FINAL PROJECT REPORT **SATYA MEHTA**

TRAFFIC CONTROL USING BLUETOOTH MESH.

Low Power Node

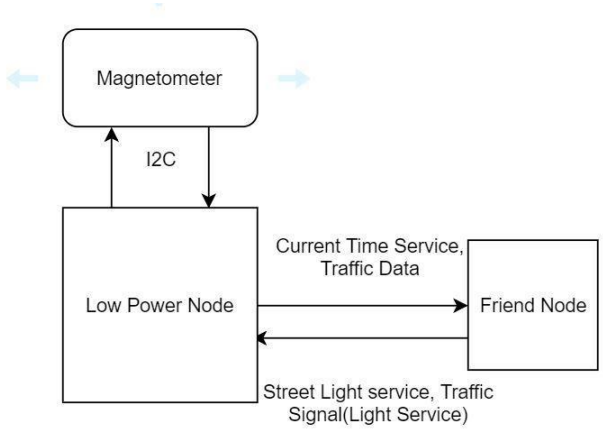
1. **Describe what the problem this project or part of a team project addresses**

   Ans. As the project name signifies this project controls the live traffic on a junction where two or more roads meet. In real life situations there are many occurrences especially in big cities where one lane suffers with large traffic while other lanes do not. The main implementation of this project is to control the signal in such a way that we allow traffic to move for more time for the way which suffers from more traffic. I am creating a low power node which will be interfaced with magnetometer to detect traffic.

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

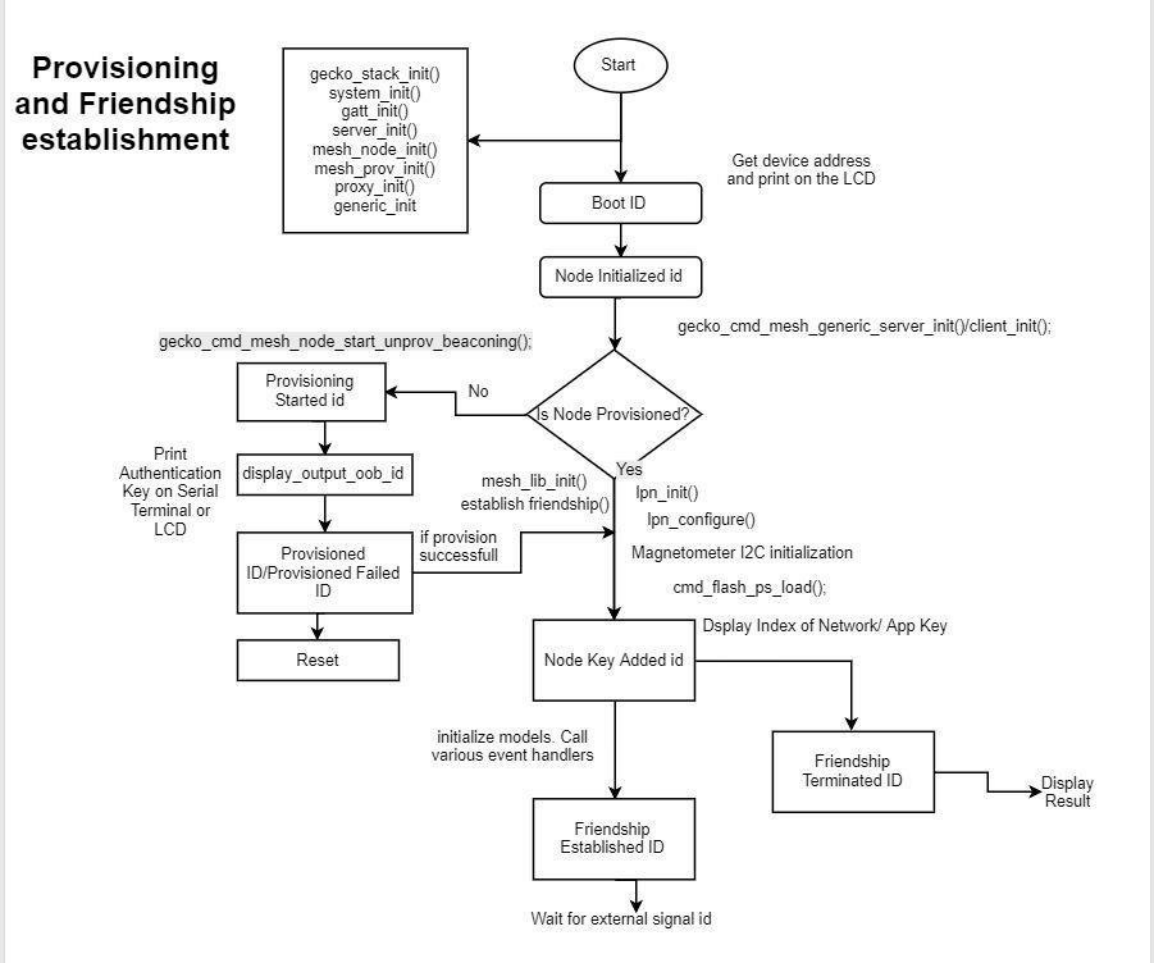
   Ans. The project uses centralized node (Friend Node) which monitors each low power nodes(Roads). The low power nodes monitor the traffic by detecting vehicles at some distance from the signal using magnetometer. The low power nodes awake after stipulated time and transfers the data to the friend node which caches the messages. Low power node is also incorporated with the 'current time' service which is used by the friend node when it awakes.

