CS 481

Project Portfolio

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# Problem Definition

Park-IT-CdA is a parking garage monitoring system located in Coeur d’Alene, Idaho at the parking garage between 3rd and 4th Avenue and along Coeur d’Alene Avenue. It is capable of detecting when a car is parked in a stall and will relay this information to a server which will monitor the parking garage’s statistics such as: time from entering the garage to finding a stall, average time a stall is occupied, average number of stalls used.

The objective of this document is to state the requirements of the Garage Sensor System (GSS). The GSS is comprised of 5 Garage Sensor Units (GSU). The GSUs will decide among themselves which is to be the Garage Sensor Master (GSM).

## Functional Requirements

**User Interface Requirements**

There are 3 categories of users of the GSS.

* Drivers – people who use the garage and park inside it. Drivers interact with the GSS when they park their car in a stall that is monitored by a GSU.
* Maintenance staff – a person who must monitor the physical condition of each GSU and clean them, change batteries as required.
* Owner – the person who owns the garage must be able to see the real time statistics of the garage.

What it should do

* The GSS is comprised of 5 GSUs.
* The GSS must periodically check and accurately detect whether a car is parked in a stall
* A Garage Sensor Unit (GSU) is assigned to a parking stall and must indicate externally with LEDs whether a stall is occupied or available
* The LEDs of the GSU must always be solid, or blink at a rate to not cause seizures. All LEDS must blink at the same time
* The GSU must use sensor(s) to determine whether a car is parked in a stall
* One GSU must be placed at the entry of the parking garage
* One GSU must be placed at the exit of the parking garage
* The GSUs must be arranged in a mesh network
* The GSUs must determine amongst themselves which will be the Garage System Master (GSM)
* The GSM must rotate on a periodic basis to conserve battery life
* The GSUs must transmit data periodically about the state of their parking stall to the GSM
* The GSUs must be synchronized to be able to send and receive the data periodically
* The GSU must operate at a speed fast enough to send and receive the data reliably
* The GSM must transmit data periodically about the status of all GSUs to the Garage Sensor Gateway (GSG) at the Innovation Den on top of the roof
* The GSG must relay this information to the server at the Innovation Den downstairs
* The server must process this data and simulate the rest of the parking garage
* The Parking Garage Simulator (PGS) must be located on the server
* The PGS must display statistics of the parking garage such as the number of and location of currently occupied stalls, number and location of available stalls, average time from entry to find a stall.

## Mechanical Requirements

The GSS consists of 5 GSUs located in the garage and a GSG at the Innovation Den.

Strength

The GSU must be capable of supporting its own weight.

Spatial

The enclosure of a GSU must fit within the following:

* Length 4 in
* Width 4 in
* Height 4 in

Or equivalent volume in cubic inches (64 in3)

Weight/Mass

The mass of the GSU must be light enough that it will not fall from its mounting point – see 5.4.

Mounting / Interface

* The GSU must be mounted to a concrete ceiling.
* The method of mounting used must not cause any permanent damage and be removeable leaving no evidence of having been there.
* The GSU must be removeable from the mounting bracket used.

Appearance

* The GSU will have a bubble-dome camera cover over it. The dome is not part of the 4”x4”x4” spatial requirement.
* The GSU must display the UofI colors – gold, silver, black, white
* The following are the primary colors used by UofI and the values used for printers, images, websites, etc.
* Pride Gold
  + Pantone 3514 C
  + CMYK 0-27-100-0
  + RGB 241-179-0
  + #F1B300
* Silver
  + CMYK 0-0-0-50
  + RGB 128-128-128
  + #808080
* White
  + CMYK 0-0-0-0
  + RGB 255-255-255
  + #FFFFFF
* Black
  + CMYK 20-20-20-100
  + RGB 25-25-25
  + #191919
* Metallic Gold
  + PMS Metallic 871

Durability

The GSU must be constructed to handle the environment that it will be located – (see section 8). A GSU must be able to last 5 years.

Reliability

Each GSU must be able to operate for 1 year continuously on one battery charge. Maintenance must be performed at the 1-year mark to clean the surface of the sensors/dome and change batteries.

## Electrical Requirements

Operational Voltage

* The GSU must be capable of running off batteries/battery packs
* During operation the voltage of the GSU must run at 3.3V to power all hardware

Operational Power Capability

During operation, the GSU must be capable of supplying enough power for all electronic components.

