Conceptual Design and Planning for Parking Lot Monitoring System

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I. Introduction

The goals of this conceptual design document are to expand upon the fully formulated problem surrounding a parking lot monitoring system to be implemented on the campus of Tennessee Technological University, the fully decomposed conceptual solution, the constraints on the solution and sources of constraints, the analytic validation of the constraints, and an optimal detail design schedule. The conceptual design of the parking lot monitoring system breaks down the concept of a parking lot monitoring system into subsystems that perform tasks to meet the specifications from the customer and other stakeholders while also satisfying the constraints generated from customer specifications, engineering standards, ethical concerns, broader implications, etc. The conceptual design informs the detailed design since the conceptual design provides the "what's" that the system must accomplish, so that the detailed design can address the "how's" (i.e. technology and components) to perform the "what's" from the conceptual design.

A. Fully Formulated Problem

The parking lot monitoring system shall collect data and provide information regarding parking spot availability to students. The conceptual design for the parking lot monitoring system consists of five major subsystems: counting sensors, ground truth sensors, a server, a mobile application, and a sign (Figure 1). The system functional expectations and constraints (demarcated by SC.x, with SC standing for "System Constraint" and x being the specific alphabetic letter) include:

(a) System shall not obstruct any parking spots on campus in a way that would not allow a person to park in a given spot.
  - This constraint was explicitly requested by the customer NAVSEA as a major requirement and echoed later by the Tennessee Tech Parking and Transportation Office, a stakeholder.

(b) System shall not interfere with parking traffic on campus in a way that would cause traffic to worsen.
  - This constraint was explicitly requested by the customer NAVSEA as well as another major stakeholder, the Tennessee Tech Parking and Transportation Office.

(c) System shall not permanently store images.
  - This constraint was explicitly defined by a major stakeholder, the Tennessee Tech University Police, to avoid any security cameras being used in the design. Security cameras fall under the jurisdiction of the University Police, so if camera technology is utilized, they must not have image storing capabilities.

(d) System shall not record videos.
  - This constraint was explicitly defined by a major stakeholder, the Tennessee Tech University Police, for the same reasons as outlined in SS.c. If camera technology is utilized, they must not have video recording capabilities.

(e) System shall operate during Red Zone parking enforcement hours of 7:30 a.m. - 4:30 p.m. on Mondays through Fridays.
  - This constraint was derived from expected system capabilities during the day vs. at night and from survey responses taken from students at Tennessee Tech. Red Zone parking enforcement hours, which are 7:30 a.m. to 4:30 p.m. on weekdays [1], are the times in which commuters are most likely going to utilize the mobile application, especially since these are considered peak hours for Red lot parking on campus. There is not as much of a critical need for commuters to use the application outside of these hours due because it has been empirically observed that these lots have a considerable number of available spots outside of enforcement hours and on weekends.
  - In addition, since counting sensors that may utilize visual technology (such as cameras) may not provide accurate data when it is dark outside, parking enforcement hours provide a reasonable time frame to collect and transmit accurate data regarding parking lot occupancy to the mobile application and the sign. Parking enforcement hours will typically be between sunrise and sunset, except in November and December, when for about four weeks, sunset will occur no more than roughly five minutes before 4:30 p.m. (and sunrise occurs no later than roughly 7:10 a.m.) [2].

(f) System shall have a primary data acquisition system that utilizes sensor technology to get parking availability of lot.

- This constraint was explicitly stated by NAVSEA, who desired that this system shall display parking availability data to students. From this customer desire can be derived that sensor technology will be needed to obtain this data.

(g) System shall include a secondary data acquisition system that utilizes an alternative sensing input mechanism to ensure system accuracy.
- This constraint was derived from the need to ensure system reliability so that it outputs accurate information to system users. The secondary data acquisition system must use a different method of collecting data in which the the data acquisition mechanisms of both systems do not affect each other. Since the error and random noise of both systems do not affect each other, combining these two systems will produce a more accurate system in which overall system error can be more easily detected and limited.

