Functional Specification

**Year:** 2023 **Semester:** Spring **Team:** 10 **Project:** Parking Tracking System

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Assignment Evaluation:

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| **Item** | **Score (0-5)** | **Weight** | **Points** | **Notes** |
| **Assignment-Specific Items** | | | | |
| **Functional Description** |  | x3 |  |  |
| **Theory of Operation** |  | x3 |  |  |
| **Expected Usage Case** |  | x3 |  |  |
| **Design Constraints** |  | x3 |  |  |
| **Writing-Specific Items** | | | | |
| **Spelling and Grammar** |  | x2 |  |  |
| **Formatting and Citations** |  | x1 |  |  |
| **Figures and Graphs** |  | x2 |  |  |
| **Technical Writing Style** |  | x3 |  |  |
| **Total Score** |  | | |  |

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted

General Comments:

**1.0 Functional Description**

  While student enrollment has continued to rise, a problem with Purdue’s infrastructure has been exposed: parking. With a record setting and consistently increasing 50,884 student population [1] and little to no new parking comes the increase of cars on campus. This can lead to headaches for the students, staff, and visitors that are trying to park their cars. Parking Tracking System is a project that makes parking a much more efficient process.

  It will utilize ultrasonic sonar distance sensors to detect when cars enter and exit a parking garage in order to keep track of how many spots are available to park. The amount of available spaces will then be displayed outside of the parking garage using a seven segment display to better inform the parker. This will greatly reduce the difficulties of parking at Purdue.

  The system will be configurable such that multiple entrances and exits can be monitored, and traffic through these portals can be aggregated to produce a total count of free spaces in a garage.

**2.0 Theory of Operation**

  The Parking Tracking System will consist of a main Aggregator Module (AM) along with car detector modules. The car detector modules (CDMs) are designed to be placed at each entrance/exit of the parking garage. The AM will contain the main microcontroller that will receive detection events produced by the CDMs to keep a running total of how many spots are available in the garage, display how many spots are currently available, and communicate through a cell module to upload the data online. The AM will also have an interface where an installer can configure which nearby CDMs are marked as Entrance CDMs, and which nearby CDMs are marked as Exit CDMs. The AM’s configuration interface will also be able to initialize a current occupancy and maximum occupancy, which will feed into the computation of the total remaining spots.

  The CDMs will utilize a proximity sensor to detect when something is entering or exiting the garage, as well as a wireless module to communicate the data of cars entering/exiting to the AM.

Graphical user interface, application

Description automatically generated

Figure 1: Functional Block Diagram of Parking Tracking System

**3.0 Expected Usage Case**

  The Parking Tracking System will be used in an enclosed parking garage to detect cars entering and exiting the facility. All modules of the Parking Tracking System will be installed in a way such that they are shielded from precipitation and stationary. The environment may be as cold as -20 Fahrenheit, or as warm as 120 Fahrenheit. The users of the system who are entering and exiting the garage must be able to read a seven segment display. The installers of this system must be able to follow a pairing procedure between CDMs and the AM. This pairing procedure will take place using a pin pad and display interface attached to the AM.

**4.0 Design Constraints**

**4.1 Computational Constraints**

 The Car Detection Module (CDM) must have enough compute power to process video footage, detecting a car entrance or exit before the next entry or exit event occurs. CDM compute power does not need to be able to process real time video, only segments of video marked by a proximity sensor where a car could be present in the frame. The Aggregator module must have enough compute power to acknowledge all detection events reported by CDMs such that event buffers on CDMs do not overflow.

**4.2 Electronics Constraints**

The CDM will utilize an ultrasonic proximity sensor to detect cars passing by, connected via SPI to the CDM’s microcontroller. Additionally, the CDM will have a wireless radio to report detection events. This radio will be attached to an SPI bus. The Aggregator Module (AM) will have a seven segment display module, an OLED display, and a wireless radio, all attached to an SPI bus.

**4.3 Thermal/Power Constraints**

 The AM and CDM will have different power constraints. With the AM designed to be central within the parking facility and communicating wirelessly with all other modules, it will have some flexibility in exact placement and no need to be moved. Therefore, the AM can be plugged into a wall outlet. Additionally, the AM module will have no high-power or need to drive any powerful loads; the electronics on board will only be used for communication and simple user I/O. Thus, the only power considerations will be a simple AC-DC wall converter, commonly found in today’s marketplace.

