothers also must keep track of their entire stock of breast milk to make sure they can use it before it expires. What makes matters worse is that if a mother forgets to label, or improperly labels their pumped milk, that serving could end up in the trash, leading to unnecessary waste not only for their baby but for those to whom that milk could have been donated. Thus, labeling and keeping track of breast milk is a critical undertaking. PUMPED, our senior design project aims at eliminating the tediousness of labeling and documenting breast milk servings so that a mother can focus on more important things. When a mother has finished pumping her milk, she can place the filled container on our portable device and it will weigh the milk, convert the weight into fluid ounces, and then print a label from the device's integrated label maker. The label's information will contain a bag number for ease of tracking, the date and time the milk was pumped, the volume, allergens, and any dietary considerations. Our device will be paired with a mobile app that keeps a running tab on all the milk servings a mother has pumped and will push notifications on servings that are close to expiring. The app will also be able to take input commands so that the labels can be customized to meet any requirements needed for institutions that accept donations.

Our sponsors, Victoria Rodriguez and Matthew Aberman pitched their real-life problem to us, and we jumped at the chance to find a solution. As parents, Victoria and Matthew have had plenty of experience with the tediousness of the labeling process. There is no set schedule to start pumping, an example of this was when Victoria had to wake up at two in the morning to pump breastmilk. She had little to no enthusiasm for filling out the details on the bag much rather opting to wait till the morning. However, as life tends to get in the way, those important details soon find themselves forgotten and a precious serving of milk becomes a mystery. Another important motive our sponsors had for commissioning this project were the possible implications it could have on the donation side of things. Many hospitals need and accept breast milk donations for newborns whose mothers cannot provide their own. These babies are often critically ill and are in the infant version of the intensive care unit. A breast milk donation can be paramount in saving those babies' lives. Even with a hospital's great need for breast milk they would still have to reject improperly labeled samples. Hospitals follow specific guidelines that ensure safety and traceability for their breast milk samples. So, with a product like PUMPED in the picture, all the aforementioned specifics that come with a serving of breast milk, could become included

in a standardized system where mothers, hospitals, milk banks, and any other entity that deals in breast milk, can meet a baby's needs without the worry of improperly labeled milk.

2.2 Review of Existing Devices

2.21 - Smart Milk Bag Labels

Smart Milk Bag Labels Created by the Cubtale store, being sold on amazon for $14.99 contains many features that are very important to consumers. This device contains a set of numbered labels that are in the range of 1 to 500. The labels contain a few sets of details. For example, each contains a designated number of four sections corresponding to date, time, volume in ounces, and name. It also contains a QR code that will allow you to connect to the mobile app provided. The physical labels are very simple, they are not self-labeled, so a mother must label them individually each time. The main selling point of this device is that it comes with a mobile app containing many features such as, expiration date alerts, information on CDC guidelines, proper handling instructions, temperature descriptions, caregiving instructions, and comprehensive milk tracking that will allow a mother to track the total amount of bags on hand.

2.22 - Walz Breast milk Labeling Device System

The all-in-one breast milk labeling system developed by Walz offers a portable solution for mothers to label their breastmilk bags. It is advertised as being simple to operate by being plug and go, having mobility due to a stand-alone ergonomic rolling cart, label printer that allows for label customization and is easy to handle. The built-in keyboard allows the consumer to add the baby's name, mother's name, current medications, and pump date. It does not contain a mobile application, so it definitely has its limitations. Due to this product size, it seems to be aimed specifically at the medical industry instead of an average mother. To obtain the price of this device, the consumer is required to request a quote from the manufacturer. This information comes off as the product being on the expensive side.

2.23 – Dr. Talbot's Mom Milkfresh Breastmilk Freshness Sensors

Dr. Talbot's MilkFresh sensors are designed to help mothers keep track of the breastmilk they have stored, and it helps with quality control via the temperature indicators. Each sensor is a peel-and-stick label that has a QR code and a temperature indicator that changes color if the milk has been exposed to potentially unsafe temperatures. The inventory tracking is done via the application called "MilkFresh". When scanned with the MilkFresh App, the sensor's activation date is recorded, and users can manually input the amount of milk stored in each bag. The app's inventory section organizes stored milk by bag number, volume, and activation date. The user can scan the QR code of an activated bag to check the quality of the milk. After scanning the QR code, the app provides the different expiration dates based on whether the milk is kept in the refrigerator or freezer. This product allows mothers to monitor storage conditions and manage their breastmilk supply through the app's tracking features and ensures quality through the temperature indicator on the label.

