Baby Monitoring Device

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***Abstract* – This paper presents a baby monitoring device system for parents to keep their newborn baby safe from SIDS (Sudden infant death syndrome). Thus, I need to develop a medical device that can measure vital sign and notify parents at the same time with a monitoring device. The use technologies which is transmission data with Wi-Fi which will help parents to monitor their infant. This device can detect the live data of heartrate, temperature, breathing from infant body. The current health data of babies are displayed on a mobile application which are helps parents to have continuous baby monitoring in any place. The alarm system of the device will notify parents about selected type abnormality of vital sign that may cause SIDS.**

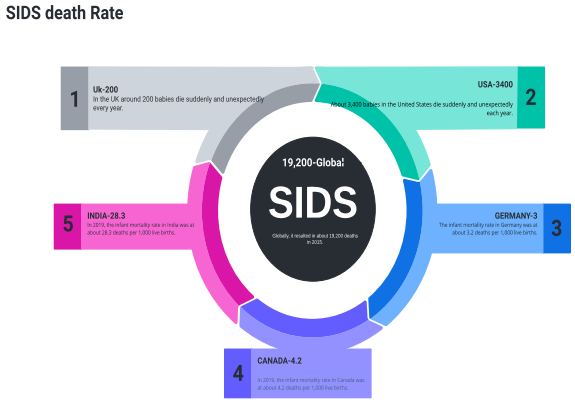
INTRODUCTION

The People these days not seem to be always in urge with their work and they may not be able to monitor the child all the time. In order to come over this difficulty, the baby monitoring system is developed.

The baby monitoring system device is a kind of alarm system which can detect baby vital sign and activities and can convey the message about the condition of babies to the concerned authority via internet through an application on mobile into any place. In proposed system baby monitoring has been designed and developed using microcontroller as control unit. The different sensors and microchip are used to assist baby monitoring and are interfaced with the phone application.The baby heart rate, Spo2 measured by an integrated pulse oximeter and heart rate monitor biosensor module. If heart rate ,Spo2 level or breathing count have any lower count than normal count the application will make notification with alarm. Applications user interface will show that abnormal vital sign count. The result obtained from the designed work of user interface shows the easier and convenient way of baby monitoring for parents while they are sleeping or busy with household work. The proposed system provides an easier and convenient way for parents in taking care of their babies.

CONCEPT OVERVIEW

Preterm birth is when a baby is born too early, before 37 weeks of pregnancy have been completed. In 2020, preterm birth affected 1 of every 10 infants born in the United States. The preterm birth rate declined 1% in 2020, from 10.2% in 2019 to 10.1% in 2020. However, racial and ethnic differences in preterm birth rates remain. In



2020, the rate of preterm birth among African-American women (14.4%) was about 50 percent higher than the rate of preterm birth among white or Hispanic women 9.1% and 9.8% respectively.
From the circle chart we find the data about SIDS victims. In UK around 200 babies die suddenly and unexpectedly every year. About 3400 babies in the United States die suddenly and unexpectedly each year. In 2019, the infant mortality rate in India was about 28.3 deaths per 1000 live births. The infant mortality rate in Germany was at about 3.2 deaths per 1,000 live births. In 2019, the infant mortality rate in Canada was at about 4.2 deaths per 1,000 live births.

This baby monitoring device can help parents listen out for or keep an eye on their baby from a distance. For example, parents might choose to use a baby monitor so you can hear your baby cry if you are downstairs or in another room where you cannot easily hear them.Also a baby monitor is costly which cannot be affordable by some parents.

But this device can easily monitor babies with reliability. So, the concept was basically designing a device that could be useful and dependable to parents.

SYSTEM BEHAVIOR

The monitoring device is designed to provide continuous monitoring of vital signs (SpO2 and HR) in newborns via a sensor-embedded sock during their sleep at the home. The device includes a base station, pulse oximeter, wireless charging, and socks. The materials will be used for the device should be durable, hypoallergenic, and safety tested for infant use. The key features and advantages of the device are sensor will be powered by a small rechargeable battery and sends the acquired data via wifi to a mobile application. The battery can last for up to 18 hours without charging. .The WiFi-enabled application serves as the primary notification system, emitting both visual and audible signals when changes in SpO2 occur and/or the HR becomes too high or too low. The mobile application will allow parents to receive alerts on their phones and monitor their infant's vital signs remotely. In a case of a Red Alert, parents can immediately view the exact cause of the alert which could be low oxygen or high or low HR. The device stores recorded SpO2 levels and HR data in a secure cloud-based system or phone storage. If the Wi-Fi or electricity becomes unavailable, the monitoring continues and stores vitals data locally, for up to 18 hours, until the connection is restored and the data are loaded into the cloud. Home alarms, cell phones, or other electronics do not interfere with the device. Using hospital-grade pulse oximeters as a reference, the device wii be the SpO2 accuracy of ±3% (70%-100% range) and HR accuracy of ±5 beats per minute (bpm; 30-300 bpm range).