Energy Storage Capacity

* The batteries of the GSU must have enough capacity to run for a year
* The hardware and software must minimize power usage
* The GSU must have the ability to go into a sleep mode to conserve battery life
* The total mass of the batteries must not be so high as to compromise the mounting system

## Software Requirements

Functionality

* The software for this project will consist of the control software for the GSU and the simulation
* The GSU software must interface with the sensors to identify when a parking stall is occupied
* The GSU must be in a sleep state to conserve battery when not transmitting or detecting
* The GSU must be activated from its sleep state when a (1) sensor detects a car in its parking stall
* The GSU must use all its sensors to confirm whether the first sensor successfully detected a car or not
* The GSU must have multiple sensor activation positives to confirm that a car is parked or not
* The GSS must be able to have the time synchronized to provide consistent LED blinking
* Each GSU must be able to communicate with every other GSU in a wireless mesh network
* There must to be a priority system in place to determine which of the GSUs will be the GSM
* The GSUs must transmit its data to the GSM periodically
* The GSM must periodically transmit all the GSU data wirelessly to the GSG located at the Den
* All communication between the GSUs and the gateway must provide Integrity and Availability of the CIA triad
* The GSG at the Den will have the ability to be able to remotely reset all the GSUs.
* The simulation software must use the data received from the GSG to perform a simulation of the entire garage
* The simulation must graphically display the current state of each parking stall, the average time from when a car enters the parking garage to when it parks, the number of occupied stalls and number of available stalls

User Interface

* If time permits, an IOS or Android app will be created to provide a visual user interface for drivers of the car park
* The app must contain the same information as the PGS
* The GSU will be able to be provisioned when installing in a parking stall

## 

## Environmental Requirements

Temperature

The GSS must have full operational capabilities in a sheltered outdoor environment and run under industrial temperatures (-40 to +85 C).

Environmental Sealing

The unit is not expected to be directly exposed to rain. However, water – brought in from vehicles during wet and snowy weather, dust – from wind, oil from vehicles and smoke from vehicles is expected.

* The GSU must be waterproof and dust tight
* The external sensors of the GSU must be able to perform without maintenance for a year with any debris build up that does occur

## Regulatory Requirements

FCC Requirements

The GSS must comply with all FCC requirements when transmitting wirelessly.

## Cost Requirements

Prototype Cost

The cost to build and install 5 prototype GSUs, including test units, batteries and housings, must not exceed $1500.

## Deliverables

5 GSU’s including all hardware

Software to run them – Arduino sketches, simulation

User manual

# Project Learning

Using LoRa – Range testing at the garage, getting mesh network implementation running – Nikolai

Testing Sleep modes on Arduino – Nikolai

Solar charging – Nikolai

Testing with MKR WANS and failing – Nikolai

Getting Adafruit Feathers - Nikolai

Using Sensors – Ultrasonic and PIR, testing with the car in garage – Zane

Simulation Environment and setting it up – Tyrel

Battery research – Everyone who looked it up

Stuff we did in CS 443 that’s relevant – everyone who took it

# Project Management

## Team Members

Nikolai Tiong

Roles

* Team Leader
* Mesh network design
* Network hardware design
* Hardware Testing
* Documentation

Zane Goodrich

Roles

* Sensors for the GSUs
* External hardware design
* Hardware Testing
* Documentation

Tyrel Parker

Roles

* Simulation Software
* Hardware purchasing
* Documentation

Joel Berain

Joined Spring 2020

Roles

* Organizing the Wiki page
* Getting caught up on the project
* Documentation

## Meeting Minutes

Date: 8/27/19

Start Time: 3:30 pm

End Time: 4:45 pm

Location: Innovation Den

Present: Nikolai, Tyrel, Zane, Dr Sheldon, Dr Shovic

Agenda: Introduction to the class, what it is, what to do. Dr Sheldon is the instructor, while Dr Shovic will be the customer in this iteration of instead of Dr Shovic being both in the previous year.

Everyone talks about themselves and how they got there – an introduction to everyone in the group.

Outcomes: The project is given to us by Dr Shovic. It involves car parks like the Park My Ride project last year but this time it will be to design and build autonomous sensors in the car park that has recently been built. We need to build 3-4-5 prototype sensors in car park stalls of our choosing which must detect when a car is park – motorcycle is optional since it is a lot harder. The units must communicate with one another and then relay their information to a “gateway” in the Den. They need to run on battery for a year. There will also be a simulation that must be created which uses data from the sensors to simulate the rest of the garage. The communications will need to be done over a wireless technology and needs to be encrypted somehow. Must have at least Integrity: it wasn’t tampered with and Authentication: it came from out devices of the CIA triangle.

To Do: None

Date: 8/29/19

Start Time: 3:30 pm

End Time: 4:45 pm

Present: Nikolai, Tyrel, Zane, Dr Sheldon

Location: Innovation Den

Agenda: Dr Sheldon goes over the official overview of the class based on what students do at the Moscow campus.

