University of Colorado Boulder

ECEN 5823 IoT Embedded Firmware

Final Course Project

BLUETOOTH BASED SMART STREETLIGHT

INDIVIDUAL PROPOSAL

By

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BLUETOOTH BASED SMART STREET LIGHT

Individual Proposal – Shreya Chakraborty

1.Describe what problem this project addresses

Street lights are very important in present day's smart cities. Along with networking and embedded sensors, they can receive and transmit data that help cities monitor and respond to any situation, from traffic congestion to accidents. Those very same networks can remotely control street lights to change their luminosity according to the requirements, offering cities a chance to maximize low-energy lighting benefits while also improving pedestrian and bicyclist safety.

The existing smart street lighting has certain drawbacks which are as given below:

1) Currently most of the street lights all over the world are controlled manually and thus it may cause error due to the human interaction.

2) Sometimes, we see the street lights on even in the broad daylight thereby causing energy wastage and sometimes they are not turned on even at night time thereby increasing the chances of road accidents.

3) Since the current street lighting system is not automated, it becomes difficult to pinpoint the cause of problem in the case of energy outage.

4) The life span of the current street lighting system is not optimal since energy consumption is uniform regardless of its necessity i.e traffic density.

2.How does this project alleviate or solve the problem?

The proposed smart street lighting has certain benefits over traditional street lighting system which are as given below:

1) The most important advantage of this system is that it is autonomous in nature and thereby eliminates any possibility of human error.

2) The client mobile application will keep the records of the data like number of cars passing per unit time, daily power consumption graph of street lights, percentage of energy saved daily which can help us with data analytics.

3) Smart Street lighting helps cities by lowering budget, optimizing energy consumption and reducing maintenance.

4) Networked street lighting built on a scalable platform can help in reducing crime up by considerable ratio and making roadways safer by improving visibility at night and in case of extreme weathers.

5) By implementing intelligent street lighting systems, we can increase lighting efficiencies and optimize traffic management.

Basic idea of this project is as given below:

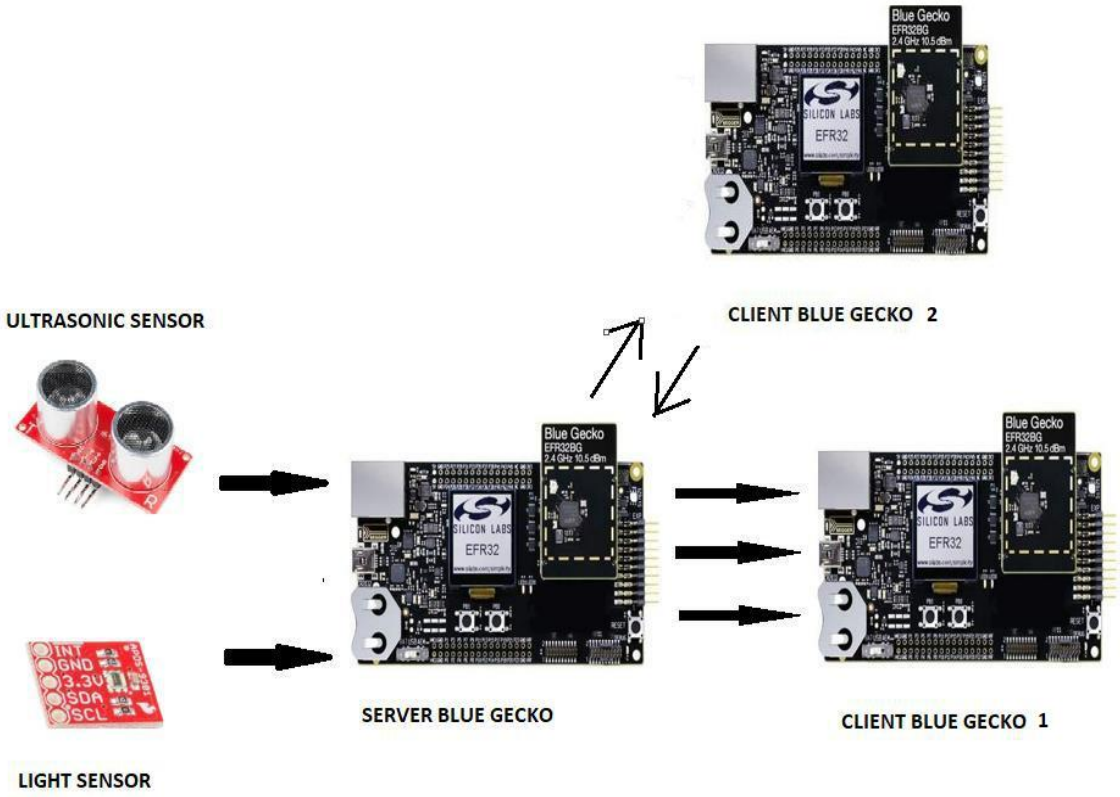
Light sensor will be used to get the time of the day. The street lights will be on only during the night. So, when the