SYSTEM MODELS

The systems modeling language (SysML) defines a modeling language for system engineering applications. This modeling language support to understand specification, analysis, design, verification and validation of a system. For modeling this system, I use two of them.

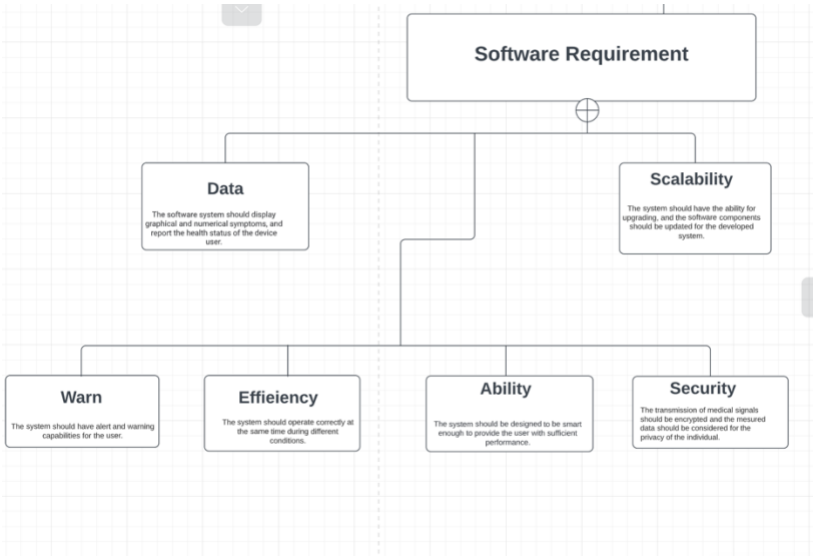
1.Requirement Diagram
2.Use Case Diagram

The purpose of requirement diagram is to specify both functional and non-functional requirements within the model so that they can be traced to other model elements that satisfy them and test cases that verify them. The purpose of a use case diagram is to give a graphical overview of the functionalities provided by a system in terms of actors. A use case diagram describes the usage of a system.

The requirement diagram of this system is describing the functionalities of the system with two different types of state.

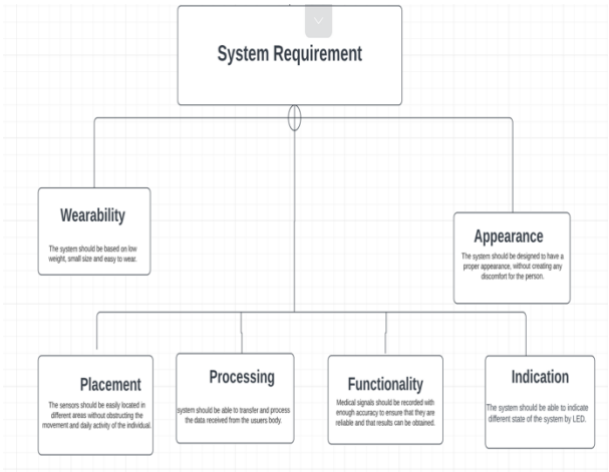
1.Software Requirement
2.Hardware Requirement

The Software requirement diagram presents the functional and non-functional requirements of the system. The software system should display graphical and numerical symptoms and report the health status of the device user. The scalability of the diagram contains the ability for upgrading and the software components should be updated for the developed system. The system should have alert and warning capabilities for the user. The efficiency of the system should operate correctly at the same time during different conditions. The system should be designed to be smart enough to provide the user with sufficient performance. Every medical device is important and sensitive for