(h) System shall have accurate vehicle counts that must be within ±5% of the total number of parking spots in the measured lot from the ground truth's counts (i.e. if there are 200 parking spots in a lot, then the vehicle count must be within 10 spots from the ground truth's count).
- This constraint builds off of SS.g. Firstly, the number of total parking spots in a certain lot can be stored a priori into the server since this information can be retrieved from the Parking and Transportation Office, who conducts regular counts of the number of parking spots of each zoning color in every lot. ±5% was determined as a reasonable tolerance for the system count of number of available parking spots. For example, in a parking lot of 500 spots, a ±5% implies a maximum error range of ±25 spots if all spots are available and a minimum error range of ±1 spots if 20 spots are available (the lesser the available parking spots, the lower the tolerance). However, if that parking lot only has 300 parking spots filled, leaving 200 spots remaining, for at least 30 minutes, then an error of 30 parking spots most likely will not affect students determining whether to park in that lot. On the other hand, if there are 490 filled, with 10 spots remaining, it is highly likely that those spots will be filled up especially during peak times such as in between classes. Thus, any error for lower numbers of available spots can be attributed to how parking availability can change rapidly. Thus, a ±5% tolerance provides a suitable range that accounts for predicted student behavior with the mobile application.

(i) System shall have a mechanism in which the sensors on the primary and secondary data acquisition systems can be re calibrated remotely.
- This constraint was derived from the necessity to be able to keep reliable data in the event that sensor data from the primary and secondary data acquisition systems were deemed to be outside the acceptable margin of error. Because these systems may be placed in areas that may be extremely inaccessible to reach, it is practical that the sensors can be re calibrated remotely via the server rather than having someone physically re calibrate them.

(j) System shall have its sensors protected against inclement weather (e.g. rain, snow).
- This constraint resulted from the requirement to shield the vital parts of our system from damage from the outside world. The ground truth components and counting sensors will both be weather-protected. The responsibility of building the cases for the ground truth components and the counting sensors will fall to the ME capstone team.

(k) System shall have outdoor signage to indicate parking availability for each lot.
- This constraint was explicitly stated by NAVSEA, who desired that this system shall display parking availability data to the student through a outdoor sign. The outdoor signage will be "enabled on" during the operation hours mentioned in SS.e. and display the number of available spots in the lot.

(l) System shall have a mobile application for people wanting to check information about availability of parking on campus.
- This constraint was explicitly stated by NAVSEA, who desired that this system shall display parking availability data to the student through a mobile application. The application will receive input data(processed data, weather data, student credentials, time stamp, and accuracy) from the server and output data(queries) aswell. Using this data the app will have notifications for the user, display current parking count, parking history,

(m) System shall have notification posted on mobile application about potential decreased system accuracy during inclement weather.
- This constraint was an extended derivation of SS.w. In the situation that the weather outside is not ideal for the system to derive accurate data. The system must display a message to make the user aware of the possibility of faulty or less accurate data.

(n) System shall have notification posted on mobile application about dangers of driving while using a mobile device as well as its illegality in Tennessee on app startup.
- This constraint was derived from the safety ethical implication. The mobile application will have a speed detection atomic block that will gather data and transmit it to the user interface. This is an imperative function as it will notify the user about the dangers of driving while using the app and will protect them from harming themselves and others.

(o) System shall have notification posted on mobile application if system is not fully operational due to system malfunctions (e.g. parts of the system are damaged).

- This constraint expands upon SS.j. If the casing enclosing the system sensors or components is incapable of performing its function. In order to alert the user and system administrator about system damage, a message or notice must be sent to them.
- In addition, this will notify the system administrator if a re-calibration procedure which expands to SS.i.

(p) System shall have mobile application display additional chart displaying average parking availability over operational times of day.
- This constraint was derived from the Future Resource Impacts as described in the Broader Impacts section (Section II-C). The collected average parking data can be used by parking administration to make parking lot related choices. For example, they could determine if a lot needs to be expanded due to it being excessively used or if lot space needs to be repurposed due to insufficient use.

(q) System shall have a server to communicate data between sensors, signs, and mobile application.
- This constraint was a derived constraint for the system to operate. It will be the brains of the system as it will be processing the data from the data acquisition systems. The processed data will be distributed to the mobile application, sign, and acquisition systems.