output of the light sensor falls below certain threshold, then only the entire functionality will be activated. So, during the day time, in the case of demo, blue gecko can sleep in low energy mode. At night blue gecko will be operating and processing the data.

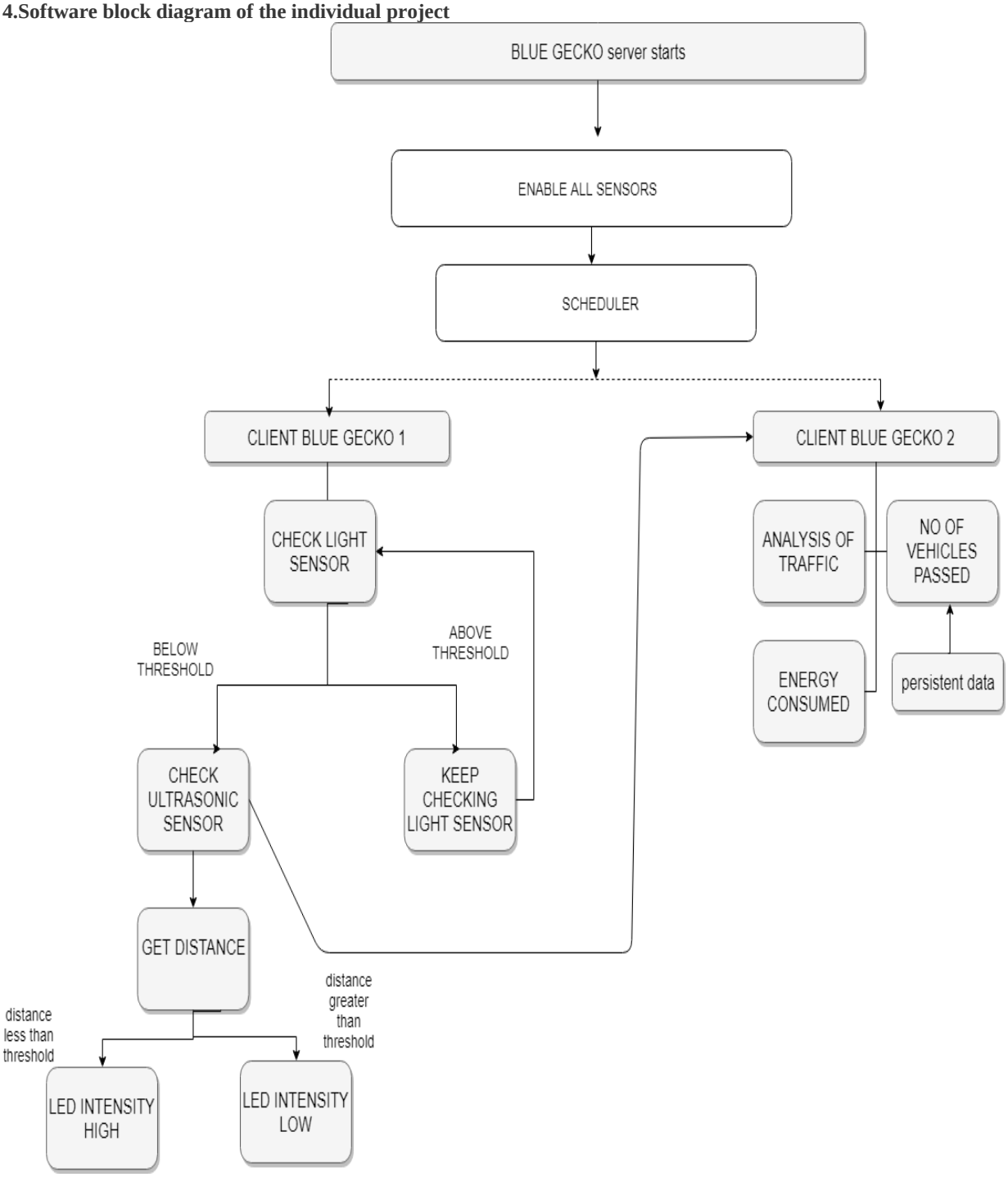
Ultrasonic sensor is used to detect the movement of the vehicles. So below a certain threshold value of light sensor, LEDs (Street light) will be on at the low intensity initially. As soon as ultrasonic sensor detects the movement of the vehicle, it will switch the next street light at the high intensity, thus improving the visibility. If no car is passing for a considerable amount of time, Street lights will switch back to low intensity.