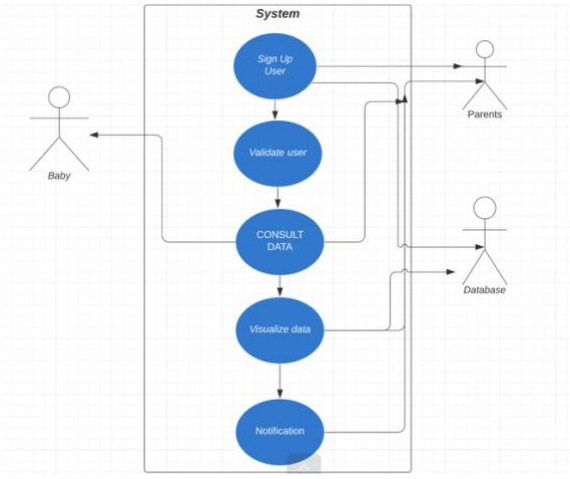
people. So the device performance can make it reliable to the users. Information and personal health data must be safe and must ensure the privacy of the users. The transmission of medical signs should be encrypted and the measured data should be considered for the privacy individual.

The requirement document used to have a clear picture of what the hardware solution must do before selecting the system. Without an optimized



set of system requirements, the hardware has no effective basis to choose the best system.

The system should be based on low weight, small size and easy to wear. The system should be designed to have a proper appearance, without having any discomfort for the person. The sensor should be easily located in different areas without obstructing the movement and daily activity of the individual. System should be able to transfer and process the data received from the user body. Medical signals should be recorded with enough accuracy to ensure that they are reliable and that results that can be obtained. The system should be able to indicate different state of the system by LED.



A use case describes a function that a system performs to achieve the user's goal. A use case must yield an observable result that is of value to the user of the system.An actor represents a role of a user that interacts with the system that you are modeling. The user can be a human user, an organization, a machine, or another external system.In UML, a relationship is a connection between model elements. A UML relationship is a type of model element that adds semantics to a model by defining the structure and behavior between the model elements.

This System have three actors with baby, parents and database. Parents must me sign up as user for the application. The data will collect from infant body and application will visualized the data. Database will collect the data when parents input the sign-up information. All the collected data from baby body will be stored in database. After store data it will send notification for different state of data collection.

DEVICE REPORTING

A combination of an accelerometer and a proprietary algorithm of noise detection reduces the frequency of false alarms. The system notifications allow users to dif-ferentiate between alerts caused by device malfunction and notifications caused by changed preset vital read-ings. There are 5 types of alerts, each represented by a specific color that displays on the base station of the device. The base station also sounds an 80-dB alarm [dB(A)/10 cm].The Red Alert is the most critical and immediate of the alarm system. When the infant's average HR dips below 60 bpm or exceeds 220 bpm or when the SpO2 Healthvalue drops below the 80% threshold, a Red Alert is issued. The processing algorithm will be limits the oxygen value to changing by no more than 1% SpO2 per second and the HR to changing by no more than 8 bpm/s, which is in accordance with physiological limits.

COLOR INDICATOR

- Green: Blinking green: system is recording initial heart rate and oxygen vitals. Slow pulsing green: system is operational, and the baby is being actively monitored. Both heart rate and oxygen levels are in the preset range.
- White: Static white: sensor package is plugged in and charging.
- Yellow: Flashing yellow: system is reporting a warning; sock is not connected to the base station or sock fit is incorrect and unable to receive a high integrity read.
- Blue: Flashing blue: sock has disconnected from the base station.
- Red.: Flashing red: system is reporting a critical alert, which indicates heart is either high or low according to preset range or oxygen saturation is at a critical low level.

All the color indication will be built for making the device easy and usable for the users. The users can easily do operate and get notified from the device that is the one of most important subject to make such a system. All users consented for data collection relevant to the system , and strict data confidentiality will be maintained. HR, SpO2, and movement data in the 2-second resolution will be collected and keep stored in a secure cloud database throughout the monitor use. All data related to alerts are preserved in the cloud database for retrospective analysis.

HARDWARE REQUIREMENT

The hardware requirements are the requirements of a hardware device. This device comes with some electronic components. All the components are known as hardware components also. For this device I use six different types of electric component. For other functionality and redundancy more other component can be installed.

- Microcontroller
- Sensor
- Battery
- Charging Plate
- Fabric
- Conductive textile Wiers.

Microcontroller

Officially known as STM32L4Rxxx or STM32L4Sxxx, the STM32L4+ components also include a new Chrom-GRC engine and a MIPI DSI controller for displays, which explains why the new architecture targets smartwatches and other wearables, among many other devices.

