PROJECT REPORT ON

SMART PARKING USING BLUETOOTH MESH

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Problems Addressed

a)The first problem that drivers face in huge parking lots is that they are unaware of the status of different parking slots i.e whether they are vacant or occupied. It becomes very difficult for a driver to keep circling around the parking slot to find a vacant spot for the car. Sometimes it can be tedious if very few parking slots are available. This results in wastage of time, energy and fuel.

b) The second problem that needs to be addressed in a parking lot is the wastage of electricity due to unwanted use of lights. The parking slots do not need lights to be switched on all the time. Lights are necessarily required when a person parks/approaches the car.

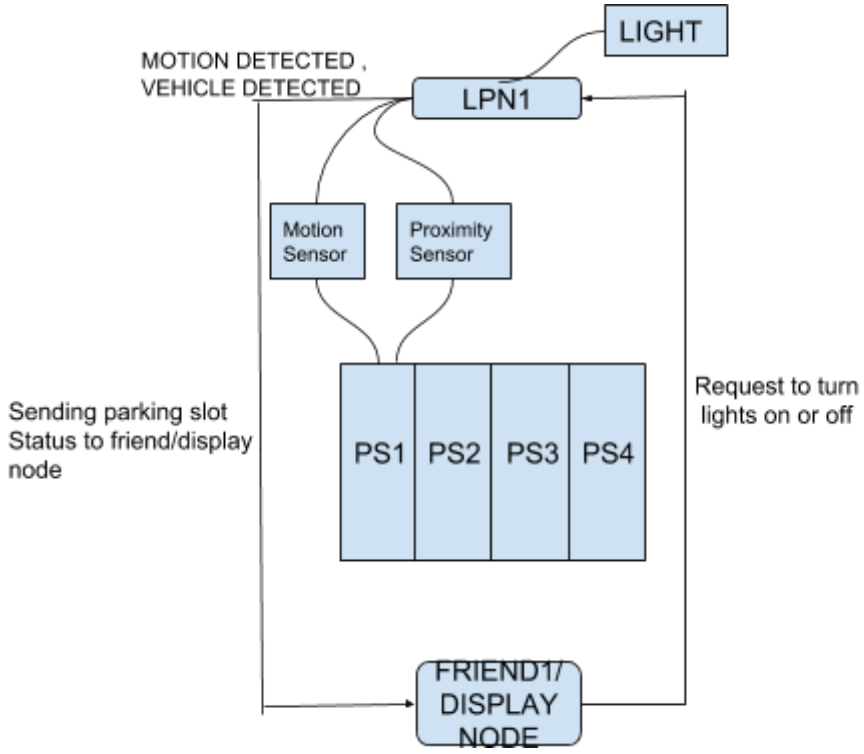
Solutions Proposed

The Low Power Node is used a SERVER MODEL.

The low Power Nodes use the Proximity Sensor to give us the status of a parking Slot.The proximity Sensor checks at regular intervals if there is a vehicle present in the slot, if so, it sends a message to the display node to display the parking Slot display as occupied or vice versa.

The second Problem is solved using a Motion Sensor. The Light gets switched on whenever there is a motion detected by the sensor and turns off if there is no motion detected for more than 5 minutes.