Summary:

Looking into existing products on the market right now, there are a lot of key takeaways and small details that are common in both devices. But there are also many differences to each. Both devices are aimed to tackle the same problem of breast milk management for mothers, but each comes with its own limitations.

In the case of our sponsored project, we are taking a different approach from the three devices mentioned above. We are planning on taking all of the smart features that each of these devices offer, and bring them into one single small device that is capable of features such as: easy to use, small and compact, user friendly, mobile application ready, abides by the CDC guidelines, prints labels with pre-written information, and much more. One major takeaway from reviewing similar devices and products is that there does not appear to be a readily available, consumer grade device that provides the all-in-one functionality, while still being portable, that we are planning on creating with our own device.

2.3 Project Goals and Objectives

Our overall goal is to create an easy-to-use device that enables mothers to automatically categorize and manage their inventory of breastmilk to ensure feeding their child is as

simple as it can be. To achieve this overall goal with our PUMPED project we have numerous smaller goals that we have classified as basic, advanced, or stretch goals. The completion of our basic goals will ensure we have a minimum viable product with our core features successfully implemented. The advanced goals represent tasks that if successfully completed will add auxiliary features or enhance our existing core features. Our stretch goals are ones in which we acknowledge that we may not have enough time allocated to us in this project to achieve them due to their lower priority relative to other features or due to their overall complexity. We are confident that all of the advanced goals will be met and that we will likely have time to complete 1 or 2 stretch goal items, but these goals are of course not guaranteed to be completed or even fulfilled in the exact way as they have been written here.

Basic Goals:

- The device accurately weighs the breastmilk bag placed on the scale portion of the device.
- Device prints a label for bag containing volume, time, date, and allergen/dietary details.
- An integrated app displays current breastmilk stock for user.
- The device is portable and easily carried around.

Advanced Goals:

- The App notifies users that a breastmilk bag is approaching its expiration date.
- The app shows detailed daily/weekly/monthly production stats.
- Users can add detailed allergen information to each bag.
- LCD screen displaying various bag information

Stretch Goals:

- Hospital Admin users can send requests to all individual users in the area for donations.
- Individual users can schedule drop-off times with local hospital / milk bank for breastmilk donation.
- Automatic shutdown of device depending on certain conditions.

2.4 Project Features

Entire device

- Portability: The device must meet the required specifications for weight and must be sized so that the average consumer can easily pack their device and use it while traveling, vacations, road trips, etc.
- Rechargeable: Since babies and their needs can be unpredictable, the device needs to be rechargeable so that mothers can use it on the go or wherever they may need it. It can be an inconvenience to have to go buy new batteries when the charge runs out, so that is another issue that a rechargeable battery can solve.

- Supports a variety of breast milk containers: There are hundreds of different breast milk bags that can be bought online, they vary in size, shape, and materials. Our device should be designed so that most breast milk bags / containers can be placed into the scale and weighed.
- Simple to understand user interface: A simple user interface is necessary for the average consumer to easily use the device and application. Time is an essential resource for all mothers and a simple interface will allow for efficient label printing.

Scale

- Measures milk weight: The user will place the breastmilk bag upon the scale, and it will automatically weigh the bag, and that information will be processed by the rest of the device.

Thermal printer

- Prints labels: Our thermal printer will be printing labels that contain some sort of identifier such as a bag number so that the user can distinguish between bags physically. Additionally, things such as date, time, volume, and allergen/dietary sections will also be printed on this label.
- Meeting labeling standards: Hospitals and milk banks which typically take in and process donated breastmilk have certain standards for how they should be annotated so we will ensure that these specific standards are met with the format of our labels.

Display

- Provides volume: The LCD screen on our device will depict basic information about the breastmilk bag which has been placed upon the device. Things such as the volume in fluid ounces and other miscellaneous information may also be depicted.
- Options screen: On an option screen users will be able to modify basic settings to make the use of the device more convenient for their own purposes.

User interface buttons

- Scale reset: The scale reset button will reset all peripherals such as the display, scale, and the printer for troubleshooting purposes
- Tares button: The Tares button will be used to zero the scale in the case that the user wants to get an accurate measurement of added weight to a container.
- Mode selection: Mode selection will allow the user to switch units of measurements such as grams, ounces, etc.
- Print Label: After the user places the breastmilk bag onto the device's scale, they will then be prompted to hit the print label button at a time of their own choosing. This will then print out a label with all the necessary information needed to organize the milk bags.

