ECE 416
Final Project Review
Team 26 - UPark
April 23rd, 2021

University of Massachusetts Amherst BE REVOLUTIONARY™

Meet the Team (Again!)

- Rehmat Kang
  - Computer Engineering
- Belma Kondi
  - Electrical Engineering
- Nikhil Sarecha
  - Computer Engineering
- Lastone Saya
  - Electrical Engineering
- Prof. Christopher Hollot
  - Faculty Advisor

University of Massachusetts Amherst

UPark - an RFID-based Smart Parking Payment System

University of Massachusetts Amherst

Problem Statement

The UMass Campus has several methods of parking payment services. These methods expect the user to either purchase a permit, carry loose change, or even install a third-party application. Overall, these different forms of payment methods make it cumbersome for the user as well as the administrator to monitor parking transactions. There exists a more convenient way with UPark.

Our Solution

We aim to solve the problem of inconsistency by introducing the use of RFID transponders, in vehicles on campus. These transponders will communicate with RFID readers at distinctive entrances and exits of parking lots across campus and charge the users accordingly. The whole parking payment process is now seamless and contactless, and managed by a centralized parking control system which allows users to track their logs.

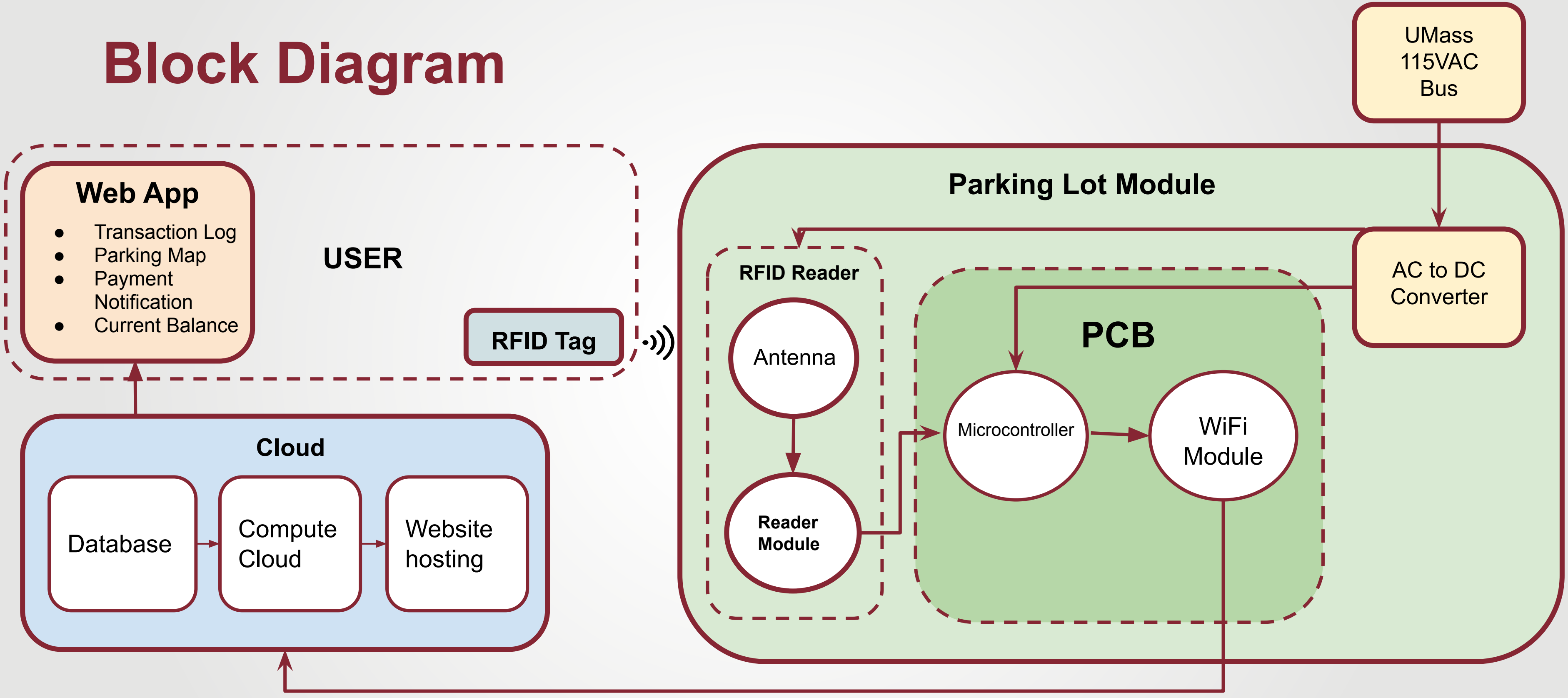
System Specifications

1. System must communicate with a centralized parking control system
2. System must automatically detect vehicles entering/exiting the parking lots with almost 100% accuracy
3. System must include a contactless payment transaction system
4. Transaction logs and vehicle activity across campus can be viewed by the administrator, UMass Parking Services, while individual user transaction logs can be viewed by the customer through a Web Application
5. System must be able to sustain extreme weather conditions between 0 ℃ and 48 ℃
6. System will draw power from the UMass 115 VAC Bus
7. As a proof-of-concept, our system will be built for parking lots with separate entry and exit points

