ECEN 5823

IOT Embedded Firmware

SYMBIOTIC HEALTH MONITORING

Final Report

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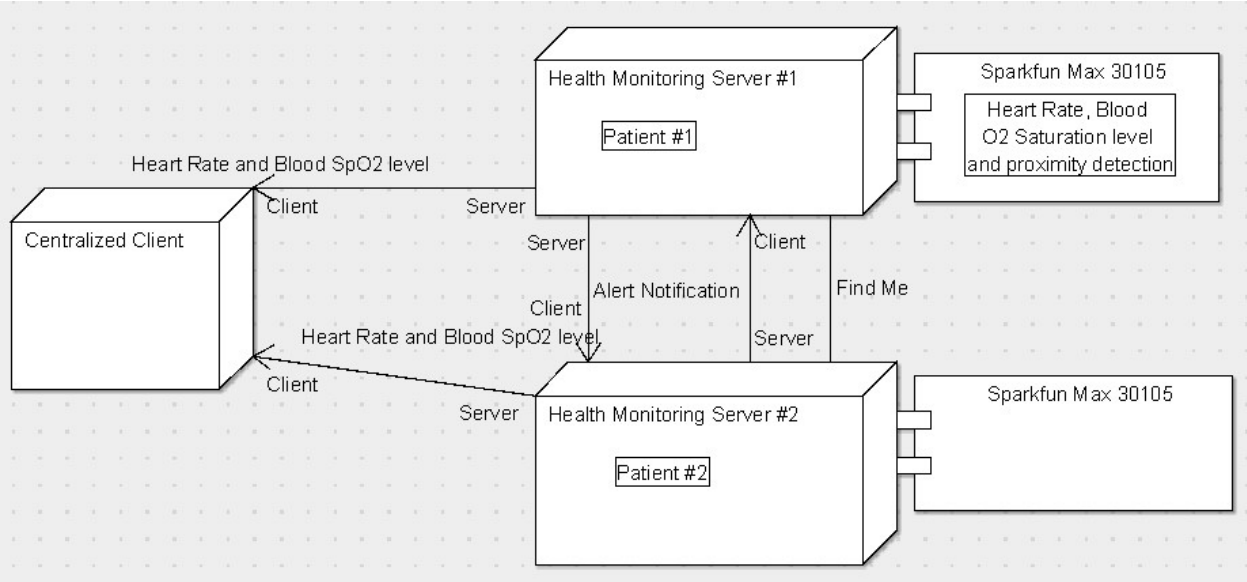
What Problem the Project Addresses

Heart ailments remain the No. 1 global cause of death with 17.3 million deaths each year, according to "Heart Disease and Stroke Statistics". Every year about 735,000 people have a heart attack. Of these, 525,000 are a first heart attack and 210,000 happen in people who have already had a heart attack. Apart from heart attacks, Hypoxemia is a widespread problem. Hypoxemia is a below-than-normal level of oxygen in your blood, specifically in the arteries and may have various symptoms such as shortness of breath. In this age of technology, for problems as severe as these, there needs to be a low power device capable of efficiently monitoring a person's heart rate and blood oxygen level. If the results from the monitoring are abnormal, then the device should be capable of informing the person's partner and/or a higher authority.

How this project alleviates or solves the problem

In this project, we consider a scenario of a couple in which both husband and wife have heart ailments. So, there would be a device for both that would monitor their heart rate and the blood oxygen saturation level after specified time intervals. If any abnormal activity is sensed on one device, then the second device will receive an alert message with the details of the parameter which is abnormal. There would also be a centralized client device, to which the heart rate and pulse oximeter data would be sent for such a scenario. Since the monitoring is done in specific time intervals and the alerts are sent only in case of abnormal activities, the system will consume less power leading to efficient monitoring.

Functional Block Diagram



Summary of each individual project

Broadly, the project can be divided into two parts:

- Centralized Health Monitoring, and
- Alert notifications between peer monitoring devices

The Centralized client subscribes to the Heart Rate and Pulse Oximeter services from each of the Health Monitoring Servers via BLE. Whenever the values for either of them cross the thresholds specified for the patients, the corresponding data is reported to the centralized client. In such a scenario, the second part of the project is also activated, where it would attempt to connect to the other node via BLE and send an Alert Notification. Additionally, any of the peer nodes can use the Find Me service to activate a buzzer alarm on the other device. In the current setup, there are 2 use cases perceived for this service: to locate the other device, or to explicitly signal the partner if the person is not feeling well and an Alert Notification is not yet generated due to some sensing error.