Bluetooth/Wi-Fi capabilities

- Phone connection: The device will be integrated with a mobile app that can deliver certain notifications to a user.
- App connection: The app will be receiving breastmilk bag data from the MCU likely either via Bluetooth or Wi-Fi connections

Application

- Tracks milk inventory: Users will be able to consult the app to view their current inventory of breastmilk bags.
- Tracks milk production statistics: Users will be able to view basic statistics of their breastmilk production while also breaking it down by day/week/month.
- Notifies users of upcoming expiration dates: Users will receive via the app a notification that previously stored breastmilk bags are soon to expire, and they will be also shown this information within the app itself.
- Takes input for dietary/allergen considerations: Users will be able to record detailed notes within the app for individual bags regarding what dietary or allergen concerns they may have regarding particular bags.
- Overview of milk storage
- Label templates

2.5 Requirement Specifications

The specifications and engineering requirements for this project can be found in Table 1. The requirements for this project revolve around making a device that is portable and usable for extended periods of time outside the home. The specifications written here represent our core functionality and the general expectations which we have for them and how they will perform in the field. We anticipate that these listed engineering requirements are feasible and that we will be able to meet all of these engineering requirements without any significant issues.

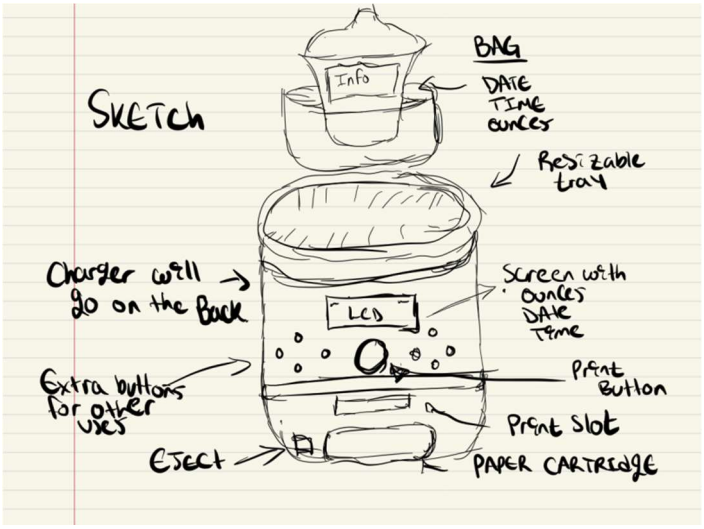
Table 1: Requirement Specifications

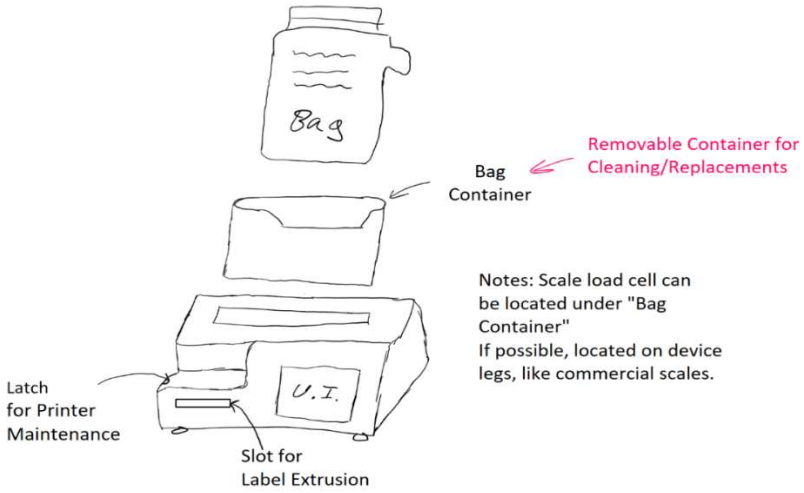
Pumped Device	
Specification	Engineering Requirement
Scale/weight sensor should be accurate	Accurate within +/- 3 grams
Time to print after print button pressed should be almost immediate	5 seconds or less
Time for recorded breastmilk bag data to be sent to mobile app should be short	50 seconds or less
Time for breastmilk bag to be weighed after placed on scale almost immediate	3 seconds or less