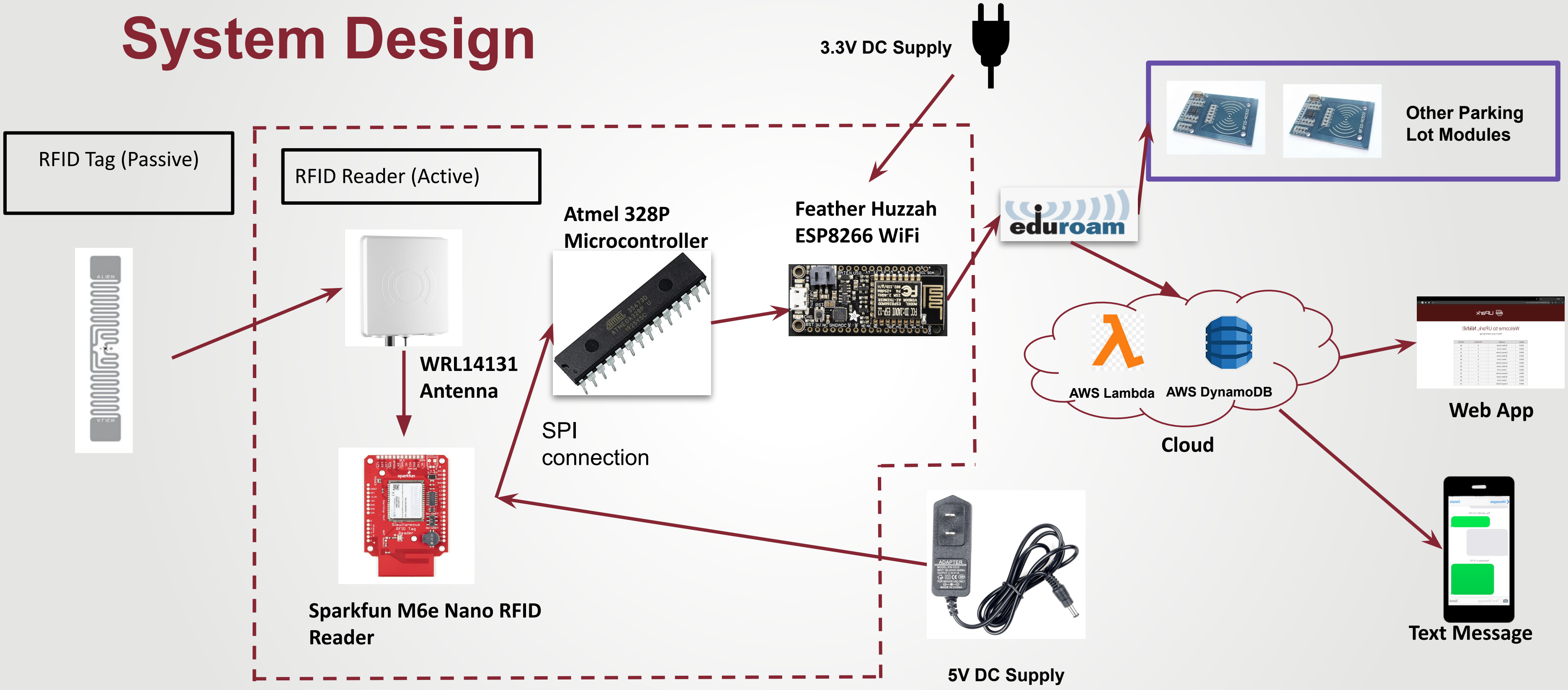
Illustration Of UPark

Represented above are the different entry and exit points of a parking lot. An RFID Reader installed at this location will detect RFID tags, embedded in the UMass Parking Stickers in vehicles entering/exiting to activate a **clock timer** accordingly, which will calculate the cost. With UPark, we aim to eliminate the need for users to stop at the entry point to generate a ticket or be required to pay for parking manually.