There is a website <https://www.webpages.uidaho.edu/mindworks/capstone_design.htm> that hosts the document templates and presentations to go over the semester.

Dr Sheldon then introduces a PhD student Muhammed who will be able to aid should we need it.

Everyone exchanges emails so that we can start communicating outside class.

We need to now work on an abstract of the project, a calendar listing milestones, use case diagrams, context diagrams and prepare questions to interview Dr Shovic shortly so that we can get a better idea of what is required for the project. Someone also needs to record meetings.

We need to share our schedules as well to coordinate meetings outside of class.

Outcomes: First assignment has been given out, prepare to interview Dr Shovic

To Do: Abstract – Zane

Use Case Diagram – Tyrel

Calendar – Tyrel

Context Diagram – Zane

Recording Meetings – Nikolai

Interview Questions - Nikolai

Date: 9/5/19

Start Time: 3:30 pm

End Time: 4:40 pm

Present: Nikolai, Tyrel, Zane, Dr Sheldon

Location: Innovation Den

Agenda: We’ve just interviewed Dr Shovic and now Dr Sheldon wants us to explain the project to him.

We need a way to organize our documents so that we can collaborate on them.

Outcomes: Tyrel has created a Github for us to store documentation.

Continue working on the upcoming deliverable, they are due Tuesday 9/10/19.

To Do: Project Overview Document – Zane

Use Case – Zane

Context Diagram – Tyrel

Schedule of Deliverables for the project – Tyrel

Tidy up interview questions and post to Github – Nikolai

Record meeting notes and post to Github - Nikolai

Date: 9/10/19

Start Time: 1:45 pm

End Time: 2:20 pm

Present: Nikolai, Tyrel, Zane

Location: Innovation Den

Agenda: We decide to meet prior to class today to go over the diagrams that need to be turned in. Tyrel thinks his use case diagram is too simple.

Outcomes: The use case diagram is simple, but it looks like it covers everything at the level of abstraction we need. The rest of the documents look ok too.

Other things discussed:

Do the parking sensors need to be numbered 1, 2, 3, 4, 5 etc. so that the simulation knows where it is in the garage.

Types of sensors to use: IR, sound, light, motion.

How long should a sensor be active for to confirm it is occupied. What base unit to use: Arduino Nano? Zane has taken Embedded Systems (CS443), while Tyrel and I are taking it right now so we are going to get some practice using it.

To Do:

Date: 8/27/19

Start Time:

End Time:

Present:

Agenda:

Outcomes:

To Do:

Date: 8/27/19

Start Time:

End Time:

Present:

Agenda:

Outcomes:

To Do:

## Client Communications

Date: 9/5/19

Start Time: 2:30 pm

End Time: 3:20 pm

Present: Nikolai, Tyrel, Zane, Dr Shovic

Location: Innovation Den

Agenda: We’ve prepared interview questions. Have printed out copies of the questions.

Interview Dr Shovic to get a better understanding of the project requirements

Outcome: We were intending to ask the questions and record answers, but Dr Shovic decided to just take the sheet and give an entire overview of the project. Then read through the questions and answered them.

The following are the questions and answers given:

Overall Project

- Could you give us an overview of the entire project?

We need to create 5 prototype units attached to ceiling inside the garage that need to be able to sense when a car has parked and when a car has left the stall

3 level garage – not going to touch the roof

Put a unit on garage entrance to check when car enters the garage and one at exit for leaving, the remaining 3 are for stalls of our choice

Display for whether the garage is full.

Discrete event simulator – simulate the rest of the garage, create graphical simulation, real time or not? Up to us to decide.

Don’t know about monitoring cars moving through the garage, probably not

Generate the rest of the sensors in the simulation ~100 or so

Unit properties

1 year on battery – need to measure currents, Dr Shovic has some tools for this and will provide them

Maybe multiple types of sensor on the same unit – IR, photocell, sonar, motion

Must detect a car, other vehicles such as motorcycles are optional

LED connected that blinks – Red – no car, Green – car, idea is that it can be seen by cars looking to park

Mesh Network – transmits to WLAN gateway located at the Den – Sigfox, LoRa – 2.1 GHz, 833 MHz, 433 MHz

Processors – use what we like

Temperature sensor would be cool – not essential

Networking - major part – each sensor can act as the gateway for battery load balancing and in case the master one goes down – need to work it out

4”x4”x4” size approx.

Attachable to ceiling – cement or something

Arduino may be enough for this

Wonderware?

QT?