Device weight should permit it to be portable	8 pounds or less
Battery Voltage	12V or less
Battery Capacity	At least 10 hours
Battery lifespan	At least 2 years

2.6 Prototype Image/Blueprint

The two images shown below are prototype sketches that were drawn by team members Eric and Kevin, respectively. They both portray similar main functionalities needed to satisfy our requirements such as having a scale to weigh the bags of milk, a display to show the user the ounces weighed, a printer, and a removable container for ease of cleaning in case of milk spills. These drawings were made to portray what our working designs could look like. Of course, the design is subject to change as we gather more information on which printer we will be using, the size of our load cell, battery pack, and PCBs. We expect these to evolve as further information is acquired and as we run into issues.





2.7 Block Diagrams

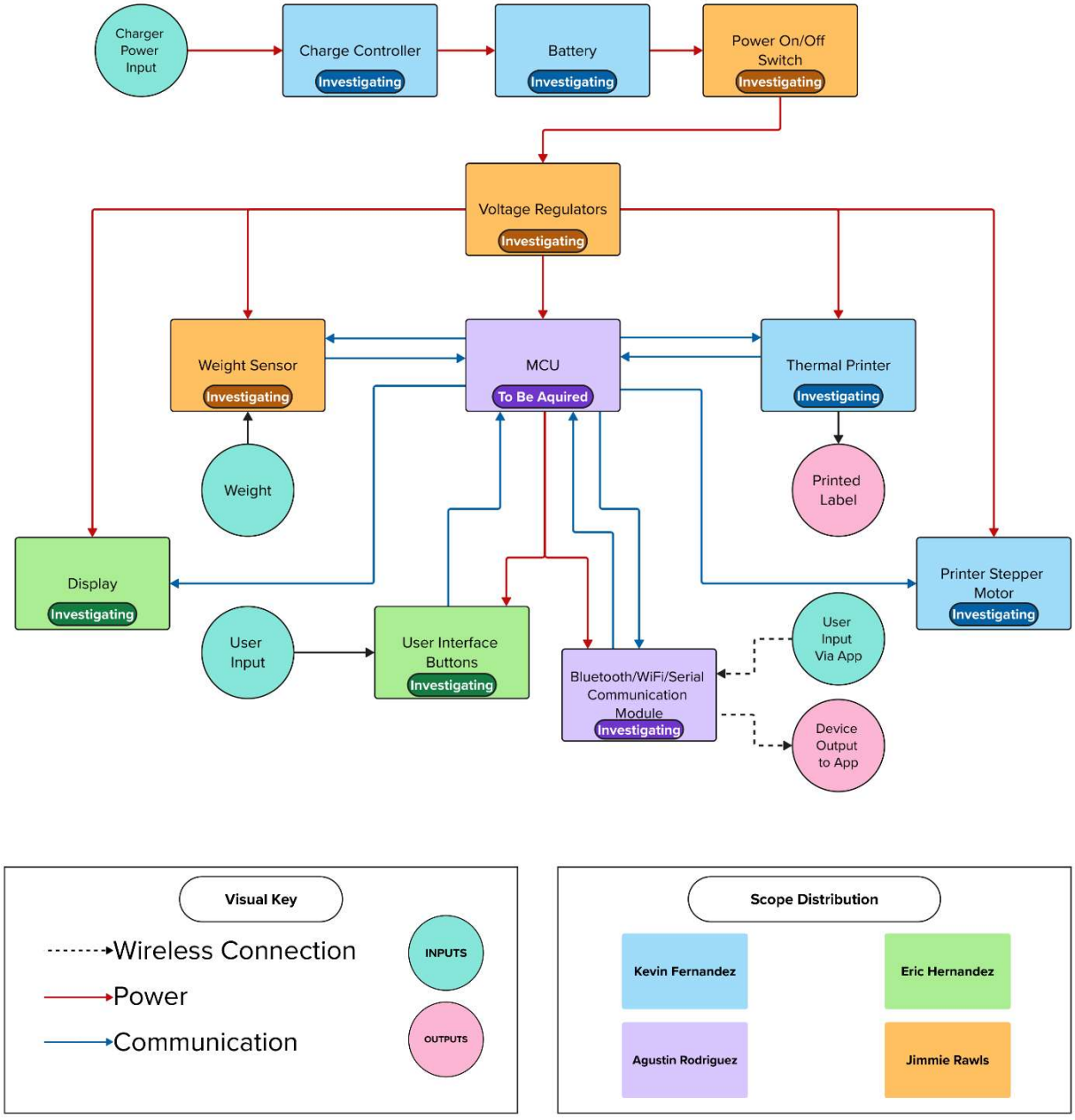


Figure 1: Hardware Diagram

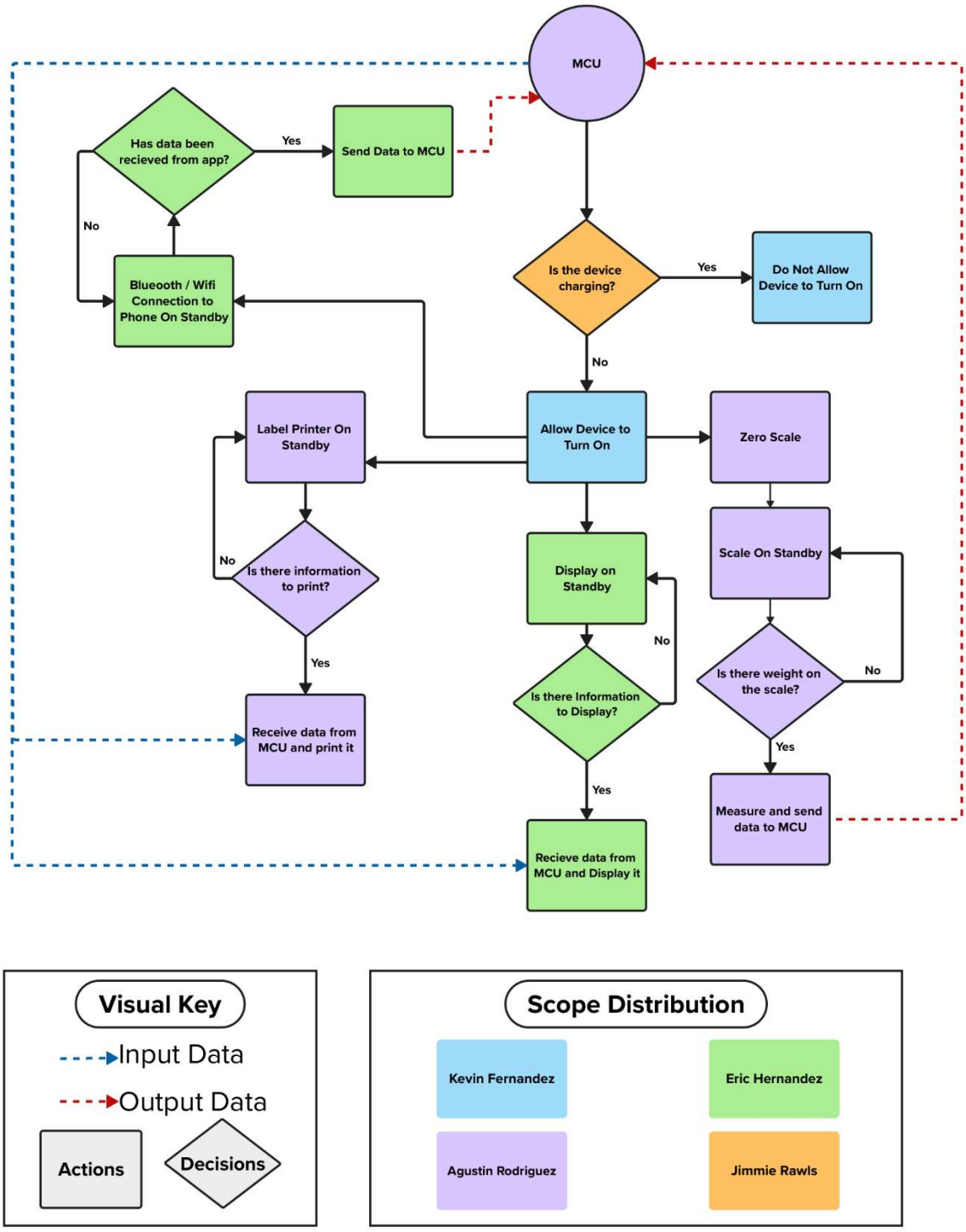


Figure 2: Software Diagram

2.8 Project Budgeting / Cost

Pumped project is sponsored by Victoria and Matthew for a total of up to $500. We are still brainstorming the parts for this project, but some of the items that we are going to be using are listed below. The prices are to be determined because we have still not found the correct model that we will be using for our senior design project. All prices here are a general estimate but we are confident that the vast majority of the project will be covered by the $500 in sponsor funds we are receiving from our two sponsors Victoria and Matthew.