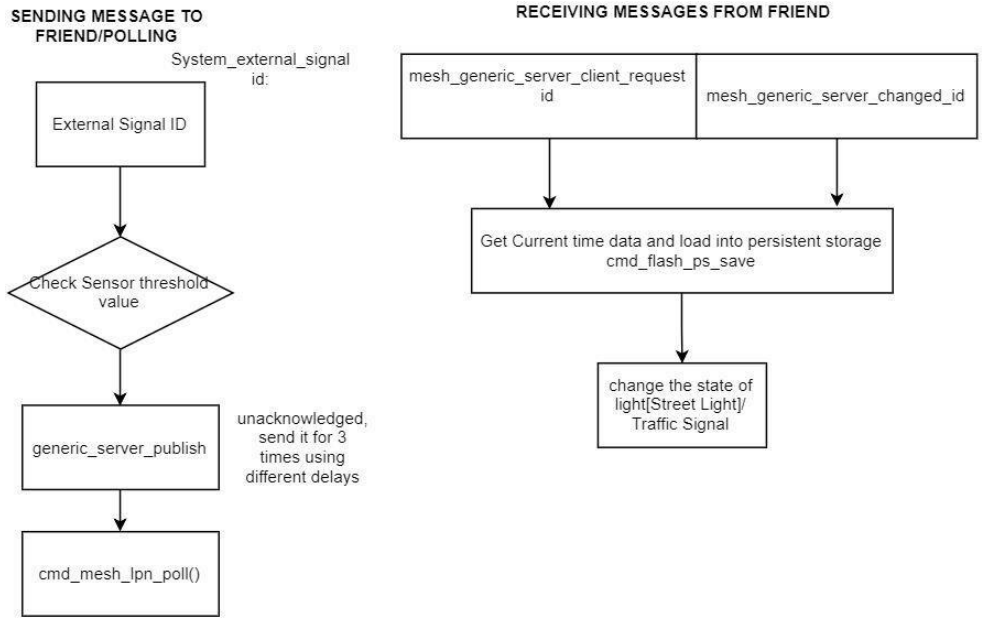
3. **Block Diagram of Low Power Node**



LOW POWER NODE INTERFACE

4. Software Flow Chart





5. **List of Sensors for this project.**

Magnetometer-

- To detect vehicles (metal object).
- Connected to Low Power nodes.
- Sparkfun Part Number - LSM303C.

6. **Exposed services and client profiles implemented.**

- Magnetometer [Traffic]- Custom service.
- Current time service- SIG GATT service.

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

The threshold values of X,Y,Z of the magnetometer will be stored in the persistent flash memory. Also, we are going to store the 'time' when the traffic signal was ON. The keys are also stored in the persistent storage which is automatically handled by the stack.

8. **Proposed development schedule**

TASK	START DATE	TIME (IN DAYS)	STATUS
STUDY THE DATASHEETS AND MESH MANUAL	10/29/2018	4	Completed
PROVISION NODE	11/2/2018	4	Completed
PERSISTENT MEMORY	11/2/2018	1	Completed
MAGNETOMETER INTERFACING	11/7/2018	4	Completed
INTERRUPT HANDLING OF I2C	11/11/2018	4	Completed
LOAD POWER MANAGEMENT OF THE NODES	11/15/2018	4	Completed
DEVELOPING THE MESH NODES RELATIONSHIP	11/20/2018	7	Completed
INTEGRATING ALL THE NODES	11/28/2018	4	Completed
VALIDATION OF THE PROJECT	12/3/2018	4	Completed