The two parts thus help in solving the problem in a mutually exclusive fashion. The Alert Notification / Find Me services between the two peer nodes help in immediate detection of the problem, so that the partner can take the necessary first-hand corrective measures. Reporting of the abnormalities observed during the day (or week) to a centralized client device can help the physician or any other family member to keep track of the patient's wellbeing and periodically alter their medications if required, without explicit intervention by the patients.

Verification Plan

Module	Sr. No	To be verified	Definition of Passing	Date test performed	Tested by	Measured result	Passed?
I2C	1	Check for Bus busy or any pending commands before performing i2c read or i2c write	In Debug mode, check the I2C Register values before sending the first Start command. Test passed if the registers have desired values	4/2/2018	Preshit	The registers have the desired values and no commands are pending	Passed
	2	Perform i2c single byte read operation from sensor	Reading a value from a specific register of the sensor, and check if the value is valid	4/2/2018	Ashish	The value from FIFOREADPTR register is read.	Passed
	3	Perform single byte write operation to the sensor	Writing a value to a register, and checking if the value is written by performing single byte read on the same register	4/2/2018	Preshit	Value is written to FIFOCONFIG register and read back from same register	Passed
	4	Check if the pulse is detected by the sensor	If the pulse is detected samples would be available in FIFODATA register of the sensor	4/2/2018	Ashish	New samples were available in FIFODATA register. Checked FIFOREADPTR and FIFOWRITEPTR registers and (readpointer!=writepointer)	Passed
	5	Perform i2c burst read on FIFODATA register of the sensor to get the value of Red and IR LED	Desired number of bytes are read from the sensor.	4/13/2018	Ashish	I2C burst read performed and received the desired bytes of data. (A NACK was being sent during i2c write operation that had caused a pending NACK problem for burst read operation	Passed

						which was later resolved)	
Particle Sensor	6	Get a stable Red and IR led reading from the sensor	After 60 seconds of burst read from the sensor, the readings must be stable.	4/13/2018	Preshit	Using letimer, a 60 second stabilizing time is used, after which the sensor readings obtained are stable.	Passed
	7	Valid Heart rate reading from sensor after processing	Heart rate reading after processing must be within range of 20-255	4/13/2018	Preshit	The values are within the range of 40-145	Passed
	8	Valid Pulse oximeter reading from sensor after processing	SpO2 value for a normal healthy person should be in range of 90% to 99%. For patients with mild respiratory diseases, the SpO2 should be 80% or above	4/13/2018	Preshit	The values tested were within the specified range	Passed
BLE Server	9	Create a Heart rate service on the server and check if the service can be subscribed through blue gecko app and the readings are correct	The blue gecko app should be able to see the heart rate service	4/13/2018	Ashish	The heart rate service can be subscribed on the app and the readings are accurate.	Passed
	10	Check if the custom pulse oximeter service can be subscribed through blue gecko app and the readings are correct	The blue gecko app should be able to see the heart rate service	4/13/2018	Preshit	The custom pulse oximeter service can be subscribed on the app and the readings are accurate.	Passed

