Group 7
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# Smart Crib

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## Project Narrative

When a baby is born, there is a lot of pressure on the parents to take care of the baby. Parents need to constantly keep constant watch on the baby to see if they are awake, asleep, or crying. Parents need to be extra vigilant during the tender months after birth since any action or inaction can have a tremendous impact on the rest of the babies's life. Typically, a crib is a small bed that is made for babies. Newborns spend a majority of their time sleeping in a comfortable and safe crib. Everyone knows that during that period of time, the parent is put through a large amount of stress from micromanaging their newborn on top of their adult responsibilities. A newly designed crib dubbed "Smart Crib" will assist the parents in taking care of their newborn and relieving stress while they do other things.

This Smart Crib will carry a lot of functionality that will allow the parent to be at ease. Some features include a temperature sensor, weight sensor, heart rate sensor, motion sensor, noise sensor, mobile app, and live feed camera will be implemented into the crib to make it a Smart Crib. Other "smart" cribs on the market nowadays are extremely costly with one or two features only. Paying thousands of dollars for a smart crib is unwise since the baby will eventually outgrow the crib very soon, so it is important to make our design as cheap as possible. The current smart cribs on the market allow the very few fortunate people that are able to afford such crib. One of the main features of the crib will be low cost design and implementation of many functionalities. This will allow a low barrier of entry to consumers looking for a smart crib.

Some of the components of the system include motion sensors, sound sensors, and cameras. The motion sensor allows the system to detect if the baby inside the crib is awake. It will periodically detect movement within a time frame to notify the parents if the baby is awake. The sound sensor will sense the detection of the baby crying to notify the parents that they are in fact awake. The sound detection in general will detect loud enough sound to set off the sensor. When sound or the motion detection happens, the parents will be notified through a mobile application that will send an alarm and text. The live feed camera is also a part of the motion and sound detection package. The camera will allow the parents to keep an eye on the baby at all time and can send a notification when there is movement or sound detected. The camera will prove useful as it gives the parent the peace of mind of seeing their baby is okay without having to go check every few minutes unless they have to.

The system will also include sensors such as temperature, heart rate, and weight to measure biometric data. This will allow the parents to keep an eye on the baby's health at all times. This is a very crucial feature as being new parents, as these sensors will give insight about keeping the baby in a healthy. The heart rate sensor is also there for another key insight about the baby's health. The heart rate monitor is one way to prevent sudden infant death syndrome (SIDS). Educating parents about these health signs are important to raising a healthy baby as the parents will have to learn about healthy weight for the baby to have. Not only that the baby should have an acceptable heart rate at all time and if something is off, the heart rate monitor will

detect it and notify the parents. Temperature is also a very important aspect of raising a baby as they can't be too warm or too cold. The temperature sensor will continuously send data to the mobile application and detect if the temperature of the baby is going too high or too low. It allows them to be at ease when everything is normal and be alert if one of the sensors is giving a reading that is alarming. The data of these sensors will be collected and sent to a mobile application that will also be paired alongside the smart crib.

A crib mobile will also be implemented as part of the smart crib. This will help the baby with visual and auditory simulation. It will provide a way to keep the baby busy for the moment when the parents are notified that the baby is awake. It will have a manual turn on and turn off that will be controlled by the mobile application for full control over when to stimulate the baby. Having full control is useful as allowing the baby to turn on the crib mobile when it is crying will be detrimental to the baby's learning.Many of these functionalities for the baby crib exists already but they are all separate products.

The smart crib is meant to encourage the parent to be more informative of their baby's health and allows the parent to take care of their responsibilities without having to constantly worry about the state of the newborn. All of these functionalities will be incorporated into the crib at a low cost design and implementation so that every household will be able to afford one. Thus, the smart crib will provide an improvement to the health of the parents and the newborn.

**Commercial products on the market**

A product on the market currently is called Angelcare movement and sound monitor. It has the functionality of sound and motion detection to keep track of the baby but lacks a live feed camera for the parents. There are various camera product options that will function as a baby monitor that includes night vision but none of the products will have any features included with the camera. Owlet Baby Care is a product that tracks the baby's heart rate and oxygen and sends it to a mobile application for the parents. SNOO is a product on the market that essentially helps your baby sleep by auto white noise, protective swaddle, auto gentle rocking They implemented this through a little baby sock. A goal of our design is to implement the functionality of many different kind of baby crib to an inclusive all in one smart crib.