9. Verification Plan of the Individual Project.

Sr No.	Verification Plan	Expected Result	Date of test	Actual Result	Passed
1.	Provision node using Silicon Labs Mobile App.	Node must enter all the events successfully and should be provisioned	11/05/2018	Node can be provisioned without oob	Yes
2.	Provisioning the node using OOB Authentication method by Silicon Labs Mesh app	Node must enter all the events successfully and it should display key with expected size on serial terminal and LCD. Mobile App should ask for the key to which we can feed with the key displayed. The nodes should be provisioned if correct key enter or else it should fail.	11/10/2018	Node can be provisioned using Out of Band authentication method	Yes

3.	Interfacing Magnetometer to the LPN	Magnetometer must give proper values of X,Y,Z axis using I2C. External signal id can be generated if the values are above/below the thresholds.	11/11/2018	I2C driver completed. Not able to get acknowledgement from the sensor.	Yes
4.	Persistent data storing.	We are able to store sensor thresholds, and time[for our traffic system application]. We should be able to load up the values of the persistent data	11/22/2018	Data can be stored and retrieved back successfully from the persistent data.	Yes
5.	Initialize Low Power Node and configure	Lpn_init function should give result 0.	11/20/2018	LPN initialization successful	Yes
6.	Friendship establishment	It should go into friendship established id	11/22/2018	Friendship established ID event can be generated when connected to the friend in a same network.	Yes
7.	Initialization of models and services.	LPN should be able to publish using client/server mesh api's. (Testing using network analyzer in Simplicity IDE)	11/24/2018	Level Model data can be sent and received. Tested using Silabs Light example	Yes
8.	Mesh addressing modes	Receive message using group addressing from the friend.	12/01/2018	LPN is able to publish and receive message using unicast and group addressing.	Yes
9.	Checking LPN node (Traffic Congestion scenario)	If the magnetometer data is more than threshold then send message to Friend node indicating traffic congestion.	12/02/2018	LPN is able to publish the message when data crosses threshold.	Yes
10.	Checking LPN node (No Traffic congestion scenario)	The LPN node should sleep and be in the lowest possible energy mode.	12/02/2018	LPN sleeps and polls at regular intervals	Yes
11.	Integrating all the modules	The 3 magnetometer modules and the luminosity module.	12/06/2018	Modules integrated and tested with required functionality.	Yes
12.	Testing the system	All the nodes are communicating with each other and the prototype is working.	12/06/2018	Prototype properly working as per the required functionality.	Yes

10. How was this project designed to Optimize Energy usage.

Ans. To optimize the Energy usage we had three LPN nodes. As per our application we had configured the poll timeout to be 5 seconds. Hence, it sleeps most of the time and wakes up every 5 seconds to poll the messages from Friend Node. The energy usage was verified using Energy Profiler in Simplicity Studio.

11. 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?

Ans. As we know, mesh is equipped with most of the security part by its stack which handles different types of key required for the communication. We added the Out of Band Authentication during the provisioning done by the Silicon Labs Mobile App. The passkey was displayed on the LCD and the UART terminal which is required to be entered in the mobile app during the provisioning. This helps us to protect against MITM attacks.

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

Ans.
1. I learned how to implement the Low Power Node feature in the board.
2. I learned how to use the Silicon Labs Bluetooth Mesh Stack.
3. I learned how magnetometer works and what kind of effect is seen on its output by placing Magnet or large metal body near it.
4. I learned practically how different Bluetooth Mesh SIG models work.
5. I learned how to work individually in a group project and then merge them to implement whole functionality.

13. Summarize the final status of your individual project

Ans. The board was initialized unprovisioned which was latter provisioned to a project group using Silicon Labs Bluetooth Mesh application. OOB Authentication key was displayed on the LCD and UART Terminal which if correctly entered the node gets provisioned. It is required to configure the correct model using Bluetooth Mesh application. The LETIMER is initialized and it gives interrupt after every 8 seconds. The interrupt service routine calls the external event and in external event we take the data from the magnetometer.

The magnetometer is interfaced to the Blue Gecko using I2C interface. Whenever there is a high magnet or a large metal object near the magnetometer we get considerable difference in output data which corresponds to earth magnetic field. We use this concept to relate with the vehicles on a road. When the output data crosses the threshold, the node publishes message to the client (Friend Node). The LPN polls data from the friend for the traffic signal (LED1) and the streetlight (LED0).