Post Project Storytime (Timelining, Thoughts, and Results)

EE Related

First Semester

The goal of this project is to create a parking monitor system that will update an iOS app in near real time, because there will always be some latency when transferring encoded data wirelessly, then gets decoded when it lands in the server, and waits for the devices’ request to update the status of the parking area that is currently being viewed. To get there, we needed a hardware side; for the sensor package, and a software side; for the iOS app. The main constraint to this project is the wireless protocol being used. It is called LoRaWAN; Long Range Wide Area Network. This is promised to achieve very long distance wireless communication with very low power usage. LoRa uses a ‘public’ frequency band, so that just means it does NOT need to be declared to the appropriate governing bodies who we are and what we are doing with said frequencies.

To start with the hardware side, we came to a consensus that a magnetometer and a Time-of-Flight sensor will be appropriate. The magnetometer detects any changes created by ferrous metals and/or any competing magnetic fields (like motors and alternators) by referencing Earth’s magnetic field. Some of the major pros is the low power consumption and it does not need special accommodations to operate in all weather climates. While this sensor by itself is quite good, it may be better to have something to visually see that a car could really be there. The time-of-flight sensor fills in that requirement. This is essentially a mini LiDAR sensor that will send infrared and bounces back to the sensor to visually see an object. In our case, we only needed to look for a distance that is mostly appropriate in terms of vehicle height. Getting a visual is the major pro in this case, the cons are more of the issue. If the gap between the top of the sensor and the top of the ‘glass’ is 2mm or greater, then the reliability takes a major hit, like it will not reliably read past 100mm (this sensor can read 1.3m with high certainty when there is no cover) and also causes an issue with reading anything below 50mm. This causes a narrowing of the distance it can ‘clearly see’ rather than just a drop in distance.

After looking at all the pros and cons of the sensors, we turned to what will operate the sensors using the LoRa protocol We came to a conclusion to make use of a board that has the LoRa module built-in and also have a relatively straightforward process of implementing it. This narrowed down to the more well-known single board computers like Arduino, Adafruit, SparkFun, and the like. We chose Arduino’s MKRWAN 1310 because of the LoRa module built-in, Arduino has their own IDE and is a very big community so resolving issues can be a Google search away, and the VERY low power consumption at sleep, 2 microamps! This looked quite option since the other ones we looked through required an add-on LoRa module board or was not as straightforward to deploy, coding-wise. Once we got the packaging sorted, now we needed to procure the particular sensors out of the many choices.

For the magnetometer, we chose the MPU-9250, because one of the groupmates was familiar with it and actually had one available to use. As for the time-of-flight, we decided to use an Adafruit product just so we have a good foundation to learn from. The model is VL53L0(zero)X. We also looked into purchasing the gateway as well, because we assumed we will need to have all the moving parts to operate it from Point A to Point B. Even after hearing we would have access to WSU’s gateway, we still purchased it on the small possibility we would run into issues we could not foresee. Once we made our choices and purchased, we received the parts by week 5 – 6 and started to learn what the sensors can do and how to work the Arduino IDE. We had a very basic operating program that would output the values the sensors output, because there are many libraries available for both sensors. We simply spliced them and managed to get it operating and we analyzed what materials would affect the magnetometer (ferrous metals only) and the reliability of the time-of-flight sensor in terms of the noise it produces at the furthest distances (after 1.3m, uncovered, it started to become noisy in the graph). One we had access to WSU’s gateway, we attempted to connect to it and we found it best if we were in GoCreate to connect. This is where having the CS team assisting us made it a smooth process when moving data from the MKRWAN, into ChirpStack, and holding the data in ThingsBoard. This process would have taken us EEs weeks, while the CS team got it in roughly a week due to using WSU’s gateway and putting our gateway aside during the first semester.

Now that all the individual components tested indoors, we needed to test it under a car outdoors. This is where some of the issues started to arise. We noticed based on the placement of the package, the magnetometer may not detect a notable change, thus not get triggered. There was also the time-of-flight, because the most common thickness of plexiglass/acrylic is 2mm we ran into the narrowing of the range it can detect with high certainty. Most of the limitations can be mitigated with adding thresholds, like if the magnetometer sees a delta change of 10 units plus or minus, this would yield a true. The same for the time-of-flight, if we detected an object above 90mm it will output true as well. Then the next issue was connecting to the gateway. We ran into an issue of roughly 50% of the data being sent isn’t getting to the destination (ThingsBoard) within the allotted window (2 minutes). We continued to troubleshoot it throughout the remainder of the first semester only to reach an initial conclusion that the Arduino may need to run in a boosted mode to send the data. There is a boosted feature for the LoRa module, but we were not able to test that by the time we made that initial conclusion. As we searched over the distance LoRa can do, we could only find anecdotal evidence that it COULD reach UP TO 2km with caveats (line of sight with no elevation changes). We were able to get it to connect and operate it by the time we reached the first Open House. At this point, we have only glanced over the power system requirements, because we were focused on having a working prototype to showcase rather a pile of parts that doesn’t work. Once the first semester ended, we looked into the areas that needed improvement and from the response of the Open House, we decided to reassess how the team operates.

Second Semester

During the first week, we decided to ensure that we are able to display our clear contributions to the project by breaking the project into non overlapping topics: Signal Integrity, Sensor Reverification, Power System, and Casing. Once those were assigned, we focused into those topics and how to tackle them.