**Broader Impacts**

This project can impact the world on the large scale depending on how cheaply we can create our design, and prove how useful this Smart Crib is to new parents. The current cribs on the market that monitors children's vitals are very expensive and are more shiny than functional. Bringing a product into the market at a fraction of the price can save more lives and improve the quality of life new parents. Since parents will be less sleep deprived and less stressful about their children's well being, on a local scale new parents will be more pleasant to be around improving relationships among coworkers, friends, and family.

**Personal Motivations**

**Brian:**

This project is my first chance to be able to work between interdisciplines. Although I won't be working with the sensors or the system itself, I will be for the first time coming up my own requirements and communicating with team members that have little to no experience with programming what I am doing. I will have to be able to share my limits of what can or cannot be done, and in the end understand the general design on parts I did not have a hand in. Regarding the idea of the project, I think it is good that we are coming up with something that is useful and that can fill a niche in the market should we continue to pursue this idea after senior design is over.

**Thinh:**

This is the first time I will be able to fully design the power supply circuit from schematic to PCB. I will be able to work on designing and learning about how to create an AC to DC conversion circuit, switching mode power supply circuit, and linear voltage regulator circuit. Not only that, I will also be working alongside another Electrical Engineer to design the PCB layout for the whole project. This is a whole new domain for me and it will be an exciting task to work with three other students to interface between analog and digital components.

**David:**

The Smart Crib project is giving me the opportunity to create a product I wish was available for my two children. From experience I know that parents of newborn babies have a lot of different needs to ensure their baby's well being and bring peace of mind to the parent. By completing this project I will also be able to showcase the knowledge and skills I have developed through my education and my internship. I will be able to demonstrate my knowledge garnered through my education by effectively researching, testing, selecting, and implementing various components and circuits. I will be able to showcase the technical skills I have garnered through my internship by creating schematic designs, pcb layouts, and meeting requirements.

**Phuoc:**

This project giving me the opportunity to work with Embedded ARM programming. This project we incorporate many sensors, this give me hand on experience with Communication protocol such as I2C, SPI, UART along with Analog to Digital Converter to interact with sensors. In addition, with this project I get to work with WIFI communication for the first time, able to gather data from the sensors and transmit them through WIFI connection is important because the data can be log from anywhere. The experience from paring software interface with hardware. Along with technical experience from this project, I get to work with a team with different background of experience.

**Requirements Specifications**

**Table 1: Hardware Requirement Specifications**

| | |
|---|---|
| 1.0 | The system shall adhere to applicable safety standards. |
| 1.1 | The system shall monitor the heart rate of the child. |
| 1.2 | The system shall sense motion within the crib. |
| 1.3 | The system shall have the ability to visually display the baby inside the crib. |
| 1.4 | The system shall monitor sounds coming from within the crib. |
| 1.5 | The system shall have the capability of transmitting data to a mobile application. |
| 1.6 | The system shall have the ability to weigh the baby. |
| 1.7 | The system shall soothe the baby. |
| 1.8 | The system shall use a single consistent power source. |
| 1.9 | The system shall have clean input and output signals. |
| 1.10 | Low cost of production. |
| 1.11 | Low operating temperature. |
| 1.12 | Low power consumption. |
| 1.13 | The system shall regulate the room temperature. |
| 1.14 | The wearable piece shall have a lifespan of 12 hours per charge. |
| 1.15 | The wearable piece shall have a rechargeable battery source. |

**Table 2: Software Specifications**

| | |
|---|---|
| 2.0 | The application shall push notifications to alert the parent if the baby is crying. |
| 2.1 | The application shall display the current temperature of the baby. |
| 2.2 | The application shall display the baby's current weight. |
| 2.3 | The application shall display track the baby's current heart rate. |
| 2.4 | The application shall track the baby's weight over a period of time. |
| 2.5 | The application shall track the baby's heart rate over a period of time. |
| 2.6 | The application shall be able to change the temperature of the baby's area. |
| 2.7 | The application shall be able to run on the Android operating system. |
| 2.8 | The application shall connect to the system via WiFi. |
| 2.9 | UI design intuitive and user friendly. |
| 2.10 | The application shall be able to control a camera to display a live camera feed. |

**Ideas**

Early Ideas considered the notion of the system communicating with the app via WIFI. This idea was discarded when we realized that this would mean the app would only be able to communicate when the user was inside their home along with the baby. By uploading the data from the system to the internet, the user can download this information at certain interval at their choosing as quick as 3 seconds even away from home. This is useful in the situations they have a baby sitter at home instead of the parent.