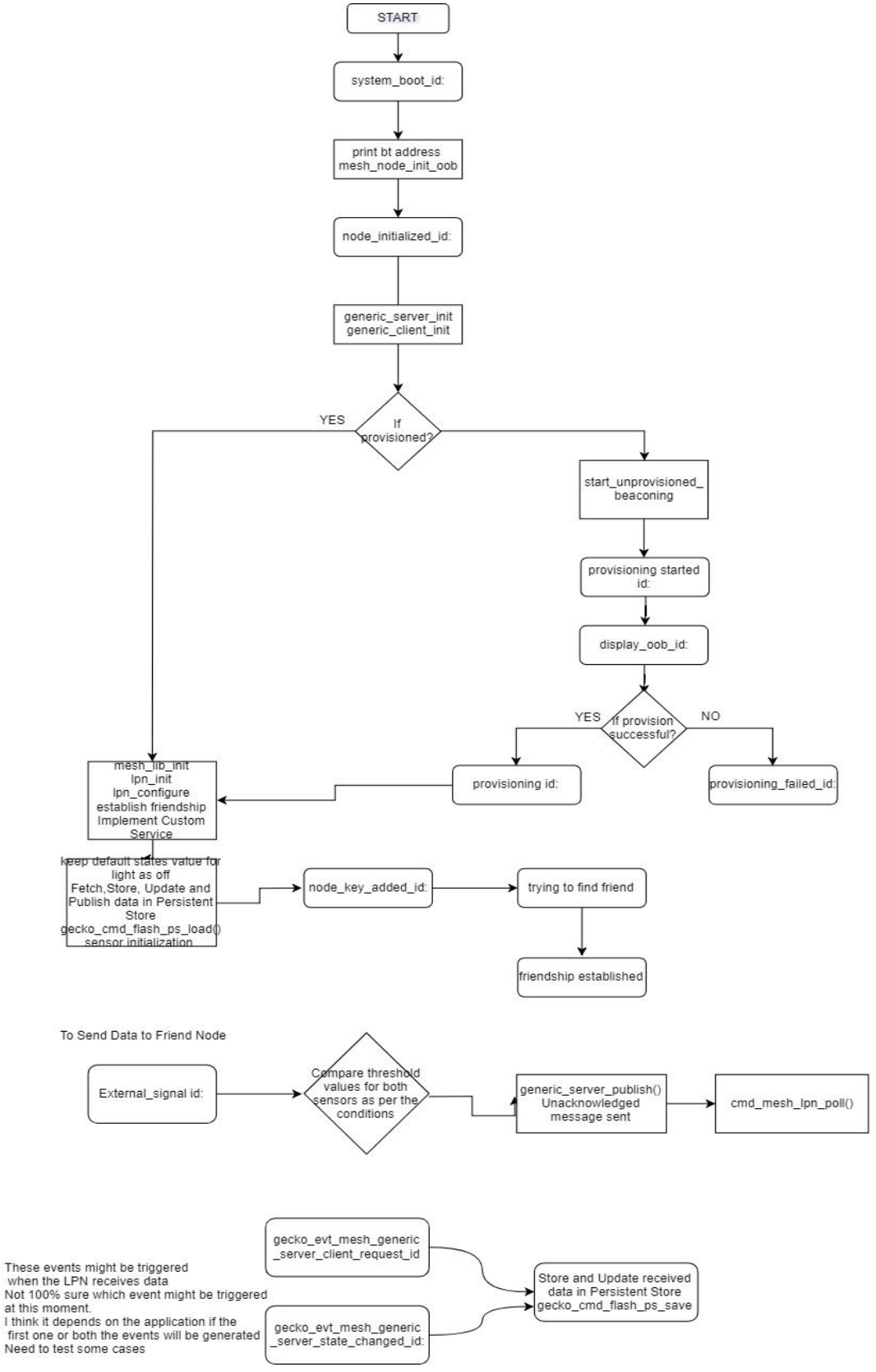
Functional Block Diagram



List of Sensors

- Sparkfun Distance Sensor Breakout - RFD77402.(Proximity Sensor) (Quantity-1), cost - $ 12.71
- Sparkfun Open PIR - $ 14.95 (Quantity -1) (Could not find the p/n number on the website)

Flowchart


START
system_boot_id:
print bt address
mesh_node_init_oob
node_initialized_id:
generic_server_init
generic_client_init
YES
If provisioned?
start_unprovisioned_ beaconing
provisioning started id:
display_oob_id:
YES
If provision successful?
NO
provisioning id:
provisioning_failed_id:
mesh_lib_init
lpn_init
lpn_configure
establish friendship
Implement Custom Service
keep default states value for light as off
Fetch,Store, Update and Publish data in Persistent Store
gecko_cmd_flash_ps_load()
sensor initialization
node_key_added_id:
trying to find friend
friendship established
To Send Data to Friend Node
External_signal id:
Compare threshold values for both sensors as per the conditions
generic_server_publish()
Unacknowledged message sent
cmd_mesh_lpn_poll()
These events might be triggered when the LPN receives data
Not 100% sure which event might be triggered at this moment.
I think it depends on the application if the first one or both the events will be generated
Need to test some cases
gecko_evt_mesh_generic_server_client_request_id
gecko_evt_mesh_generic_server_state_changed_id:
Store and Update received data in Persistent Store
gecko_cmd_flash_ps_save

Exposed Services and Client Profiles Implemented

The services used would be the values obtained from the motion sensor and the proximity sensor with the help of GENERIC ONOFF MESH Model.

Persistent Data Usage

The threshold values of the Sensors, Out of Band Data, Latest State Values of Sensor if in case the device is switched off abruptly.

Project Verification Plan

No.	To be Verified	Definition of passing	Date Test Performed	Tested By	Measured result	Passed
1.	All Devices provisioned with the help of OOB	Displayed successfully as provisioned devices on the silicon labs app by entering the passcode	11/7/2018	Siddhant	Provisioned using app and checked the result of the api command	Yes
2.	Sensors Interfaced with the board. (MOTION SENSOR AND PROXIMITY SENSOR)	Receiving output values correctly as viewed on display LCD	11/10/2018 (Motion Sensor) 11/18/2018 (Proximity Sensor)	Siddhant	Both Sensors interfaced accurately. Received Correct Values for Proximity Sensor using i2c. LED glows if motion detected.	Yes

3.	Persistent Data routine implemented as expected	Sensor data, threshold values and state information retained on system boot id	11/20/2018	Siddhant	By Checking the values after reset	Yes
4	Handle on Power up Behaviour	The states should retain the last values on Reset. For example - Lights On or Off	11/21/2018	Siddhant	By checking the state values on terminal	Yes
5.	Friendship established between LPN and friend	Making sure it enters the friendship_established on both nodes by printing on serial port	11/11/2018	Siddhant	Checking the result of the api commands and viewing on terminal	Yes
6	The LPN nodes detect human presence accurately and turns on light accordingly	Testing the sensor and making sure the corresponding LEDs are turning on.	11/10/2018 11/30/2018	Siddhant Siddhant	Human presence detected Turning on light Completed	Yes Yes
7.	LPN correctly detects the empty slot using proximity sensor and sends the data to friend	The client_server_status is generated and the friend successfully receives the correct data.	16/10/2018 11/30/2018	Siddhant Siddhant	Car detected Sending data to friend Completed	Yes Yes
8	LPN correctly receives values from the friend node	By checking the received value on the terminal.	12/2/2018	Siddhant	Light glows when Data received	Yes