Able to reset everything

Goal – minimize people’s time and effort to find parking spot

App – optional if can be done do it

Gateway – realistic behavior – car enters, time to go to first level, second level

Tracking entrance and exit

- Title/name? Up to us

- Patent searches. Has this been done? How did they do it? It has, do some research

- Timeline for class? When are our deliverables? The entire system and hardware working for 5 units. We need to come up with milestones, design review. Get through spec phase fast so we can work on hardware and coding faster to sort out issues when implementing.

- How often do we get to meet with our customer? – didn’t answer, will be up to us to decide

- End users - who is expected to use the system? People wanting to park in the garage

- How do they interact with the system? The app

- Do we have a budget for this project? ~$3000 – sensors, gateway, server

- Which parking garage is this project being done on? How large - number of stalls and levels, is it? Believe it is the new one on 3rd street it is 3 level, we must work out the number of stalls by actually visiting the site.

- Have the stalls been selected already, or will we get to visit the garage and pick? We can pick what we want

- Will there be some advertising or advisory saying that monitoring will be going on once the sensors are installed? Research if legal

Hardware

- What base model should we use? esp8266? Something with good power down modes

- What mesh network requires less power? Bluetooth? Don’t know, we have to find out

- Does the entire garage need to be on a single brain?

- Does the brain need to be in the garage? No, it will be in the Innovation Den, do we need a bidirectional data link however? – battery level, synchronized clock, when to have them listen for transmission

- Deep sleep? Heck yes

- Need to save any data from previous time of wakefulness? Maybe/maybe not – eeprom

- How often does each unit need to report? How long does it take on average for a vehicle to enter and exit a stall? Get data. – Go on field trip and find out

- How large are the units expected to be - Will they need to be inconspicuous? 4”x4”x4”

- How do we physically secure these units? Adhesive, tape, maybe put a black dome to look like a camera

- Cost per base? Cost per satellite unit? How do we get component purchases approved? Didn’t answer this, we have a $3000 budget to work with though.

- How do we sense the vehicles? Motorcycles and cars and trucks? Accuracy? What is the definition of stall being full? Lasers cost too much power? – we must work it out ourselves

Software

- Does the data being sent from the sensors need encryption? Confidentiality, Integrity, Authentication – PKI to prevent people forging the data, hashes, CRC

Broadcasting for the sensors – how to determine which sensor gets to broadcast – wait for acknowledgement to be broadcasted? Random fallback time for collisions, number seeding, assigning a serial number to base seeding off, secret – private key, system clock, uptime

Must have Integrity and Authentication at the least

-App – IOS/Android, what is its purpose? Either, allow people to see current state of parking garage

- Will hardware, software and licensing be provided to produce the apps – IOS – need apple computer hardware for Xcode, apple store dev license, iphone/ipad to test the software.

We’ll get it all free – software, hardware didn’t mention, probably not due to the cost of istuff and our budget

- the simulation – is this going to be computationally expensive? Would want to use a PC for it

-Are there any regulations that would limit our implementation? Tools, language, hardware, software regulations that exist? Dr Shovic will obtain permission from the city. Do our own research for the rest

## Schedule

## Budget

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item** | **Quantity** | **Price** | **Total** | **Notes** |
| Adafruit Feather M0 LoRa | 5 | $34.95 | $174.75 | The Arduino we will be using |
| 6V 1W Solar Panel | 5 | $19.95 | $99.75 | For Charging the Battery |
| Solar Charger | 5 | $17.50 | $87.50 | For Charging the Battery |
| 3.8 mm/1.3mm to 5.5/2.1 cable | 5 | $1.50 | $7.50 | Connects Solar Panel to Solar Charger |
| DS3231 RTC | 5 | $13.95 | $69.75 | Clock Module to keep Arduinos in Sync |
| 3.6V 20.1Ah Li ION Battery | 5 | $92.15 | $460.75 |  |
| LoRa Gateway | 1 |  |  |  |
|  |  |  | $900.00 |  |

# Design Solution

## System Diagram

## Component Selection

## User Interface

## Description of Key Features

# Implementation

## Bill of Materials

## Manufacturing Plan

3D printer for case

Soldering as required for electronic components

Installation of gateway on roof of Den

## Engineering Drawing Package

# Design Validation

## Experiment Design

## Data Collection

## Data Analysis

## Client Acceptance

# References

## Cited Documents

University of Idaho, Color Identity,

<https://www.uidaho.edu/brand-resource-center/visual-style-guide/color-identity>

## Acronyms and Abbreviations

* Den – Innovation Den, located at 418 E Lakeside Avenue, Coeur d’Alene, ID
* GSG – Garage System Gateway
* GSM – Garage Sensor Master
* GSS – Garage Sensor System
* GSU – Garage Sensor Unit
* PGS – Parking Garage Simulator