(r) System shall have server process data collected from sensors to get parking availability counts.
- This constraint was explicitly stated by NAVSEA, who desired the system have sensors to get a parking count.

(s) System shall have a database on the server to store processed data such as parking availability counts and parking availability average.
- This constraint was derived from SS.p. The ability to compute an average of parking counts requires a history of vehicle counts stored. A database will allow said function so the server can compute the data and transfer it to its corresponding subsystems.

(t) System shall have server get and store local weather data to determine if weather related notifications should be sent to mobile application.
- This constraint was derived from the culmination of SS.m and SS.q. Local weather data will be acquired from an API and processed by the server. Once, the server detects abnormal weather conditions it can transfer a signal to the mobile application so a notification will appear.

(u) System shall have server communicate parking lot availability information to mobile application for display.
- This constraint builds off SS.l and SS.q by further detailing the relationship between the server and the mobile application. In order for SS.l to be fulfilled, the server must communicate the needed information, regarding parking availability to the mobile application to be displayed. There must be an intermediary between the data acquisition systems and the mobile application to process and transmit this data.

(v) System shall have the server communicate the correct processed parking availability count to the signs for display.
- This constraint builds off SS.k and SS.q by further detailing the relationship between the server and the sign. In order for SS.k to be fulfilled, the server must communicate the needed information, that is, parking availability count, to the sign to be displayed. There must be an intermediary between the data acquisition systems and the sign to process and transmit this data.

(w) System shall, at a minimum, perform its intended function in ideal conditions (i.e. clear weather).
- This constraint was explicitly stated by NAVSEA, who desired that the system operates during pristine conditions. This implies that the system will generate accurate vehicle in parking lot count data during clear weather(no rain, and sunlight).

(x) System shall have detailed documentation about the system's design and operation so future owners of the system can easily make adjustments to and maintain the system.
- This constraint resulted from the system's intended usage as a long-term fix for the parking issue. Due to this, any system administrators or operators in the future will require an operation document in order to make the necessary modifications and keep the system functioning at its best.

(y) System shall follow electrical safety measures as specified by NFPA 600.9.
- This constraint is derived from the standard NFPA 600.9 with regards to the location of electric signage to mitigate the risk of an electrical fire, especially if they are easily accessible by vehicles or pedestrians.

II. Broader Considerations

There are numerous considerations that were taken into account during the conceptual design and planning of this project, including ethical implications, engineering standards, and broader impacts, all of which had produced additional constraints on the system. These considerations and their produced constraints will be discussed in this section.

A. Ethical Implications

Safety - With the use of a mobile application to check for parking availability, there exists the risk of increased traffic accidents due to the apps usage while driving. Also, in Tennessee it is illegal to use a mobile device while driving unless the device is hands free (TN Hands Free Law).

B. Engineering Standards

Electrical Safety - In order to maintain the safe design, operation, and maintenance of the system, the project will follow the National Fire Protection Association (NFPA) 600.9 on electrical signage since the system will use an electric sign