Table 2: Bill of Materials

Component	Subsystem	Quantity	Unit Cost	Total Cost
ESP32	All	1	$14.78	$14.78
LCD Screen	User Interface	1	$15.99	$15.99
Battery Pack	PSU	1	$19.99	$19.99
Thermal Printer	Printer	1	$39.00	$39.00
Load Cell / Wheatstone Bridge	Scale	1	$15.49	$15.49
Physical Buttons	User Interface	1-kit	$7.99	$7.99
More components are TBD	PCBs, Device Frame, etc.	TBD	TBD	TBD
Total	$113.24			

Budget Provided by Sponsors	$500

2.9 Project Milestones

There are several meetings and events that will be occurring in the next few months. These meetings are required for a successful project so that we do not fall behind on our project and risk getting ourselves into a bad position. The list will be updated accordingly, but for now, the items listed have been planned for. A key part of our project milestones that may be different from some other groups is that we have a sponsor attached to our project. Since we have a sponsor attached to our project, we will likely have to regularly check in with them on all of our project milestones. After meetings with them we may or may not have to engage in modifying our work depending upon their feedback. We anticipate making weekly progress on our project milestones and are committed to attempting to maintaining that pace as we believe it will help stave off issues such as procrastination which may be an issue on this kind of project. We also are

planning on committing to the weekly milestones in order to take advantage of the mentors we have around us. We would like to ensure that by sticking to a preplanned timeline that we are able to arrange meetings or consultations with subject matter experts among our professors and faculty or our sponsors at the appropriate times. The project milestones are therefore important not only for us but also for the people around us who can plan their own schedules so that they have time to assist us.

Table 3: Project Initialization Milestone

Project Initialization			
Task	Start Date	End Date	Description
Formation of group	1/06/2025	1/08/2025	Eric Hernandez - CPE Jimmie Rawls - EE Kevin Fernandez - EE Agustin Rodriguez - CPE
Brainstorming Ideas	1/06/2025	1/09/2025	Brainstorming for possible project ideas that we can pursue.
Sponsor Meeting	1/16/2025	1/16/2025	First meeting with the sponsor. Its purpose for introduction of us, also to talk a little bit about goals for the project
D & C Document	1/19/2025	1/24/2025	First 10 pages of D&C to declare the project's purpose and details.
D & C Group Meeting	1/29/2025	1/29/2025	Meeting with SD faculty that will determine whether the project is approved or not.
Mid-point, 60-page milestone	1/31/2025	3/24/2025	Halfway point of the Report
60-page Group meeting	TBD	TBD	Meeting about the 60-page milestone for checkup.
Final Document & Mini Demo	3/24/2025	4/22/2025	Completion of report and mini-Demonstration.

Table 4: Project Fabrication Milestone

Project Fabrication			
Task	Start Date	End Date	Description
Purchasing / Selecting Components	2/01/2025	3/01/2025	Gathering all of the required components for the project and creating a BOM.
Designing the System	2/20/2025	4/01/2025	Putting together and modifying the schematics for the PCB
Testing	3/20/2025	4/01/2025	Testing different components to make sure that they are compatible and work together.
PCB Design	TBD – SD2	TBD - SD2	Designing the PCB design, passing it through with our sponsor and placing the order for it.
PCB Testing	TBD - SD2	TBD - SD2	Testing the design as early as possible to make sure it's working properly. We will have to order a new one if there's an issue.
Completion of Prototype	TBD - SD2	TBD - SD2	Completion of the protype and making sure it works without errors.

References and Disclaimer

Disclaimer: This idea is solely credited to our sponsors, Victoria Rodriguez and Matthew Aberman. They will retain full ownership of the final prototype, and any engineering design assets/materials created.

[1] https://walzeq.com/products/labeling/printers/specialty/breast-milk-labeling-system/#gsc.tab=0

[2] https://a.co/d/7PHHq0T

[3] https://www.themilkbank.org/donate-milk/

[4] https://www.advocatechildrenshospital.com/health-resources/support-services/donor-milk-program

[5] https://www.milkbanktn.org/guidelines

[6] https://drtalbots.com/products/milkfresh-sensors