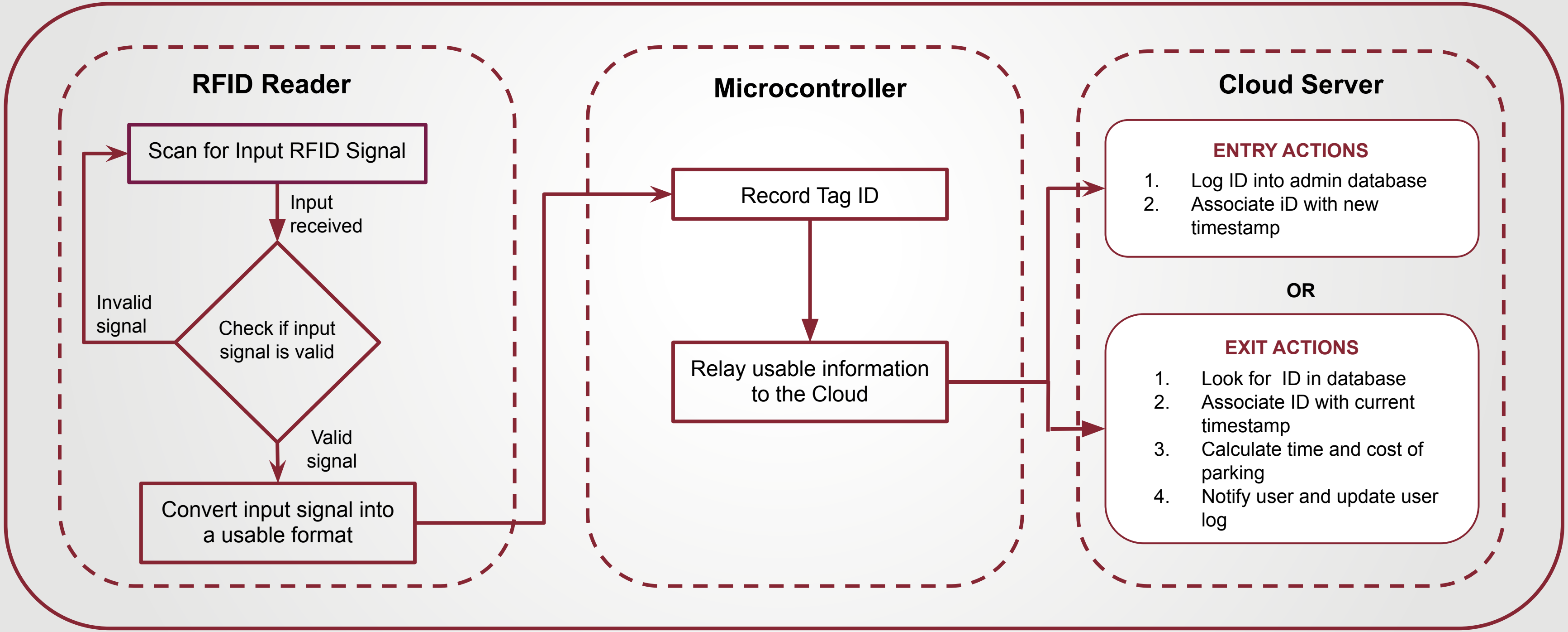
Block Diagram



System Design



Software Diagram



FPR Deliverables

- **End-to-end integration of all subcomponents to perform the entire cycle of operations for a vehicle entering and exiting a parking lot**

Delivered:

1. Prototype will be able pick up an incoming RFID signal via the RFID module
2. The RFID tag data will be sent over to the microcontroller via serial communication
