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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Where2Park is a battery-powered Internet of Things (IoT) project aimed for deployment in parking garages. Where2Park relies on a series of sensor nodes embedded in parking spots. The nodes will feature metal detecting sensors and battery management hardware, and will interface with a microcontroller. The nodes will all be part of a Zigbee mesh network, and each node will be capable of being configured as either a router or a coordinator. The network will interface with a centralized application. This application will feature a map of the parking spaces that indicates their availability, and will also display a running count of free spots as well as the battery status of each node. The graphical user interface (GUI) will update in real time. This project is being developed in the context of a stark increase of IoT nodes and the rise of the "smart city." In addition to the desired integration into smart cities, the end goal of the project is to aid users in efficiently finding parking spaces in the face of growing urbanization.

STS Prospectus

Introduction

A parking sensor is something that is regarded as a step towards becoming a SMART city. However, this technology is something that is not so clear cut. This technology must be explored in full detail to understand its societal impact and if this technology should make its debut in a particular area. There are areas where questions must be raised. For example, The sensor itself would have to be embedded into the concrete and parallel to the parking spot, or alternatively encased in a hard resin at the center of the parking spot. There would have to be significant labor and resources used to make this change. Concrete makes up 8% of all carbon emissions. To make sustainable choices, there has to be significant research done. The system itself may require a significant amount of power, however, for our capstone purposes, we chose to have the system powered by batteries. Batteries need to be appropriately thrown away as they may contain alkaline which may be harmful to the environment. Each sensor module will likely be powered with an alkaline or lithium-ion battery. This means a replacement battery will be needed after a certain period of time to keep the system working long term negatively affecting the sustainability of our project[6].An economic constraint might be the GUI access. Many people may not have roaming data or even regular access to the internet. Given the common hardware shared by the nodes, the network size can easily be scaled.

The user will be interacting with the software based GUI so there are not significant health risks associated with our end product. Ethical issues associated with our product include protecting end user privacy issues since the system tracks specific parking sports [8]. Remote access to parking data could possibly facilitate stalking or robbery, but the ambiguity of the data provided by the system negligible, especially given that the same dangers can come from visual investigation on the part of nefarious parties.

Research Question

The focus of my thesis is devising a parking sensor that will enable a user to check where there is available parking. The initial application of this product was for the UVA Engineering School; however, this can have applications in local venues. For example, public parking lots can benefit from having less congestion from CO2 emissions while searching for a spot, can allow a user to spend less time looking for spots and can allow the government to find ways to spur local public transportation. In an example, if the local government understands that at a certain point in the day, there is a high volume of traffic, they can offer an alternative, public transportation. The parking sensor can potentially help the user to choose when it’s appropriate to drive and when it’s appropriate to take public transportation. Another application is that 20% of all car accidents occur in the parking lot. This can happen in parking lots because the drivers are preoccupied with finding a spot to look for. With an app/tracker, these accidents can be mitigated. As someone with personal experience of a parking lot accident, I can say that an app/tracker can most definitely prevent accidents. Beyond the safety concerns, having an app can also mean more efficient parking and prevent traffic.

My STS Question is whether society will benefit from a parking sensor or will it become another technology that has the potential to be abused. It will allow a user to find a parking spot before entering the parking lot and will update the interface with open positions and taken positions. It will also allow governments to spur local transportation options. However, this will also allow the potential for abuse. For example, what if a local business would like to use this opportunity to advertise on the interface or if the government decides to make the free parking paid due to volume. There is also the question of if the users want to be a participant in the data collection. Some of the public will probably not hear of this technology and will inadvertently be a part of data collection if they choose to park in a parking lot with sensors. There will have to be security precautions as this technology can have the potential to be exploited.

In regards to the construction of the sensor, I will be creating this product from the resistor up. It will require a metal detector to detect the car and software engineering to get the whole system to work. The metal detector schematic includes an oscillator that will display frequencies to indicate that a metal has gone over it. We as a group decided to use a metal detector because a metal detector would be the most accurate. If we had used a proximity sensor, random objects or debris could be considered a car. The details are getting worked through, however, with the help of the group's advisor, we will work through each potential problem.

Literature Review

The project review from Huawei has allowed me and my group mates to develop an understanding of the impact of the parking sensor on the general public. The aim of the project was to lessen the stress of finding a parking spot in parts of China. The companies involved, China Unicom Shanghai, Huawei and TransInfo, used a magnetic vehicle detector, a mobile app, a handheld charging terminal, data management and eNodeB to create smart parking. The general impact of this was positive and they have plans to expand this system throughout Shanghai. The scale of this project is massive and it took the efforts of three companies to get the trial running. One critic I have of this project is that it seemed more catered to the car parking management companies rather than the general public. The app seems to have a payment option that companies use to charge the users(Huawei, n.d.).