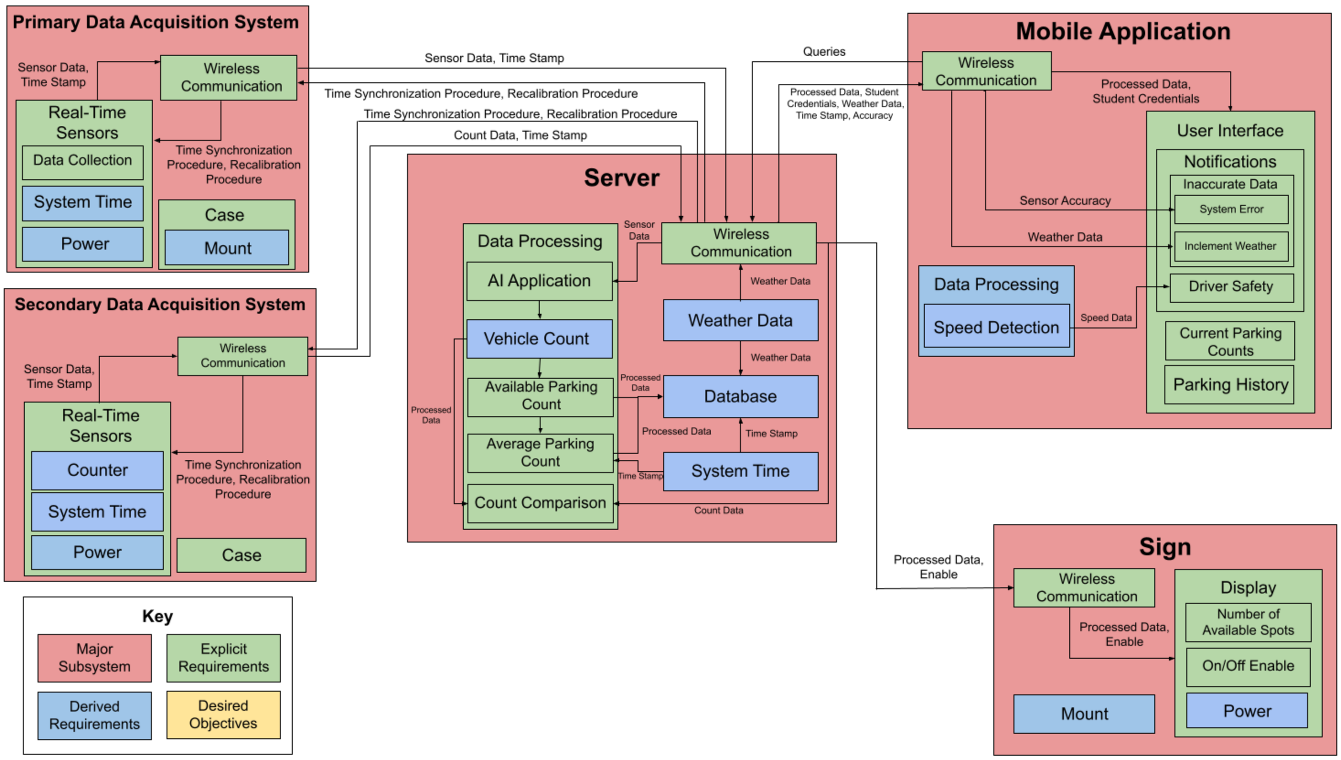

Figure 1. Block Diagram of Conceptual Solution

to display information, and this sign can pose a fire safety risk if not placed and protected properly.

Power - If solar energy is utilized to power any of the components in the system, the project will follow solar panel installation standards established by Clean Energy States Alliance (CESA).

Communication - Since multiple subsystems will be communicating with a server, the appropriate network communication protocols will be used to ensure proper transfer of data.

C. Broader Impacts

1) Cost Impacts: Due to the initial cost of deploying parking lot monitoring technology across the university, inflation in on-campus parking may be a possibility. Even though it would start out somewhat expensive, this cost would eventually go down, which would irk the student body. The goal is to aim to reduce hardware expenses to solve this issue by making sensible selections and only investing in features that are essential. Investing on an 8k camera system, for example, when it is not necessary.

2) Accident Impacts: The adoption of the parking lot monitoring system may result in an increase or decrease in accident rates. If the parking software was used appropriately, students looking for parking places would feel less anxious. However, if the app is used improperly (for example, by continually glancing down at the app while driving), it could lead to more collisions.

3) Parking Enforcement Impacts: The addition of the parking lot system could be utilized to enforce proper parking. With upcoming system upgrades, it might be feasible to detect improper parking (i.e. obstruction of two spots). The system might also benefit from the ability to recognize colored parking passes. The appropriate parking pass for the parking zone is obtained in this way.

4) Future Resource Impacts: The addition of the gathered park data might be a fantastic resource for Tech's future growth. Knowing how each parking lot is used and at what time slots is useful information for potential expansion or refurbishment. With this information, Tech management may visually determine whether a lot is underutilized and whether it could be used for another structure or function, or perhaps a frequently utilized parking lot has to be expanded.