3. Microcontroller will parse through the tag data and send it through the WiFi module over to the Cloud server to log into database
4. Database will determine entry or exit based on previous data log and calculate parking time and cost accordingly
5. The calculated cost will be reflected on admin database and user's GUI profile in real time

FPR Deliverables (continued)

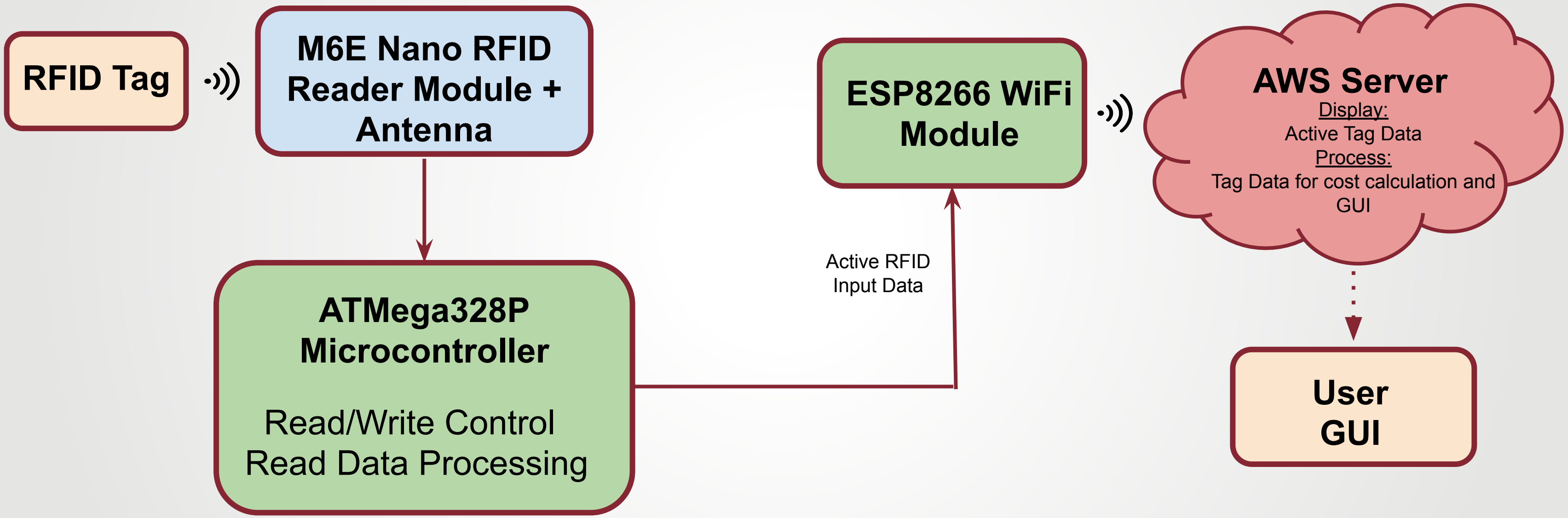
Not Delivered:

1. **Integration of PCB into final prototype**
   a. **Reason:** First PCB failed due to short circuit. Not enough time to order another PCB for FPR.
   b. **Alternate Solution:** Deployment of a protoboard housing the ATMega328P MCU

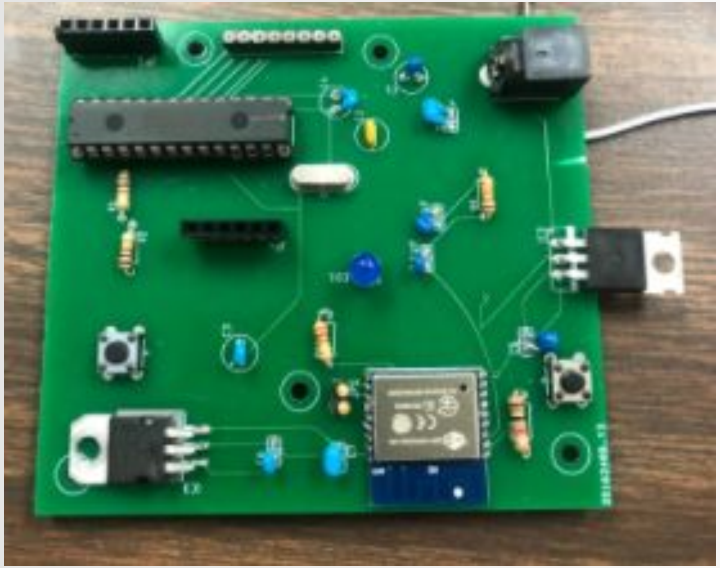
2. **Integration of WROOM-02 WiFi module into final prototype**
   a. **Reason:** Limitation of AWS libraries for bare metal firmware
   b. **Alternate Solution:** Deployment of Feather HUZZAH ESP8266 WiFi Dev Board

3. **Testing enclosure for weather resistance**
   a. **Reason:** Time constraints
   b. **Alternate Solution:** Use of off-the-shelf plastic box which gives IP65 resistance

Integrated System Demonstration



PCB



First Iteration

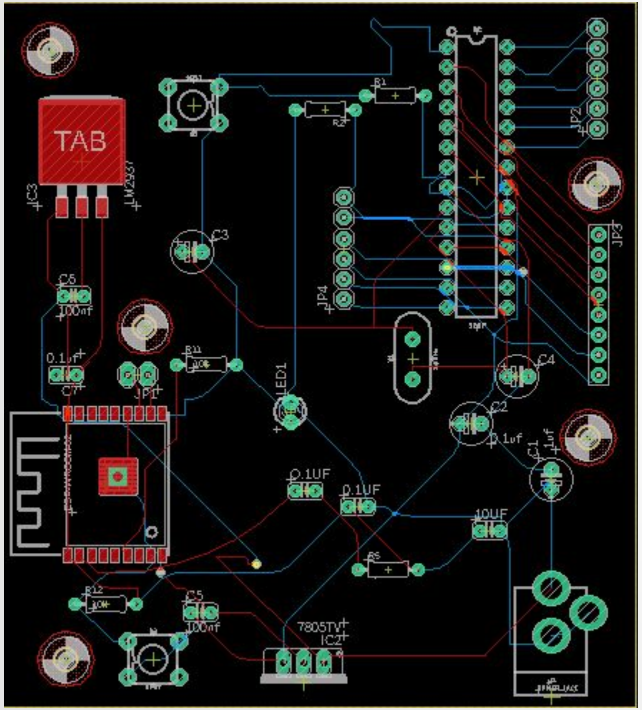
Failed due to short circuit:

- LED off when the PCB is powered
- Output voltages, Pin 19 and Pin 7 grounded

Reasons:

- PCB layout issue
- Manufacturer issue
- Voltage regulators issue

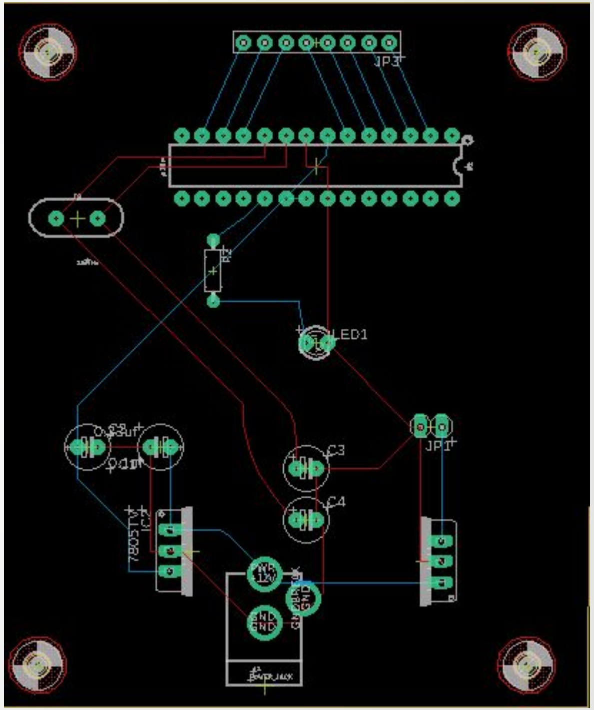
Changes Made On New PCB



- Much simpler PCB
- 2 layers
- No WiFi module
- Easier to debug
- No unused header pins