Supply Voltage min	1.71 v
Supply voltage max	3.6 v
core	Arm cortex -m4
Memory	2048 Kbyte's Flash

Sensor

The MAX30102 is an integrated pulse oximetry and heart-rate monitor biosensor module. It includes internal LEDs, photodetectors, optical elements, and low-noise electronics with ambient light rejection. The MAX30102 is an integrated pulse oximetry and heart-rate monitor biosensor module. It includes internal LEDs, photodetectors, optical elements, and low-noise electronics.

ISUPPLY (µA) (typ)	600
Dimension	5.6mm*3.3mm*1.55mm
Model	14-pin optical Module
Shutdown ModeSupplyCurrent (µA) (typ)	0.7
VSUPPLY (V) (min)	1.7
VSUPPLY (V) (max)	2
Resolution (bits) (ADC)	16

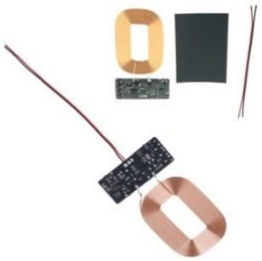
Battery

Lithium-ion polymer batteries are thin, light, and powerful. The output ranges from 4.2V when completely charged to 3.7V. This battery has a capacity of 350mAh for a total of about 1.3 Wh.

Dimensions	approx. 37mm *20.8mm *5.8mm
Weight	12g
Capacity	350mAh
Voltage	3.7V
Type	Li-Po

Charging Plate

Qi is an open interface standard that defines wireless power transfer using inductive charging over distances of up to 4 cm. It is developed by the Wireless Power Consortium. The system uses a charging pad and a compatible device, which is placed on top of the pad, charging via resonant inductive coupling.



Antenna size	32*48mm
Circuit Board Size	30*42mm
Connecting ware length	20mm
Charge current	200-600mAh
Transmitter Distance	1-4mm

Fabric

Medical textiles are an important part of the large variety of technical textile products, ranging from high-volume disposable products for baby diapers, feminine hygiene, and adult incontinence through to extremely specialized and high-value textile products for use in blood filtration, surgical sutures, prostheses, and most recently, scaffolds for new tissue growth.

Material	cotton
Extensibility lengthwise	85%
Extensibility sidewise	40%
Weight (GSM)	310g
Color	Multi color

Conductive textile Wires

Electrically conductive textiles make it possible to produce interactive electronic textiles. They can be used for communication, entertainment, health care, safety, homeland security, computation, thermal purposes, protective clothing, wearable electronics.

User Interface

This device user interface is simply designed. The main screen has various parameters like HR, Spo2.At the lower edge there is home panel. The notification and account are just next to it. At home panel there is oxygen percentage data. The second box contain data for sock placement. The sock connection history will be bellow there. At the end there will be past red notification.

USEABILITY AND REDUNDANCY

The device is easy to wear and can be worn with or without clothing. Also no seasonal limitations. Securely placement for accurate continuous vital readings. Prevent dislodgement and poor signal transmission due to weak contract with the surface. The wireless device connection with no cables between base station and baby's body. So there is no risk of strangulation. This device is optimal and portable. The parents do not have to carry a heavy monitor or another device for use it. For avoid damage or burn of infant skin this device is built with low powered battery. Also using of medical fabrics ensure that there will be no allergic or skin reaction. The long WIFI range is used for better user experience. Base station is the primary alert if internet is down; backs up information into the cloud once WIFI connection is reestablished. The device ability to cache information locally for up to 18 hrs. No interface between the device and other electronics. So there will be no signal failure. The system will continuous measurements of spo2 and heart rate by 2 second resolution for enhanced accuracy. For more accuracy accelerometer and proprietary algorithm could be used for reducing false alarms rate and reduction in parental anxiety.

CONCLUSIONS

A smart and modern baby care product suggests excellent parental acceptance and experience. When combined with technological advances of the system for continuous nonobtrusive monitoring in newborns, overall advantages of the OSS could be leveraged into solving important clinical and public health problems.

The Milestone was creating a device that could detect vital sign and notify the users. This system uses multiple sensors to provide an effective solution for ensuring babies good health and growth. Also this is a distinguished product to keep babies safe from SIDS. The hardware components. Ware carefully chosen in order to achieve the highest level of reliability.

FUTURE DIRECTIONS

- There can be an addition for more electronics components for more functionality.
- The device can be also improved.
- There can be make more changes in user interface.
- Also hospital or emergency organization could be informed in case by improving and updating the device and system.

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