**House of Quality**

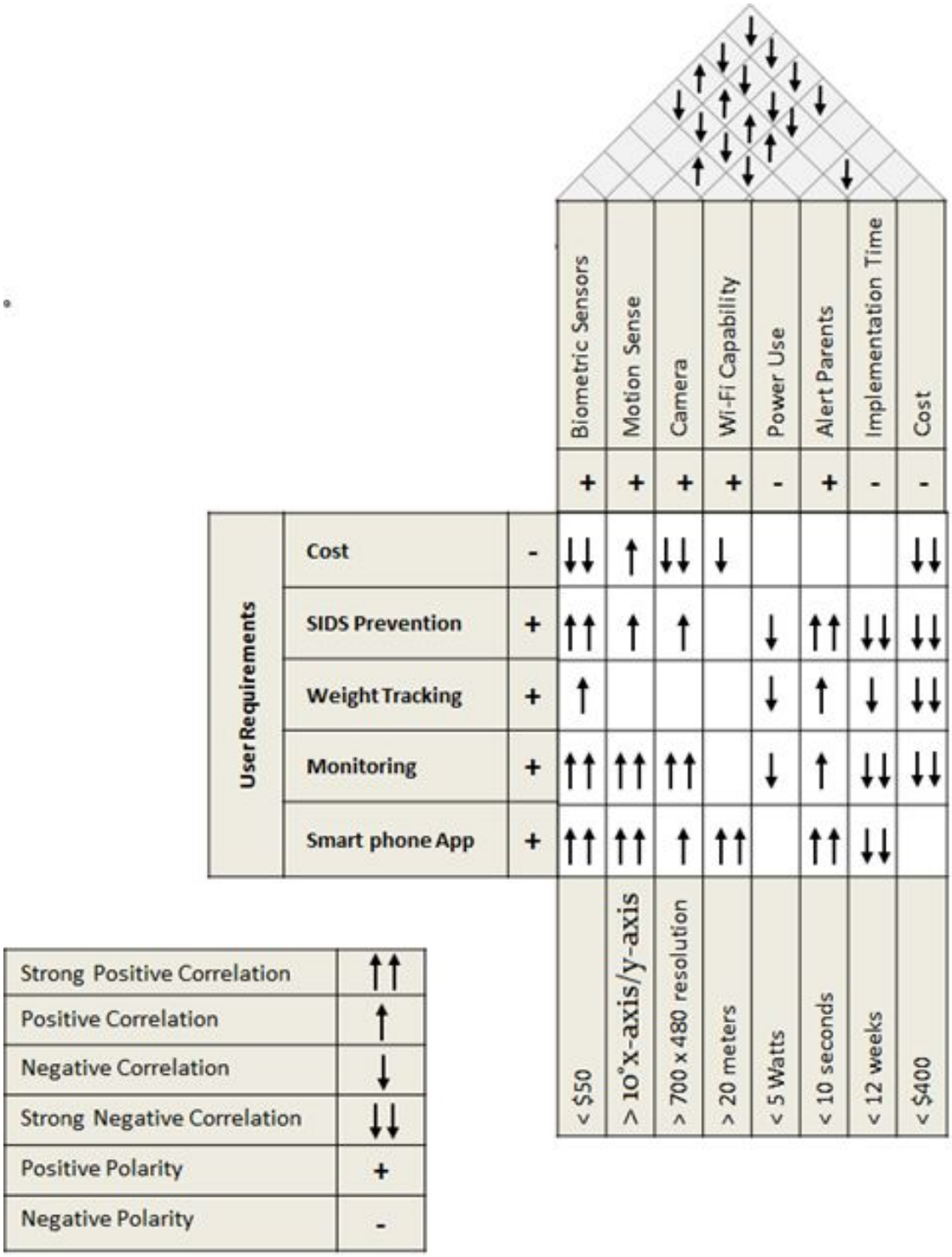


**Figure 1: House of Quality**

## General Description

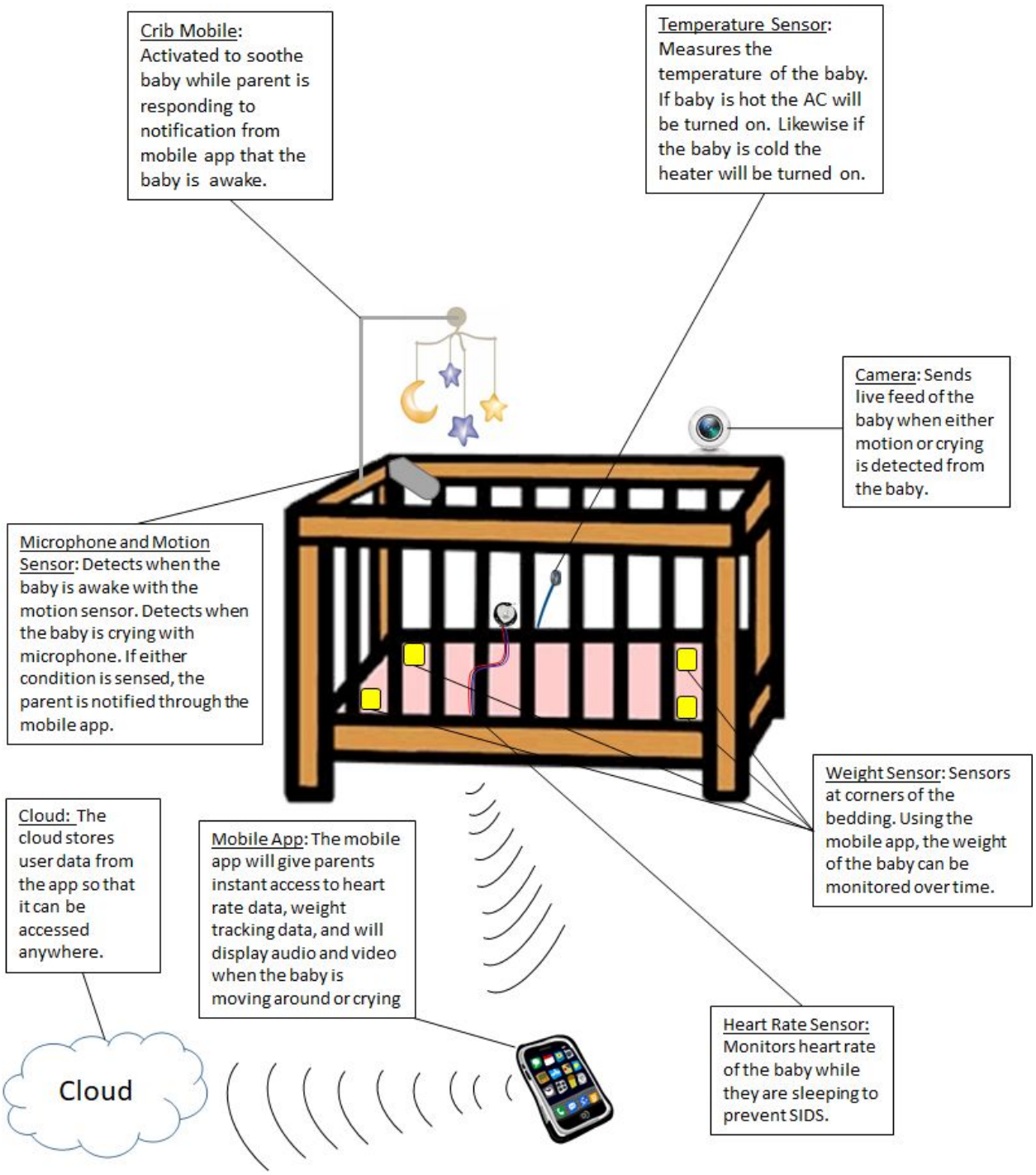


**Figure 2: General Description**

**Hardware Block Diagram**

The main PCB board with its components is shown in Figure 3. The main PCB board will house a majority of our components and connections for the sensors that will use in the smart crib. In Figure 3 the blue squares represent connection points for our components, red squares represent intermediary devices or circuits used to communicate signals from the sensor to the MCU, yellow squares represent voltage regulators, and the purple square represents the MCU. Furthermore red lines indicate voltages, thin black lines from components to the MCU represent signal transfers, and thick bold lines to components represent cables.