First PCB

Second PCB



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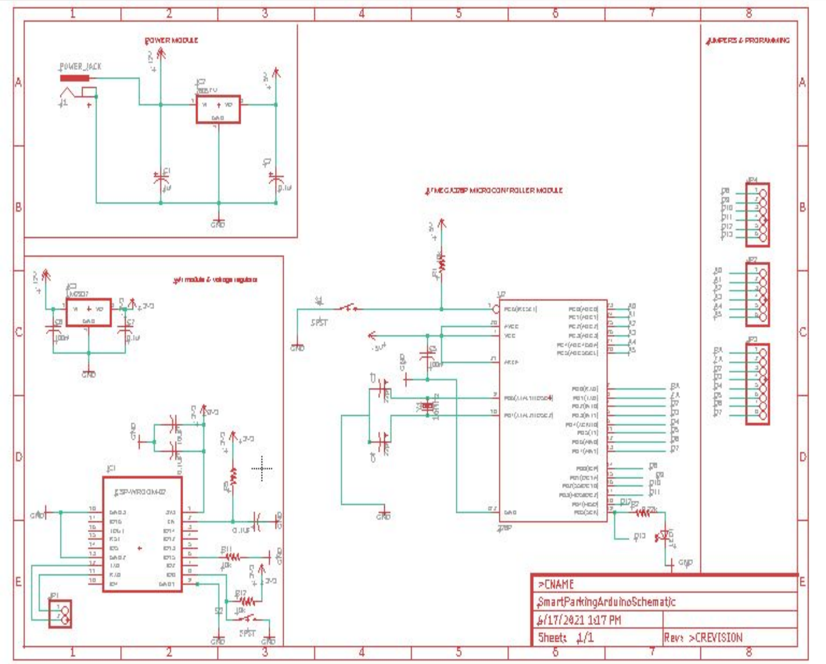
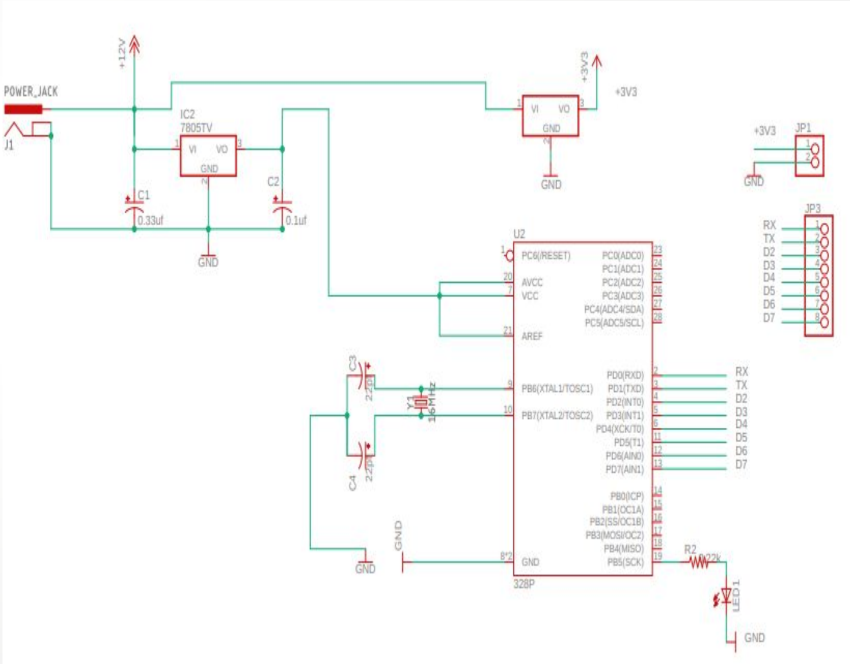
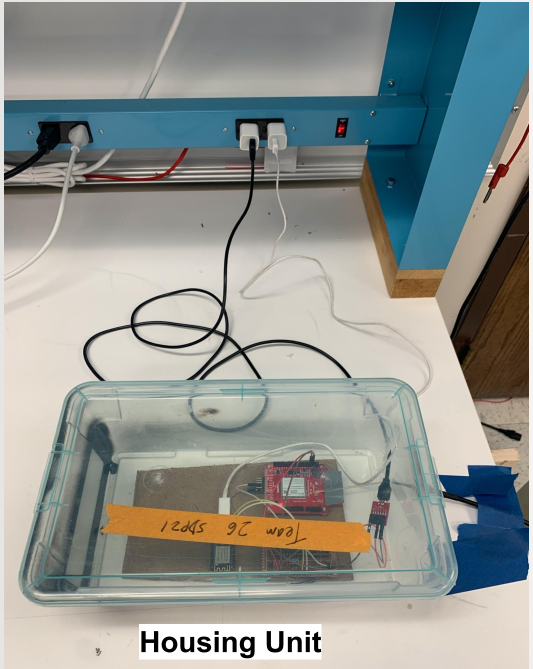
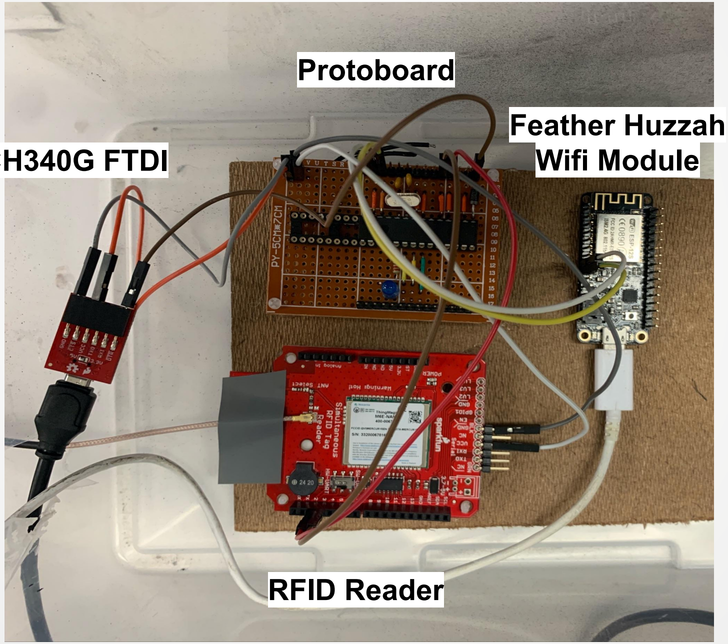
PCB Schematic (First and Second Iteration)