One Blue Gecko will be interfaced with these sensors and work as a server. Other Blue Gecko will do the data processing and control LED (street light) and work as a client. The 3rd blue gecko will also work as client and will be responsible to process and log the important information such as number of cars passed per unit time, power consumption hourly and percentage of energy saved daily which can used for further optimization with some data analytic.

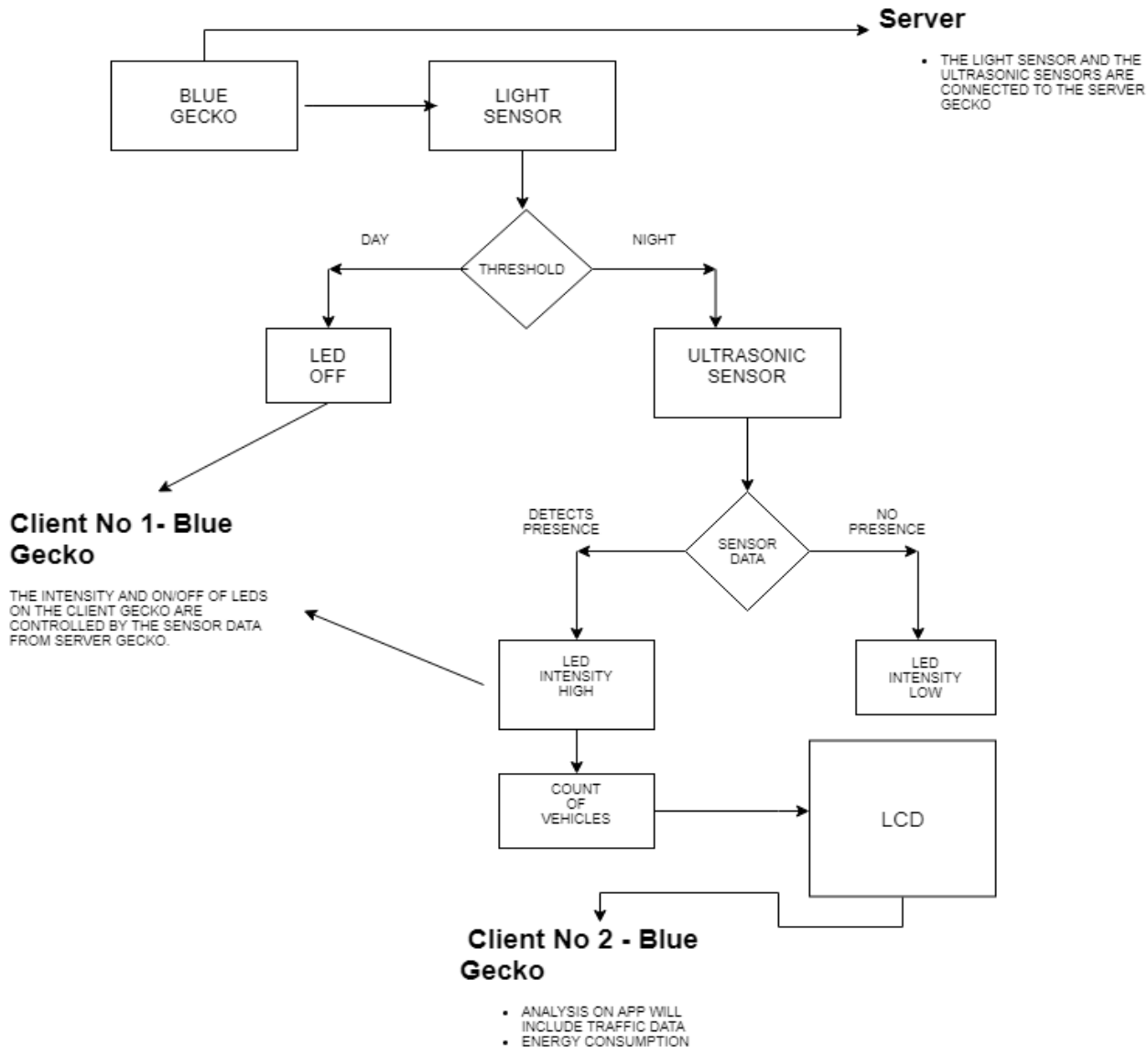
3. .**3.Functional block diagram of the team project**