**Microphone**

As seen from Figure 3 a microphone will be used to detect when the baby is crying. The microphone will have a cable coming off of the main PCB as depicted with a bold line. The microphone will be placed on the outside frame of the crib and oriented to pick up sounds coming from the crib. A filter will be created for the microphone which will filter out other sounds and activate the 555 timer circuit when a frequency inside the range of a baby's cry is detected. The 555 timer will be used in monostable mode. Upon detecting sound within the crying frequency the 555 timer will send a pulse to the MCU notifying that crying has been detected.

**Ambient Temperature:**

The ambient temperature of the room will be monitored to notify the parent of the environmental conditions of the crib that the baby is in. The ambient temperature device in Figure 3 will require its own small PCB be made to implement the outside components that will allow the MS5611-01BA03 integrated circuit to operate. From the main PCB to the ambient temperature sensor the power and I2C lines are depicted by the think bold line. The I2C lines will be used to communicate the room temperature to the MCU.

**Weight Sensor:**

To keep track of the baby process of weight gain, our method is to place four Strain Gage at each corner of the mattress and paired with an instrumentation amplifier to amplifier the analog signals from each of the strain gage before the ADC happen at the MCU to determine the weight.

**Power Rectification**

Switching power mode supply design will be used to convert 120VAC to 12DC. The 12DC volt will be converted to 5v DC through a DC to DC switching power regulator design. The 5 volt will then be stepped down to 3v DC through a linear regulator  This will be on a separate PCB.

**Camera**

One aspect that would give the parent a lot of comfort is being able to see their baby on demand. There are already video baby monitors already on the market, but they cost over a hundred dollars alone. Incorporating this feature into the all in one Smart Crib project will be necessary to provide a complete package of baby monitoring and at a lower cost.The camera feature will allow the user to check up on their newborn via an IP webcam to application. The application will handle the video encoding necessary to make this possible.