D. Constraints Produced from Considerations

Safety Constraint - The constraint generated from the ethical issue of driving safety is denoted by constraint (n) which clarifies a notification given to users of the mobile app to remind them of the dangers of using a mobile device while driving as well as its illegality in the state of Tennessee.

Electrical Constraint - Constraint (s) is generated in relation to the safety standards established by the NFPA which will influence design choices made for the system.

III. Conceptual Solution

Figure 1 shows the block diagram of the conceptual solution for a parking lot monitoring system that meets the requirements and constraints detailed in the fully formed problem. This section will briefly explain the functional expectations for each subsystem block and the associated constraints for each block.

A. Subsystems

1) Primary Data Acquisition System: This subsystem will be the eyes of the system and will be responsible for counting vehicles from the entire parking lot at once. This subsystem will include an atomic block for wireless communication with the server. An atomic block for the case/mount for protecting and determining how and where the primary data acquisition system will be placed . There will also be a real-time sensors sub-subsystem that includes a data collection atomic block, system time atomic block and a power atomic block.

(x) Proper documentation must be developed for this subsystem. Team review will verify that this has been achieved.

Real-Time Sensors

(f) The purpose of the counting sensors will be to collect parking data regarding a certain section of the parking lot. This function can be verified following data processing.

(w) These sensors must be sensitive enough to achieve accurate vehicle counts in clear weather. Verification of this will be accomplished by comparing the data from this sensor system to the ground truth sensors.

Data Collection

(c) This sensor system should not store any images, only send them. This constraint can be fulfilled by instantly sending any images that this subsystem should receive to the server immediately upon capturing an image.

(d) This system can be built to provide a series of images as a live feed. Fulfillment of this constraint can be observed server-side.

System Time

(e) There shall be a way to turn off the sensors when the system is outside of operating hours. This can be verified by ensuring server-side that there is not data being receive past operating hours.

Power

(i) There should be a way to reset the device remotely. This can be verified by observing the data received server-side.

(y) This subsystem must be developed in following with the proper electrical safety codes. Team review of the system will ensure that these standards are followed.

Wireless Communication

(i) There should be a way to reset the device remotely. This can be verified by observing the data received server-side.

(q) The system must be able to communicate with the server. It will send data to the server and the server will tell it when to record said data. This can be verified server-side.

Case and Mount

(a) In order to fulfill this constraint, this subsystem will be placed outside of any valid parking spot. A lack of obstructions can be verified by visually verifying its location and ensuring that no pathways to spots have been blocked.

(b) Care must be taken in the placement of this system of sensors in order to ensure that parking traffic will not worsen. This should be visually verified in ensuring that drivers do not have to go around any part of this subsystem.

(j) There will be a protective casing around this sensor. Protection from the elements can be observed by inspecting the outputs of the system as well as the system's physical appearance to see if there is visible damage.

2) Secondary Data Acquisition System: This subsystem will be responsible for measuring how many vehicles are leaving or entering the lot.

(g) This secondary system is needed to act as a form of redundancy for the primary system, similar to how a safety system has redundancy in it. Implementation of this can be visually verified.

(x) Proper documentation must be developed for this subsystem. Team review will verify that this has been achieved.

Sensors/Counter

(f) These sensors must be able to tell if a vehicle has entered or exited a a parking lot. Multiple ground truth sensors would be needed for a parking lot with multiple entry/exit points. The implementation of these sensors can be visually verified.

(w) These sensors must be sensitive enough to achieve accurate vehicle counts in clear weather. Verification of this will be accomplished by comparing the data from this sensor system to the ground truth sensors.

System Time

(e) There shall be a way to turn off the sensors when the system is outside of operating hours. This can be verified by ensuring server-side that there is not data being receive past operating hours.

Power

(i) This system will need to have a form of remote re-calibration in the event of system failure. This can be verified by viewing the data server-side and monitoring the resulting data for the reset value.

(y) This subsystem must be developed in following with the proper electrical safety codes. Team review of the system will ensure that these standards are followed.

Wireless Communication

(i) This system will need to have a form of remote re-calibration in the event of system failure. This can be verified by viewing the data server-side and monitoring the resulting data for the reset value.

(q) The system must be able to communicate with the server. It will send data to the server and the server will tell it when to record said data. This can be verified server-side.