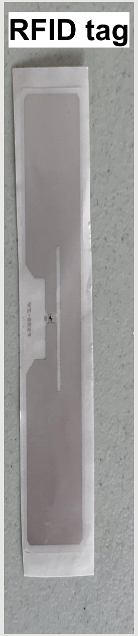




Documentation of Final Prototype







Final Project Illustration

- RFID Tag placed on the rear side window of the vehicle

FPR Demo

Video Demonstration

System Evaluation

1. System detects vehicles that enter/exit parking lots 100% accurately for an ideal read range of 3.5 ft. ✓
2. Contactless payment transactions ✓
3. Administrators have access to all vehicle activity and transaction logs ✓
4. Users have access to their own transaction logs ✓
5. Draw power from UMass 115 VAC Bus ✓
6. Sustain extreme weather conditions ✗

Design Choice

- **RFID Reader mounted at a height of 5 ft. from the ground**
  - Height of 5 ft. was chosen based on data collected on the average heights of vehicles in the US

Type of Vehicle	Lowest Height (mm.)	Highest Height (mm.)	Average Height (mm.)
City Cars	1460	1610	1535
Mini Cars	1414	1578	1496
Compact Cars	1424	1530	1477
Family Cars	1418	1575	1496.5
Executive Cars	1377	1529	1453
Luxury Cars	1294	1496	1395
Sports Cars	1116	1475	1295.5
Estate Cars	1429	1550	1489.5
MPVs	1530	1860	1695
Crossovers	1529	1679	1604
Compact SUVs	1494	1740	1617
Lareg SUVs	1623	2035	1829
Pickup Trucks	1775	1815	1795

Total Average Height (mm.)	1552.115385
Total Average Height (ft.)	5.0889029

Source: https://anewwayforward.org/average-car-length/

Experimental Data

- **Experiments performed for accuracy of RFID Tag detection**
  - Read range = distance between RFID Tag and RFID Reader Antenna in feet
- **Survey of parking lots at UMass showed 3.5 ft to be an ideal read range**
- **Read range could be amplified by supplying more current to the reader**

	Speed of Vehicle (mph)		
	5	10	15
Read Range (ft.)			
3.5	100%	100%	100%
4.5	100%	70%	40%
5.5	50%	0%	0%

Primary Responsibilities for FPR

1. **End-to-end integration to perform the entire cycle of operations for a vehicle entering and exiting a parking lot and design enclosure**
   - (Entire team)
2. **Transition from the Arduino Uno to bare-metal ATMega328P**
   - (Belma)
3. **Have PCB tested and integrated into final product**
   - (Lastone)
4. **Optimize cloud infrastructure for necessary backend processing operations**
   - (Rehmat)
5. **Complete building a functional GUI interacting dynamically with AWS**
   - (Nikhil)

Project Management: Responsibilities

- **Lastone Saya - Altium Lead**
  - RFID Reader and Microcontroller
- **Belma Kondi - Budget Lead**
  - RFID Reader and Microcontroller
- **Rehmat Kang**
  - Microcontroller and WiFi Module
- **Nikhil Sarecha - Team Coordinator**
  - Web Server and GUI

Project Expenditures

Current Expenditures	Cost
UHF Antenna	62.47
UHF RFID Tags	17
Sparkfun RFID M6e Board	224.95
Arduino Stackable Headers	1.5
Male Break Away Headers	1.95
Sparkfun Serial Basic Breakout CH340G	7.95
Interface Cable RP-SMA to U.FL	4.95
Interface Cable for RP-TNC to RP-SMA	5.95
Wall Adapter Power	5.95
Shipping	13.1
ESP-Wroom 02	18
PCB	40.13
Total	**403.9**

Thank You!

Any Questions?

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