An article from Harvard helped my group mates with understanding the impact of Internet of Things. Internet of things brings formerly inert objects into information technology. The author goes in depth to explain the different applications of Internet of Things. She specifically explains the different applications of Internet of Things. One of the examples is Parking; it is a popular IoT application since it uses sensors to track availability. She also gives examples of companies that are trying to develop this technology. She does criticize part of this application because she recognizes that companies have mentioned that they can use data to adjust pricing based on demand of the parking spots(Harvard, n.d.).

Bosch is a company that has created a parking sensor quite similar to how we are trying to create. The difference is that we are using a launchpad to create a mesh network. The impact of this source has led my group mates and I to think about the social impact of such a sensor.

This sensor is marketed to wealthy customers versus our project that is catered towards the general public. This implementation also uses LoRaWAN, a protocol for wireless communications. The company's selling points for this product is the environmental impact. They claim that the 20 minutes spent on searching for a parking spot will be reduced with this product, thereby reducing up to 35% of CO2 emissions. They also mention that this product creates a more rigid parking rule structure(Bosch, n.d.).

Internet of Things can be described as a network of physical objects that are embedded with sensors, software and other technologies over the internet. There are multiple different sources that may help with the construction of the network. The author of this source tests the two protocols and gives an explanation of their findings. What I have gathered from this source is that the limitations of LoRaWAN inhibit the overall project progress. The is a limit on how much data is can maintain and has a lower product quality than Zigbee. My group mates and I have decided to use the Zigbee network versus the LoRaWAN(Daytech, n.d.).

Building the metal detector circuit was tricky. However, I studied the Colpitts Oscillators and it is an integral part of the system. A Colpitts Oscillator allows the system to release a frequency whenever a metal comes into contact with the system. The other components of the circuit is to prevent any electrical shorts or problems when you connect it to the launchpad/Internet of Things. The author of this research has provided steps to follow to create similar responses. The author however, does not expand upon his findings in a more concrete manner. This research of his was mostly as a guide piece(Electronics Hub, n.d).

When creating a product that is going to be designed for public use, the product should be up to safety standards. The safety standards that apply to our project is the voltage levels of the oscillator to the launchpad. The NEMA safety standard uses various grades of electrical enclosures typically in industrial applications. Each has ratings on hazardous parts and additional type-dependent designated environmental conditions(NEMA, n.d).

The IEEE standards have been developed to have green and clean technologies to protect and improve the quality of the environment and the earth. The application to our project is the soldering aspect of the circuit and the battery life of the application. The battery life is monitored by a separate circuit and will be replaced properly. The batteries have alkaline and need to be disposed of properly(IEEE, n.d).

The code of ethics is another standard that needs to be followed as it allows the access to consumers in a safe manner. As engineers, we should be expected to show the highest standards of honesty and integrity. Engineering has an impact on society and can change based on the criticism of people. This impacts our project since we have to make sure that the application must adhere to the highest principles of ethical conduct(NSPE, n.d).

Another code that we had to follow is the Electronic Code of Federal Regulations. The Electronic Code of Federal Regulations has specific details regarding the bandwidth of certain circuitry. " Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW"(eCFR, n.d).

One of the reasons for creating the sensor in the first place was about the safety in parking lots. 20% of accidents occur in the parking lot. The number of accidents can be mitigated if the user is less invested in finding a spot. The sensor will enable the user to be a safer driver. The research done by this author is based primarily in the United States. Many cities have different parking situations and the statistics may be higher or lower depending on where you go. However, the differences should be kept in mind when creating the product(MyParkingSign, n.d).

STS Framework and Method

Winner's perspective can be summarized by discovering and acknowledging the underlying politics of a system. For example, bridges on local roads or even on highways have the height limit warnings and bypass roads to detour around them. This is because they were purposefully made lower so that buses would not be able to go on the road because historically minorities would use buses. Something as simple as a height warning is embroiled in historical biases and politics of that time.

Although in the United States parking spots are generally decent sized to accommodate large American cars, in other countries, the parking spots are significantly smaller. In Japan for example, car spots are adequate enough for Japanese made cars but can not accommodate large American cars. The underlying politics of Japanese preference inhibits consumers from purchasing American cars. Countries which have domestic cars tend to show their preference for domestic cars rather than foreign cars with underlying architecture.