Case

(a) This subsystem must be placed in such a way that it does not obstruct parking spots. This can be verified by visually verifying its location and ensuring that no pathways to spots have been blocked.
(b) Care must be taken in the placement and selection of this system of sensors in order to ensure that parking traffic will not worsen. This should be visually verified in ensuring that drivers do not have to go around any part of this subsystem.
(j) There will be a protective casing around this sensor. Protection from the elements can be observed by inspecting the outputs of the system as well as the system's physical appearance to see if there is visible damage.

3) Server: This subsystem will be responsible for processing all received data and sending processed data to the mobile application and the sign.

(x) Proper documentation must be developed for this subsystem. Team review can verify that this requirement has been met.
(y) This subsystem must be developed in following with the proper electrical safety codes. Team review of the system will ensure that these standards are followed.

Wireless Communication

(i) The server will have a function that sends a re calibration signal to the sensors. If the server detects inconsistencies, it may alert a manager to perform the re calibration procedure. This can be verified by ensuring that after reset, the data is automatically fixed.
(o) Data from sensors should be consistent. If inconsistencies arise server will communicate data to mobile application and sign.
(q) Networking between each device will be designed based on which systems are communicating with the server. Each network will be verified by its individual needs.
(u) The server will have appropriate networking in place to send appropriate data to the mobile users. This can be verified by viewing the mobile application.
(v) The server will have a communication system set up with the signs. Verification can be performed by checking that the sign displays the appropriate data.

Weather Data

(t) The server will process weather data and decide whether an alert should be sent to the mobile application or not. This can be verified by seeing if the mobile application gives the notification in inclement weather.

Database

(c) Extra care will be taken to ensure that a system is in place to either regularly delete images, or never put them into permanent storage at all. This can be verified by viewing saved files.
(d) Videos will not be stored server-side. This can be verified by viewing saved files.
(s) The server will store processed count data in long-term storage. This can be verified by manually checking that the desired data is in the long term storage.

System Time

(e) The system will not be needed before 7:30am and after 4:30pm. Server is needed to process the time stamp and enable/disable the sensors, sign,and app. We can verify this by ensuring that data is not saved outside of those hours.

AI Application

(f) The AI application will need to be included server-side as an add-on to the primary sensors. Using artificial intelligence, the system will be able to process the inputs received by this primary system into numbers. This will be verified by viewing what data is saved in the database.

Vehicle Count

(h) Server will compare data from upper level/ lower level systems to verify accuracy. This can be verified manually this is working properly by viewing the data.
(r) The server will collect the data from the sensors and process it to get the available parking counts. This can be verified by manually checking the data.

Available Parking Count

(h) Server will compare data from upper level/ lower level systems to verify accuracy. This can be verified manually this is working properly by viewing the data.
(r) The server will collect the data from the sensors and process it to get the available parking counts. This can be verified by manually checking the data.

Average Parking Count

(p) The application must have the average and so it needs to be calculated here. Verification of this calculation can be viewed in the saved data.
(s) The average is needed for the database's storage. Verification of this calculation can be viewed in the saved data.

Count Comparison

(g) The system will use the count gathered from both the primary and secondary systems in order to perform a comparison. It will likely be that an average of the two will be performed. Verification of this procedure can be done by ensuring the system utilizes the comparison in its output data.
(h) The system will verify that the count is accurate in this stage. It will likely be that an average of the two will be performed. Verification of this procedure can be done by ensuring the system utilizes the comparison in its output data.

4) Mobile Application: This subsystem will be the first form of user interface for the system. The mobile application will receive processed data, student credentials, weather data, time stamp, and sensor accuracy signals. These signals will be received by the wireless communication atomic block in the system. Inside the mobile application will be the data processing atomic block which will be in charge of detecting user speed. The user interface subsystem will include the additional atomic blocks (system error, inclement weather,driver safety,current parking counts, and parking history) which will be in charge of displaying notifications to the user.

Wireless Communication

(u) The server will have appropriate networking in place to send appropriate data to the mobile users. This can be verified by viewing the mobile.