  The CDM, on the other hand, requires different power considerations due to its functionality within the larger system. Specifically, the CDMs will need to be placed along the ramp entering or exiting the garage and may need to be moved during calibration. Additionally, the sonar sensor will add some more power consumption; although not much, it will be running at all times because a car could drive by at any time. These differences result in the CDM most likely needing to be powered by a battery of some sort. Even though the possibility exists that an AC line could be run to the CDM along the ramp, it’s not as guaranteed as for the AM, and the battery pack will enable more flexibility in location. The three main components on the CDM will be the microcontroller, radar sensor, and wifi module. The microcontroller, which will most likely be from the STM32F20 family, will draw 93 mA at 3.6 V in worst case scenario . The HC-SR04 Ultrasonic Sonar Distance Sensor will draw 15 mA at 5 V. The ESP8266 wifi module will draw at most 215 mA at 3.3 V. This will result in a total power requirement of 334.8 mW + 75 mW + 709.5 mW = 1,119.3 mW. Using a RGVOTA USB Portable Charger with 38,800 mAh at 5 V output, our CDM will be powered for 173.3 hours, which is 7.2 days. While this may not be sustainable for a garage with many CDMs operating all year long, this will be plenty of power for a prototype and even during field testing after our project, especially since the battery pack can be replaced after a week, and recharged for the next use. Additionally, for large scale garage systems implementing CDMs on ramps, they can wire AC lines or set up alternative power supplies (e.g. solar cells to recharge the portable batteries).

  The thermal constraints will be similar for both the AM and CDM. Since there will only be a few electronics on both, and the packages themselves will be far away from any other electronics, heat dissipation and operating temperatures will not be a critical concern. That being said, we would not like our project boards to exceed 70 ℃. This should easily be achievable with the combination of spreading out our electronic pieces and the package being located in an environment that will hardly ever exceed 30 ℃.

**4.4 Mechanical Constraints**

 Parking Tracking System is made up of microcontrollers, ultrasonic sonar sensors, wireless communication, seven segment displays, and a keypad. It is important that the seven segment displays be large enough to be viewable by the parker. All other size and weight requirements are restricted to the ability to be mounted onto a wall or pole. All of the components are going to need to be able to withstand the temperature fluctuations of the climate. Since our system is designed for Purdue, it will have to be able to withstand temperatures around -23℉ [2], as well as around 100℉ [2]. Systems that are not monitoring a covered parking garage will also need to be able to withstand the typical weather for the respective climate. Since most of our system is designed for a covered garage, only the AM will have to deal with wind, rain, snow, and hail.

**4.5 Economic Constraints**

  The initial Parking Tracking System will cost approximately $300.00 for the single AM, as well as two car detector modules. This could be expanded into becoming more expensive when using more than two car detector modules (i.e., for a garage with more than one entrance and one exit). For testing, permission will need to be granted from Purdue to allow us to set up our prototype in the Hawkins Hall Parking Garage. The project will need to pull power from one of their electrical lines, as well as have two car detector modules set up along the entrance and exit of the garage.

**4.6 Other Constraints**

  A constraint that will also need to be taken into consideration is potential for Wi-Fi regulations to come into effect, since we will be using Wi-Fi modules as our source of communication between the Aggregator and Car Detector modules. Along with this, it also needs to be taken into account that since this project will be added ultrasonic sonar sensors to the side of the entrance and exit, it needs to be ensured that cars/bikes will still have the space they need to enter the garage.

**5.0 Sources Cited:**

[1] P. N. Service, “Purdue sets all-time student enrollment record in West Lafayette,” *Purdue University News*. [Online]. Available: https://www.purdue.edu/newsroom/releases/2022/Q3/purdue-sets-all-time-student-enrollment-record-in-west-lafayette.html#:~:text=Total%20enrollment%20by%20gender%3A%20women,enrollment%20in%20West%20Lafayette%3A%2050%2C884. [Accessed: 18-Jan-2023].

[2] Weatherbase, “West Lafayette, Indiana Köppen Climate Classification (Weatherbase),” *Weatherbase*. [Online]. Available: https://www.weatherbase.com/weather/weather-summary.php3?s=424921&cityname=West%2BLafayette%2C%2BIndiana%2C%2BUnited%2BStates%2Bof%2BAmerica. [Accessed: 18-Jan-2023].