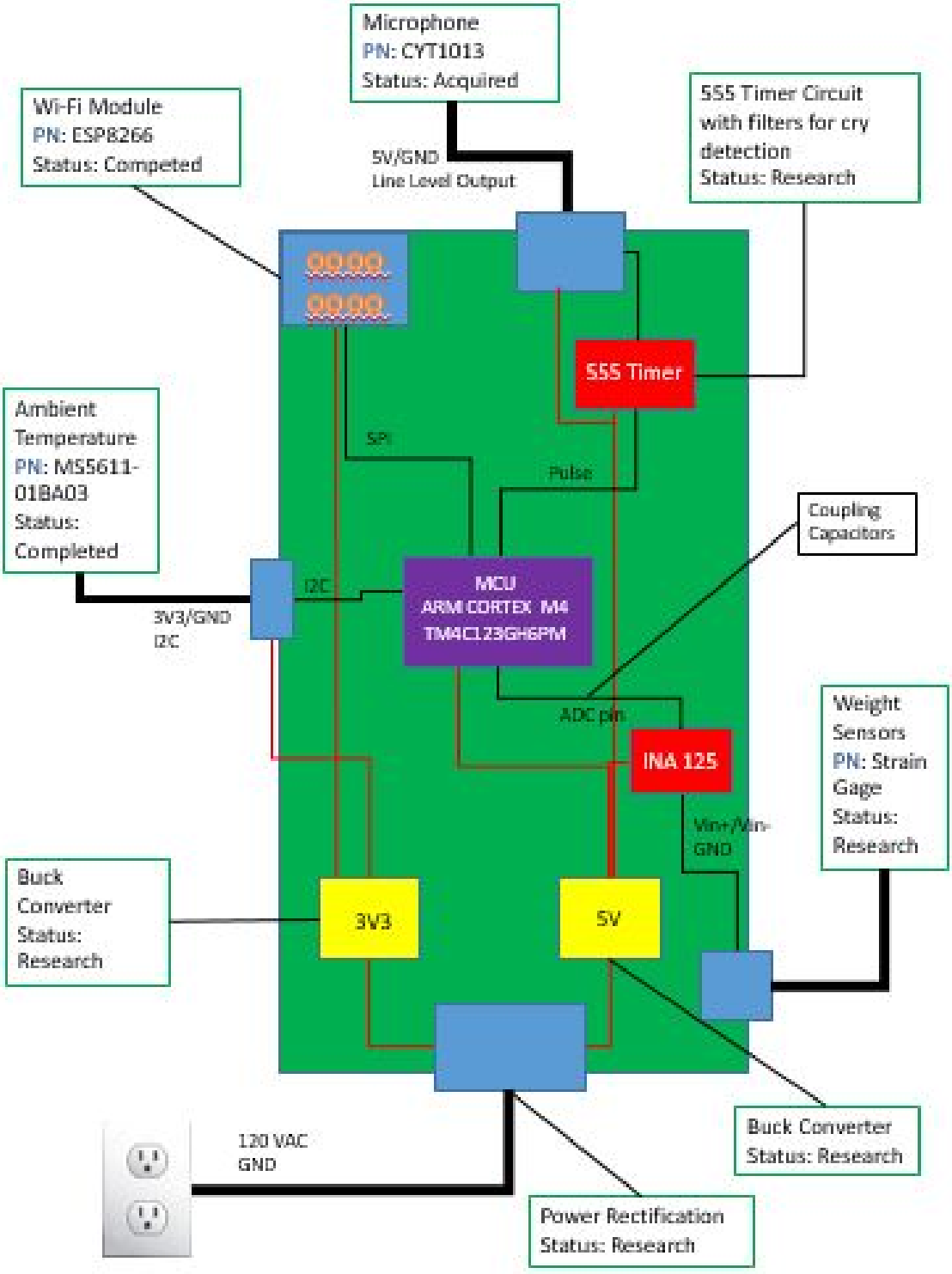


**Figure 3: Main PCB Layout**

**Wearable PCB**

The wearable PCB layout that will be placed onto the baby's foot is shown in Figure 4. The color coordination of the board follows the same logic and blueprint described for the main PCB layout. The wearable PCB will use a rechargeable battery source for power and will have a switch to turn on and off the piece.

**Motion Sensor**

The MPU 6050 will be used as an accelerometer to monitor the motion of the baby when it is inside the crib. One of our objective for this project is to able to notify the parent when the baby is awake and need attention. To be able to detect when be baby is awake we decided to use an accelerometer to detect movement. When the sensor detects +- 10 degree pitch/roll, the MCU will send out an alert to the parent.The motion will be monitored to detect when the baby is awake. The motion sensor will communicate with the MCU via I2C.

**Pulse Sensor**

The pulse sensor will be used to monitor the baby's vital signs will the child is sleeping, ensuring the baby has not succumb to SIDS. The pulse sensor will have a small cable leading from the wearable PCB with a length of less than two inches. The small length of cable is needed to ensure the pulse sensor is flush to the baby and taking proper vital signs. The analog to digital (ADC) pin of the MCU will be used translate the analog signal generated by the pulse sensor.

**WIFI Transceiver:**

The ESP8266 is used to transmit heart rate and motion data to a mobile device. To able to use ESP8266 to transmit data to be mobile, we have to pair it with TM4C123GH6PM through UART. From the TM4C123GH6PM, all the data will be transmitting to a web database to be data log by the mobile device.