Data Processing

(n) Visual verification of user notification during initial startup of the application when speed is greater than campus speed limit.

User Interface
System Error

(o) Data from sensors should be consistent. If inconsistencies arise server will communicate data to mobile application. A visual verification of the notification during inconsistencies will be the form of validation.
(h) Server will compare data from upper level/ lower level systems to verify accuracy. This can be verified manually this is working properly by viewing the data.

Inclement Weather

(m) A visual verification of the notification during inclement weather will be the form of validation.
(t) Weather API data will be processed by the server and sent to the mobile application. A visual verification of the notification during inclement weather will be the form of validation.

Driver Safety

(n) Visual verification of user notification during initial startup of the application when speed is greater than campus speed limit.

Current Parking Counts

(l) Visual verification of current parking data on app will be the form of validation.

Parking History

(p) Visual verification of average parking on app will be the form of validation.

5) Sign: This subsystem will be the second form of user interface for the system. The sign will receive processed data from the server and an enable signal. These signals will be received by the wireless communication atomic block in the system. The display sub-subsystem block will have three separate atomic blocks in it. There will be the "number of available spots" atomic block, the "on/off enable" block, and the "power" atomic block. Finally, it will include a "mount" atomic block.

Wireless Communication

(v) Processed data from the server will feed into the sign and be displayed for the user. A visual check of server side data matches sign data being displayed.

Mount

(a) In order to fulfill this constraint, this subsystem will be placed outside of any valid parking spot. A lack of obstructions can be verified by visually verifying its location and ensuring that no pathways to spots have been blocked.
(b) Care must be taken in the placement of the sign in order to ensure that parking traffic will not worsen. This should be visually verified in ensuring that drivers do not have to go around any part of this subsystem.
(y) NFPA 70 code 600.9 refers to the placement of signs of this sort and all aspects of this regulation must be followed.

Display
Number Of Available Spots

(k) Processed data from the server will feed into the sign and be displayed for the user. A visual check of server-side data matches sign data being displayed.

On/Off Enable

(e) Sign usage will not be needed before 7:30 a.m. and after 4:30 p.m. Server is needed to process the time stamp and enable/disable the sign. We can verify this by ensuring that the sign is turned off during operating hours.

Power

(y) This subsystem must be developed in following with the proper electrical safety codes. Team review of the system will ensure that these standards are followed.
(x) Proper documentation must be developed for this subsystem. Team review can verify that this requirement has been met.

IV. Optimized Detail Design Timeline

As examined in Figure 2, each task in the detail design is broken down into a time slot and the responsible parties. These tasks were assigned to parties based on related skills and concentrations. Kester is in charge of the counting sensing system due to his computer engineering background and experience with artificial intelligence. Gabe is in charge of the server and database due to his experience from his last co-op and computer engineering background. Reggie is in charge of the ground truth sensing system due to his background with controls and electrical engineering. Aaron is in charge of the sign due to his background with human machine interface displays and controls. Eve is in charge of communications due to her electrical and computer engineering double major.

The mechanical engineering team will then be working on the housings for the sensors as well as setting them up. This part of the timeline is crucial due to having to wait on the team for further progress if more time is taken. Lastly, the computer science team will be completely designing the app based on the data received from the sensing systems. They are given from the point that communication was started till close to