4.Software block diagram of the individual project



5.Software organization or flow chart/diagram of the individual project



6.Summary of each individual project and how it plays a role in solving the problem

In this project we used Light sensor and Ultrasonic sensor to monitor and change the intensity of light based on the motion of cars on the highways. At night time, as soon as the Ultrasonic sensor senses motion of cars, the intensity of the street light is increased and in other times its kept dim. During the day time the street lights are kept off.

One blue gecko interface with light and ultrasonic sensor works as server. One blue gecko will act as client, whose LED functions as street light. Another gecko which logs the important parameters also works as a client.

This way we achieve not only energy saving but also efficient and smart street lighting system will also lower expenditure, reduce maintenance cost, eliminate human errors while controlling street light.

Individual Contribution:

I will be working on the Blue Gecko which will be interfaced to light and ultrasonic sensor. This Blue Gecko will act as server. I will also be working on another Blue Gecko client which will process the data and control the LED (Street light) accordingly.

7.List of sensors for this project:

1. Ultrasonic Sensor: https://www.sparkfun.com/products/13959

2. Light Sensor: https://www.sparkfun.com/products/14350

8.What BLE exposed services and client profiles will be implemented?

(a minimum of 2 not including TX power or Health Temperature) We have used 2 sensors for this project:

1) Light Sensor
2) Ultrasonic Sensor

BLE Services:

1) Custom service – light service
2) Custom service – Ultra service
3) Custom service – Data service

9.What persistent data will be stored to enable the project?

The persistent data is the value which needs to remain constant even after the reset. Our project is Bluetooth based smart street lighting in which we control the intensity of the street light according to the traffic density. We use light sensor to detect whether it's daytime or night time. Next if it is night time then data is collected from ultrasonic sensor to detect the vehicles. If vehicle is passing by, then street light glows at high intensity else street light is glowing at lower intensity. We also are using client gecko 2 which will keep the record of number of vehicles, traffic density according to the time of the day, energy consumed daily and energy saved daily. All these data can be considered as persistent data which we don't want to lose even when the power is down. For example, consider number of vehicles passed. In the project this value will be incremented every time the vehicles pass the street light and store this value as persistent data.

10.Proposed development schedule for this project broken down to discreet components including target implementation dates. Blocks which have been completed are marked with GREEN STAR, those in progress are marked with BLUE STAR the rest are unmarked.