In the United States, parking garages with sensing technology is typically in richer white neighborhoods. This can be related to the sentiment discussed in the beginning of the discussion. It can be assumed that minorities live in impoverished neighborhoods and thus having a parking garage there can be considered a waste of money. However, in rich neighborhoods, there is no limit to the extravagances that the neighborhood can afford.

The parking sensor my team and I are working on is for UVA usage and even within UVA there are divides in each district. For example, in apartment complexes like the Standard, they have parking sensors to detect which car has a parking pass or not. In parking spots near Bond or Bice, an attendant comes in person to inspect each and every car for a pass. The team that I am working on has a bias towards the Engineering school and thought to put the system in the Engineering parking lot. I am intrigued by Winner's perspective and will thoroughly consider the underlying politics of each decision made by the team.

Hughes' socio-technical theory mentions that "technological systems contain messy, complex, problem-solving components" (Hughes, 1989 p 51). The project involves a parking sensor that will show on a user interface which parking spots are taken and which aren't. The system builder is the Capstone group in the Electrical and Computer Engineering Department. The project is broken up into 3 parts, the initial hardware creations, embedded systems and the software interactions. I have the responsibility of coming up with the schematic for the metal detector sensor that will let the overall system know which spot is taken or not. The embedded systems involve networking the sensors together so that we can see multiple spots in the user interface. The software interactions will show the parking spots and will be updated as the cars move in and out of the spots.

Technical momentum is a theory that states that the relationship between technology and society is reciprocal and time-dependent. The parking sensor system is a system that is relatively uncommon and new. The technology will help us students working on the project understand the hardware and networking in more depth and the project will hopefully help the society by lowering the stress induced by finding parking spots.

The reverse salient in the project is essentially the three main objects of the project, hardware board, networking and software aspects. Without any of the three, the overall project will be difficult to salvage.

A parking garage sensor is unique in that it can affect many stakeholders while also appearing simple. A few social groups that follow the SCOT framework are the local government and the general public. The local government can have a wish to have more of the public to use the public transportation to develop the infrastructure of the city. Based on this information, my group can add garage/spot price information and the ability to check the predictions for spots at a given time. This may allow the user to decide if public transportation is a better alternative. This is an example of a desired human action and technology that is shaped based on it. The design for this product was initially intended for UVA engineering, however, if it can be of benefit to the community, that is also a desired outcome. Another form of government involvement can be the regulation of this parking sensor for government locations such as the DMV. This can allow users to determine the best times to make that visit.

A social group to consider is the general public. Given the assumption that the users will use this app to find where to park, we can also assume that they would want to know if the parking is free or paid. This assumption can also lead us to include free and paid sections for parking. Depending on the area, we can also include paid options and then surrounding free options. Another user interface we can potentially develop upon is the creation of the parking reserve. This would allow the user to reserve a spot ahead of time to ensure that they will receive the spot. This will allow the user to choose a time that suits both parking preferences and openings. This interaction between the user and designer allows for the technology to mimic what the user would like in the product.

Another social group are the Hardware Companies. Many companies, such as Bosch, create their own sensors. To create such hardware, they usually follow a list of specifications given by a third party. In the case of an in house invention, companies have to follow a set of engineering standards. For example, they must follow NEMA, IEEE Environmental Engineering standards and Electronic Code of Federal Regulations. These standards regulate what a company can do with user data and make sure that no user gets hurt. In the event that a third party sends in a list of requirements, the company builds upon it accordingly(keeping the standards in mind).

In the process of creating the metal detector for the parking sensor, there are a few nonhuman actors involved. The first being the relationship between the inductor needed to indicate the frequencies and the rest of the hardware circuit. I mention this bit because in order to have a parking lot of these sensors, we will need to develop a mesh network of these sensors. To properly tie them together, we will need to make sure in our circuit we use a specific piece of hardware that may cause problems for production. The piece of hardware needs to be ordered from Texas Instruments and while talking to one of their engineers, they have pointed us in the right direction. However, this piece of hardware is not something that any of the group members, myself included, have ever worked with. This is one of the nonhuman actants in the research.

The social groups in this project include the general public, local government and the developers. The interaction between each group will dictate the progress of the product. For example, the local government may ask the developers, the capstone group, to include a listing of public transports which may not entirely align with what we initially intended for this project. Or a user would like to include advertisements in the application. The interactions between each group is quite dense and for developers, it may be hard to keep up. There is also the issue of privacy and who is allowed to access what. For example, given the data of which times have the most cars can spur the government or a user to capitalize on it. There could also be a potential for crimes to be committed when there are few cars in parking lots. Access to the application would have to be vetted. The point of this application was to create a tool for the public. If the public has any worries regarding the product, the developers will definitely need to address them. For example, if the public wishes to have a reservation system. This way the users will be able to reserve the spots beforehand. However, as simple as it was to describe, the hardware aspects would change completely. There would have to be many additions made. However, the interactions between the social groups will allow this product to grow.