9	Implementing Models and Services	Accurately obtaining the correct state of the model and services	12/2/2018	Siddhant	Displaying the Correct State on LCD	Yes
10	Flooding	Using Friend Nodes as Relay Node. The LPN data is relayed to the Central Display Node.	12/8/2018	Siddhant	By placing two nodes apart at a distance such that they can no more receive any messages. A third node is then placed in the middle so that the node	YES
11	Energy saving implemented on low-power nodes	Monitoring energy profiler readings for LPN .	12/3/2018	Siddhant	By checking if the LPN goes into sleep state in the Energy Profiler	YES
12	Integrating all Modules and testing of the systems	All nodes should communicate and function correctly	12/8/2018	Siddhant	The whole project function as required	YES

Schedule

TASKS	DATE TASK COMPLETED	STATUS
Integrating LCD to application code	11/1/18	Completed
Developing BLE Service / Client code	11/8/18	Completed
Developing Bluetooth Mesh Friend/Low Power relationships	11/15/18	Completed
Developing persistent memory routine	11/18/18	Completed
Interface software to new sensor	11/22/18	Completed
Flooding	11/4/18	Completed
Integrating sensor to application code	11/27/18	Completed
Implementing Services and Models	12/1/2018	Completed
Integrating team member projects	12/5/18	Completed
Validation of the project	12/7/18	Completed

Optimizing Energy Usage

The Project uses an LPN at each parking slot and only wakes up at specified intervals of time as configured to poll any messages from the friend node. In addition to this , the LPN only wakes up at interrupts from motion sensor and switches on the light and then turns off the light after a specified interval of time thus saving electricity and goes to sleep again. In conclusion, the LPN only wakes up if there is any motion detected and is awake only for a certain period of time and then goes to sleep again. Thus , energy usage has been optimized to a great extent.

Security Implementation

The Project uses Out of Band authentication in order to authenticate users before adding any node to a network. Every node is assigned a network key by the provisioner which represents that the node is a part of a specific mesh network and can send and receive messages to and from the nodes in the mesh network. A passkey is displayed on the node which needs to be entered on the provisioner while provisioning in order to add the node in the mesh network. The provisioner used here is a Phone with a Silicon Labs app.

Lessons Learned

- Refined Basic Concepts of programming, implemented coding guidelines as opposed to previous style of coding by incorporating them over different assignments and projects.
- Learned about memory manipulation and what and where do the variables get stored on initialization.
- Learned to write code efficiently.
- Used various peripherals and learned about different sleep modes and load power management.
- Most importantly, went through different datasheets of different sensors and application notes, software api manual and reference manual of Blue gecko and again and again. This makes it easier for me for any further projects as I would know exactly what to do.
- Using Soft timers efficiently as implemented in the Final Mesh Project.
- Learned how to implement Bluetooth Mesh
- Debugging Skill have been improved a lot over time.

Final Status Summary of Individual Project

The LPN functions normally as expected.
It was expected to do the following things:

1. Sleep for as much time as possible
2. Out of Band successfully Implemented.
3. Wake up and turn on the Light of the Parking Slot whenever motion is detected.
4. Check again for interrupt after a certain specified time and not continuously.
5. Turn off the light after a specified amount of time if no motion is detected.
6. There are MACROS to change time to turn off the light and and the frequency to check for interrupts.
7. The Proximity Sensor checks for the distances between the sensor and the car continuously till the time lights are on.
8. Sends the Parking Slot status to the friend accurately.
9. Turning on lights if requested by the friend node.

The role of LPN in the project is to detect any motion using the motion sensor and turn on the light immediately. It also uses the proximity sensor to detect a car and thus sends the parking slot status in order to display it on the friend node. The LPN sleeps in between this functionality. The LPN also turns off the light after a certain specified time. It also switches the lights on or off if the friend requests so.
The Proximity Sensor is used to detect if the slot is occupied or not. But I have also used it as a Parking assist in addition to the basic functionality.
The values of the proximity sensor are taken at a greater frequency , the LPN displays the distance the car is from the sensor accurately thus helping the driver to park the car. In addition to this , the LEDs start blinking if the car is too near to the the sensor thus letting the driver know when to stop the car while parking.
The LEDs also blink whenever the node is being provisioned indicating the particular node being provisioned.

Problems Faced

1) The OOB authentication process took a lot of time because of incorrect Mesh documentation. The oob_init api command parameter values were incorrect in the documentation.
2) The Proximity Sensor distance reading required some calibration to be done.
3) It took a lot of reading to understand publish and receive commands, implementing Mesh models and services and integrate into the code.