Starting with the Signal Integrity, this was assigned to Damian. Since he was working more intimately with this issue during the first semester, giving him this task made sense. He created a gameplan to verify the signal integrity and sine he lived close to WSU (5 minutes away) he could test it with relative ease. After testing, he managed to reach 300m with a line of sight with no signal drop. I’m not sure if there was a data test, but I shall assume so since we would test it by connecting the Arduino to a PC and send ‘true’ or ‘false’ (1 or 0) while viewing ThingsBoard to verify the data passed through successfully. From his analysis, using the boost function may not be necessary. He also concluded the issues we had may come from elsewhere, either a drop from the Arduino to ChirpStack or a drop from ChirpStack to ThingsBoard.

With verifying the sensor package, I believe that Martin was the best choice since he presented us with the magnetometer (MPU-9250). While we actually were analyzing the sensors during the first semester, we did NOT record any of the information to present. This creating a massive gap and Martin was tasked to capture the data to support our choices and how we came up with the rational in terms of the thresholds used to minimize false positives/negatives.

With the power system, I wanted Max to prove himself that he contributed work so this was assigned to him. My confidence was quite low when I gave him this, but being able to have some initial research into the power system so we could move forward with an integral part of the system is the goal. Unfortunately, that was not the case. This resulted in a loss of 3 – 5 weeks in power system research and testing. This became an unfortunate prediction that came true. I did attempt to ask him if he made any step forward, insights, or recommendations that differs from what was presented in the first semester.

The casing was assigned to myself (Alex), as I thought I have the most available time to see what it would take to create a viable housing to package the system. Unfortunately, this was not seen as important and the option to independently research the power system (and present it as an Option B) was given and I did just that. I looked through the documented power consumption and what would be required. I concluded that the system would consume 1000 mAh based on 1 hour of status changes through the entire day. The assumption is that each status change (Vacant/Occupied) takes 3 minutes to send and 10 cars for each parking spot would be a high number since at WSU, student’s classes tend to be around 90 minutes on average. Most students tend to take their classes in succession and if there was a small gap, they would stay on campus. This resulted the capacity to be at least 4500 mAh for it to operate in the heavy operating days (M, T, W, R, and 1st half of Friday). To recharge the battery in 2.5 day, it would require a solar panel 4” x4”, while a 7” x 6” panel would charge the battery in 1 day. The charge time is assumed to be in sunny weather. The estimates for cloudy and overcast, the efficiency would drop to 25% and 10% respectively. When I asked Max if he had anything to add to the power system research, he only referred to doing the recommendation I mentioned during the TPR. So, with 4 weeks left, I assumed the power system was appropriate and purchased 3 sets, because we wanted 3 units to present at this Open House.

During this time, we ran into an issue with access to WSU’s gateway. For some reason, it got reset and was unavailable at the beginning of the second semester, because they were updating the network (if I recall that correctly). Also, our sponsor for this wasn’t any help to us nor the other LoRa teams as well (they also lost access). Due to this, Damian brought out the gateway we purchased during the first semester (RAK 2245 Pi Hat Edition) and got it running. This was an odd moment of being able to resolve an unforeseen issue in a relatively short amount of time. Losing access to the gateway caused issues within the team: couldn’t test the power consumption when it is sending/receiving and continued refinement of the iOS app on the CS side (also had to expand more work to fill in) to name a couple of things.

With the gateway issue resolved, we started to create the multiple packages (three) to try and simulate the load. This was another unforeseen issue. A sensor we used over the first semester (MPU-9250) was a discontinued sensor and was revised with a new model. I thought when it first occurred that this was just an anomaly. Unfortunately, after testing 5 more, it did not output the magnetometer while it DID output the accelerometer and gyroscope values. With 2 weeks left, I purchased the sensor Adafruit is using (LSM303DLHC). While it did not purchase the ones from Adafruit ($15 and out of stock), I did purchase ones that used that sensor in particular. This also gave me the flexibility to use Adafruit’s library for the magnetometer. Unfortunately, I could not get this to properly function in time due to my lack of understanding what lines of code needed to change in the original showcase program. After the showcase, I was able to resolve the code and manage to get it working.

Conclusion

Overall, this worked as expected. We ran into issues, some expected while others were unexpected. It seemed like some of us had a feeling that our sponsor would not be someone we could rely on when we needed some assistance. This feeling was founded during the entire Senior Design 1 and 2. We hardly heard anything from him and for some reason, there was an expectation to ‘report’ to him on a regular basis. While I understand keeping the sponsor in the loop is generally good etiquette, his posture said otherwise. This felt like a method for the sponsor to hold the Service Learning Credit just because he felt like it. This is a concerning situation. Since there was three of us that requires it to graduate, we had to try to obtain this in a roundabout way. While this was resolved in some manner, I believe there needs to be some sort of supervision for the sponsors or the sponsor needs to have at least two people overlooking so there is some sort of fallback if one of them becomes unresponsive. How this is implemented is another question I would not be confident to answer. If there is anything I could inform the next class, do NOT have him as a sponsor (Clayton Allen [wants to be known as Coach]). There were also team dynamic issues. Some were apparent issues (little to no contribution) while one was more hidden (this may be because we worked separate from one another). This raises the issue of working in a team in the first place. It only reinforced some of the initial thoughts I had for my teammates, mostly good.