Timeline

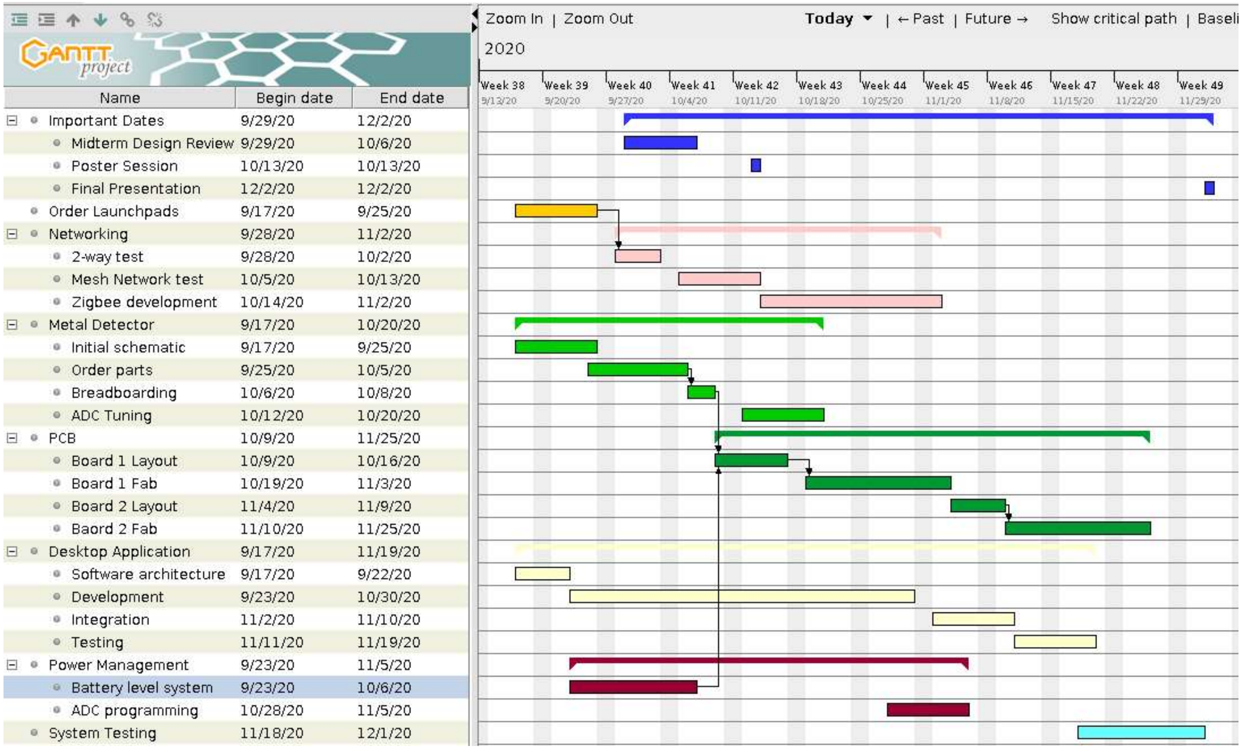

Figure 1: Gantt Chart

The Gantt chart above shows the project timeline that will be referenced. The main components of the project include the Desktop Application, Metal Detector, Networking and Power Management. The desktop application can be built alongside the initial bouts of the project. For example, the basic GUI layout can be done even without the connections with the Zigbee Mesh Network. The initial steps of the project include the hardware aspects such as Metal Detector and the PCB fabrication. The Zigbee Mesh Network will be tested on three metal detector sensors to test the Where2Park system.

Conclusion

A parking sensor must be explored in full detail to understand its societal impact and if this technology needs to be modified to fit standards and criticisms from society. Throughout this process, the technical aspect of this project has been modified slightly to make due of the advice and research. For example, the sensor will now be placed in the middle of the parking spot to mitigate false readings and include motorcycles. Another impact was the privacy clause added to the application. With data that has the potential to be abused, certain rules must be set out. Rules regarding information distribution and user awareness are in the process of being developed. The STS exploration of the technical project has opened up the conversation about how technology is not just related to engineering, but embedded into society as well.

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