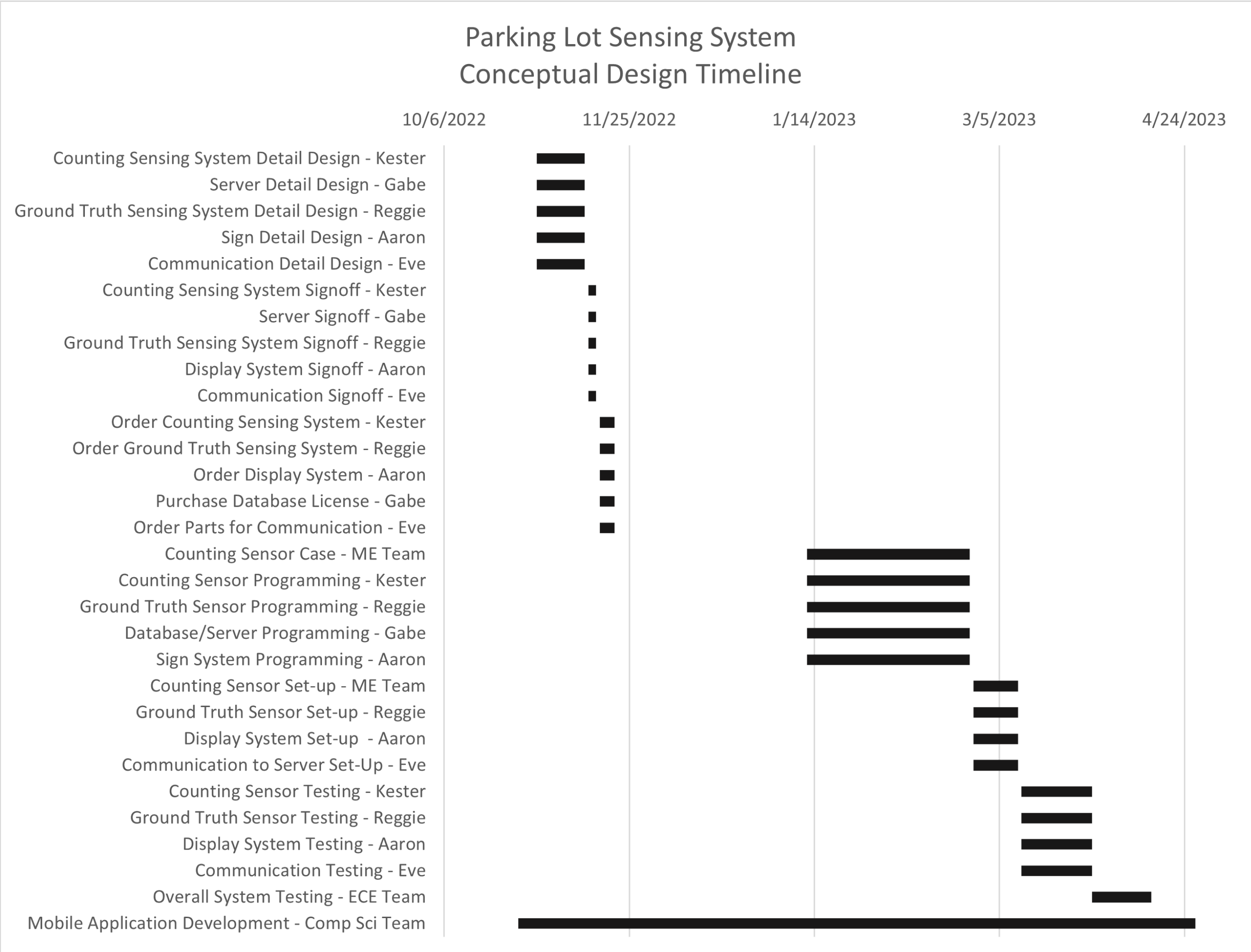

Figure 2. Conceptual Design Timeline

the end of the project to fully develop this app. Their progress will be shared with the Electrical and Computer Engineering (ECE) team, but they are a separate team nonetheless. Their progress also does not directly affect the ECE side of the project as well. It can also be seen that the entire ECE team will then be working together at the end of the project to ensure that all subsystems work together through testing. Each aspect of the Gantt chart are specifically pertaining to the design. For presentations, documentation, etc. see the project proposal timeline.

V. Conclusion

The conceptual design of the parking lot monitoring system consists of five major subsystems: counting sensors, ground truth sensors, a server, a mobile application, and a sign. Each of these major subsystems are then broken down into atomic subsystems. The conceptual design stage of the engineering process allows for the organization of system tasks and requirements to inform the detailed design in which actual technological components are designed.

References

[1] T. T. University, “Parking regulations,” Available at https://www.tntech.edu/parking/rules-and-regulations.php (2022/10/24).

[2] Time and Date, “Cookeville, tennessee, usa — sunrise, sunset, and daylength, november 2022,” Available at https://www.timeanddate.com/sun/usa/cookeville?month=11&year=2022 (2022/10/23).