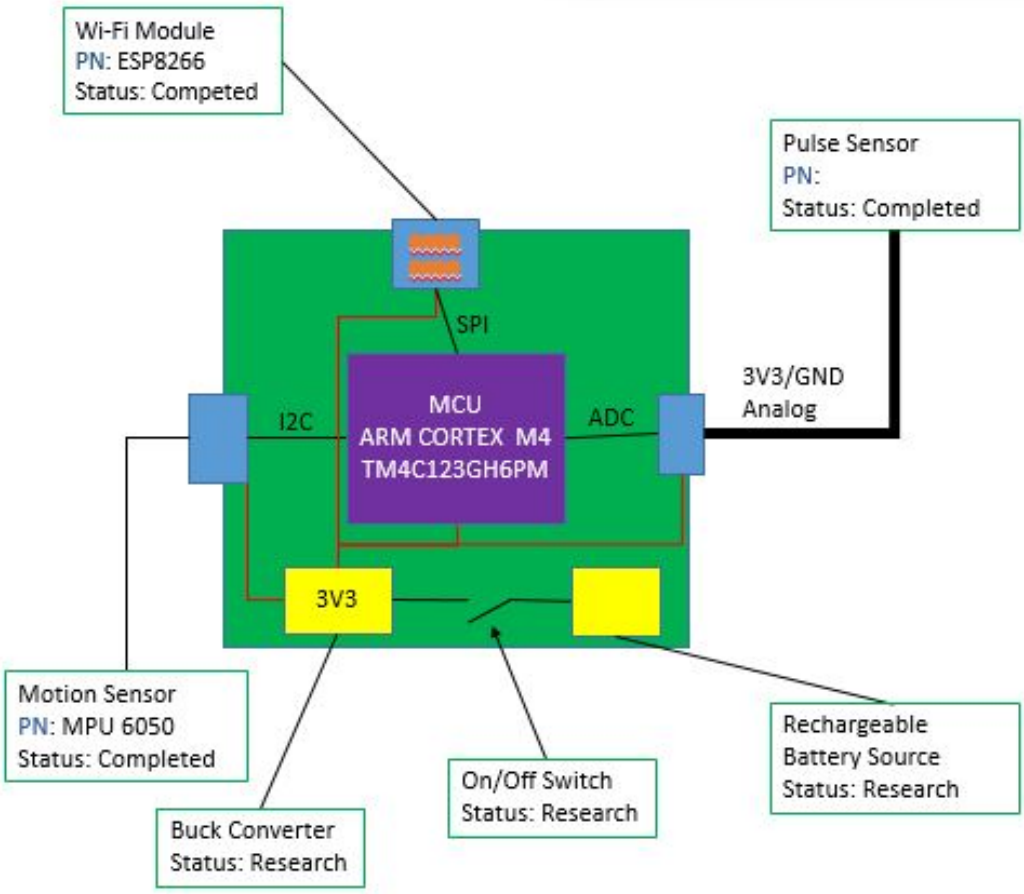


**Figure 4: Wearable PCB Layout**

**Software Block Diagram**

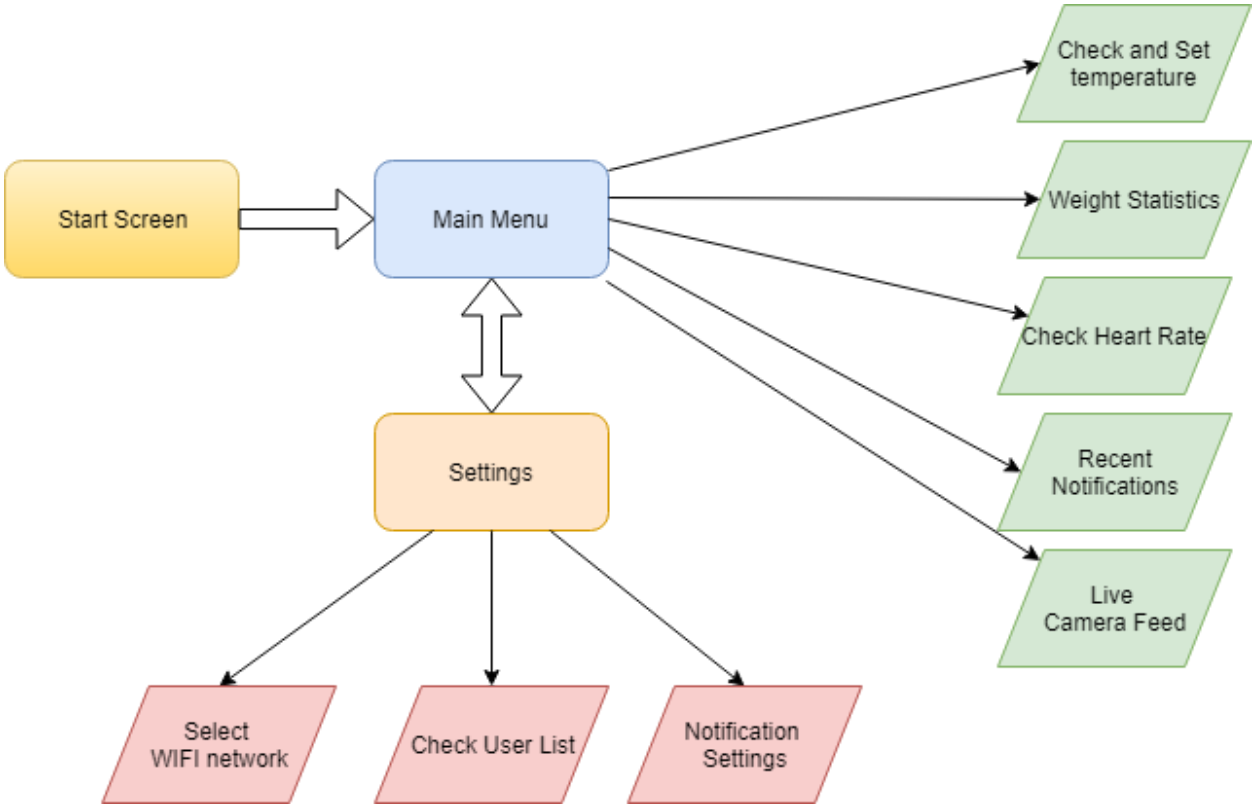


**Figure 5: Software Block Diagram**

Application side:

The startup screen will be there to show our choice of display for our project. The application overall will be at most at 3 layers at most with information rich pages instead. The green and red tabs will open up to a new screen.

Database side:

On the database side, the data will be hosted on AWS mobile with Amazon DynamoDB. This service is NoSQL cloud based database service hosted on Amazon's servers. This will allow for quick lookup and scalable storage.

**Project Budget - Hardware**

The smart crib project will be completely self funded among team members with minor equipment donations made. One of our primary goals is to make a cost effective smart crib. Each group member has pledged a $100 contribution to the project, creating a total project budget of $400. Without accounting for engineering errors and prototyping the parts needed for the project will come in under budget as shown in the table below.

| Part | Price |
|---|---|
| **2 x MCU**<br>**Part:TM4C123GH6PM** | **$12.99** |
| **1 x Microphone**<br>**Part: CYT1013** | **$2.99** |
| **1 x Motion Sensor**<br>**Part: MPU6050** | **$4.99** |
| **1 x Pulse Sensor** | **$24.95** |
| **1 x Temperature Sensor**<br>**Part: MS5611-01BA03** | **$13.99** |