BLE Client	11	Check if the connection is opened between client and server	If the connection is opened, *gecko_evt_le_connection_opened_id* is triggered on the client	4/8/2018	Ashish	Opened Connection is displayed on LCD of the Server Gecko	Passed
	12	Check if the Services advertised by the server can be discovered by the client	For every service detected *gecko_evt_gatt_service_id* event is triggered on the client	4/8/2018	Ashish	The services advertised by the server are displayed on the LCD of the client	Passed
	13	Check if the characteristics of a service can be discovered by the client	For every characteristic discovered *gecko_evt_gatt_characteristic_id* event is triggered on the client	4/9/2018	Ashish	The characteristics of the service are displayed on the LCD of the client	Passed
	14	Check if a valid characteristic value is received by the client.	For every abnormal value of heartrate or spo2 sent by the server, a notification is received through *gecko_evt_gatt_characteristic_value_id* event	4/9/2018	Ashish	A valid characteristic value is displayed on the LCD of the client.	Passed
	15	Check if the client can subscribe to two services simultaneously.	The client should subscribe to two services i.e. heartrate and pulse oximeter service for same connection.	4/17/2018	Ashish	The client subscribes to two services and valid readings are received	Passed
Dual-Mode Client/ Server	16	Functional findme service on the dual-mode client/server peer nodes	The peer node can subscribe to findme service from other peer node and the centralized	4/27/2018	Preshit	A peer node subscribes to the findme service from another node and the client does not.	Passed

			client is not triggered for this service				
	17	Functional alert message service on dual-mode client/server peer nodes	When either heartrate or spo2 value goes above the threshold, an alert message is sent on other peer node.	4/27/2018	Preshit	Peer node subscribes to alert message service from other peer node for abnormal values of heartrate and spo2	Passed
	18	Power off Sensor	Power off sensor by Pressing the button PB1 on either of the peer nodes	5/1/2018	Preshit	The sensor is put in shutdown mode when the button PB1 is pressed and turned back on if the button is pressed for the second time	Passed
	19	Working as a server only if the readings are above threshold	The peer nodes should function as a server only if its heartrate and spo2 readings go above threshold	4/27/2018	Preshit	The peer node operating as a client switches to server mode only if the readings are above threshold	Passed
MITM	20	Random and identical passkeys are generated on both the client and server	The passkeys generated on both the client and server are identical and random	4/30/2018	Ashish	The generated passkeys are displayed on the LCD and can be observed that they are random and identical	Passed
	21	Only secured connection is established	The client subscribes to the services from the server only when a secured connection is established	4/30/2018	Ashish	When the passkeys are displayed on the LCD, a button press request is offered to the user. If the user presses the button, only then is the connection established	Passed
	22	Does not ask for the passkey if a secured connection is	The client does not request the passkey if the bonding is established with the server.	4/30/2018	Ashish	If the server has already established a secured connection with the client, the passkey request is not done and the client	Passed

		already established				subscribes to the services offered by the server	
DMA	23	The data is logged to the desired location	The data characteristic value received by the client is logged by the DMA at given location	4/28/2018	Ashish	The data is logged by the DMA at given location(0x2000000) and is displayed on the LCD	Passed
	24	The data logged by the is the abnormal heartrate and spo2 values.	The characteristic value received by the client and the data logged by DMA should be the same	4/28/2018	Ashish	The data logged by the DMA are accurate i.e. the abnormal values received are being logged with any error	Passed
Persistent Memory	25	The threshold values for heart rate and spo2 are stored in the persistent memory	The heart rate and spo2 threshold values can be loaded from the persistent memory	5/1/2018	Preshit	The values are loaded from the persistent memory and displayed on the LCD.	Passed
	26	If no values are loaded in the memory, the threshold values must be stored in the persistent memory	Check the persistent memory for any stored values. If no values stored, then save the threshold values on persistent memory	5/1/2018	Preshit	New values are stored in the persistent memory and loaded back and displayed on the LCD	Passed
Load Power Management	27	Check if the Server always runs at lowest possible energy mode	Observe the current and average current values using Energy profiler	5/1/2018	Preshit	Load power management was done on the sensor by giving it a off-time of 200 ms for a period of 2 seconds. The average current was significantly reduced from 10 mA to 4.5 mA.	Passed
	28	Power off Sensor	Power off sensor by	5/1/2018	Preshit	The sensor is put in shutdown mode when	Passed

			Pressing the button PB1 on either of the peer nodes			the button PB1 is pressed and turned back on if the button is pressed for the second time. The average current in power off mode goes down to 2 mA	
	29	Check if the client always runs at the lowest possible energy mode	Observe the current and average current values using Energy profiler	5/1/2018	Ashish	Load power management was done on the client by decreasing its scanning frequency using *gecko_cmd_le_gap_set_scan_parameters().* The average current significantly dropped down to 6 mA from 10 mA	Passed