1. Interface code to SPI LCD display: 25th March
2. Developing persistent memory routine: 30th March
3. Interface software to new sensor (Ultrasonic sensor): 2 nd April
4. Interface software to new sensor (Light sensor): 2 nd April
5. Integrating both the sensor to application code: 7th April
6. Integrating LCD to application code:10th April
7. Load Power Management of sensor: 15th April
8. Developing BLE Service / Client: 22nd April
9. The 2nd client Blue Gecko with services: 27th April

11.How was this project designed to optimize energy usage?

Ans: This project was designed to optimize the energy savings. This system won't be working in the broad daylight when it is not required to save energy. So, it will sleep in the lowest energy mode possible. During night also, if there is sparse traffic density, the street lights will switch to lower intensity thereby leading to further energy saving.

12.With security in mind, how does your project's security implementation support the end application and provide details on how it was implemented in your project?

We have implemented the MITM protection from the security point of view. Our second client is doing the work of logging the vehicle count as well as how much energy is saved at the night time. So, this feature should be accessible only to the authorized individuals. MIT protection ensures the confidentiality and integrity of the data.

13.List 5 lesson learned from doing the assignment that were not taught in lecture or an earlier assignment?

1) Server-Client interface

2) Worked on the android studio while designing an app (which discovered devices as well as characteristic)

3) Pulse width modulation for changing the intensity of LEDs (street light).

4) Interfacing ultrasonic sensor and writing it's routine from scratch while pulsein() API is available on other development boards.

5) Always export your working project.

14.Summarize the final status of your individual project

Ans: The main purpose of our taking up this project was to showcase energy saving. On an average smart street lighting can save upto 35% of the total energy spent by a typical government of a country in a year. We initially decided to implement two clients one client gecko and one mobile application however due to some issues we decided to implement another client gecko instead and keep the mobile app as future scope. So now we have two sensors connected to the server which sends data to each client separately.

11.Validation Plan

Sr.No	Developments	Description	Tested by	Test Date	Progress	Passed/failed
1.	**Developing persistent memory routine**	**State of Leds retained even after power off/reset and the count of vehicles retained**	**Shreya & Nikhil**	**March 28th**	**State of leds &number of vehicles retained**	**Passed**
2.	**Interfacing code to SPI LCD display**	**Displaying the no of times obstruction occurs and increments the no each time.**	**Shreya & Nikhil**	**March 24th**	**Successfully displaying values**	**Passed**
3.	**Interfacing with ultrasonic Sensor**	**Server gecko connected with ultrasonic sensor in normal gpio mode**	**Shreya**	**March 30th**	**Ultrasonic sensor working and gives proper waveforms in oscilloscope**	**Passed**
4.	**Data from Ultrasonic Sensor**	**The Ultrasonic sensor shows distance of the obstacle**	**Shreya**	**April 6th**	**The distance of the obstacle from the sensor is obtained in cms**	**Passed**
5.	**Interfacing with ultrasonic Sensor through GPIO**	**Server gecko connected with ultrasonic sensor in**	**Shreya**	**March 30th**	**Ultrasonic sensor working and gives proper waveforms**	**Passed**

		normal gpio mode			**in oscilloscope**	
6.	**Implementing BLE service/ Client Profile – Alert Notification Service/profile**	**service exposes alert information in a device**	**Shreya**	**April 11th**	**exposes information about the count of new alerts.**	**completed**
7	**Connection of the Server gecko to the client gecko and data transmission**	**The sensor values from the server gecko control the intensity of the LEDs on client gecko**	**Shreya**	**April 10th**	**Connection established with the client code, moving onto MITM protection**	**completed**
8	**Usage of Software scheduler**	**Scheduler will handle the multiple client situation**	**Nikhil & Shreya**	**April 12th**	**Software scheduler to schedule entire process**	**completed**
9	**MITM protection during Client Server pairing**	**For security and preventing man in the middle attacks**	**Nikhil & Shreya**	**April 12th**	**Passkey validation completed**	**completed**
10	Client 1 implementation for dimming the LEDs	**LED intensity controlled according to**	Nikhil and Shreya	April 11th	LED intensity controlled	Completed

		the	successfully	