| **4 x Weight Sensor**<br>**Part: Strain Gage + HX711** | **$14.99** |
| **1 x Camera**<br>**Part: Mini WIFI Camera** | **$29.99** |
| **1 x Crib** | **Donated** |
| **2 x PCB board** | **$150** |
| **2 x Voltage Regulator (Capacitors, Resistors)** | **$20** |
| **2 x WIFI Transceiver**<br>**Part: ESP2866** | **$8** |
| | **Total: $282.89** |

**Table 3:Project Budget**

**Project Budget - Software**

For this project, we will be mostly using AWS mobile, Android Studio, and Github as the softwares needed. The size of the database in AWS tentative, but will definitely fall under the free tier of AWS mobile unless it is scaled up to dozens of systems. Most if not all of the costs of this project will come from the hardware rather than the software for this reason.

**Timeline**

| Number | Milestone | Group Member | Planned Completion Week (SD1 and SD2) |
|---|---|---|---|
| 1 | Acquire all necessary part | All member | 2/11 |
| 2 | Electrical: Research Components | Thinh & David | 2/11 |
| 3 | Electrical: Wiring Schematic | Thinh & David | 2/21 |
| 4 | Interface sensors | Phuoc | 3/11 |
| 5 | Software App in Mobile | Brian | 4/11 |
| 6 | Power Supply | Thinh & David | 4/11 |
| 7 | PCB Design/Order PCB | Thinh & David | 4/30 |
| 8 | PCB build | Thinh & David | 5/11 |
| 9 | Working Prototype | All member | 5/20 |
| 10 | Building the Smart Crib | All member | 6/11 |
| 11 | Testing/Improving | All member | 6/11 - 7/11 |