Team Skateboard

High Level Design

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Introduction

In an increasingly interconnected world full of technology, new opportunities for wireless communication opens avenues which were previously unreachable. One of these avenues is faster, easier to use, short-distance transportation. Currently, companies like LimeBike have utilized these wireless communication technologies by allowing users to rent bicycles for short periods of time almost anywhere, revolutionizing short-distance transportation systems. Unfortunately, LimeBikes are clunky and slow, which detracts from the potential benefits of the revolutionary system. We believe that an electric skateboard can solve this problem because its faster and requires minimal effort to use, assuming the user knows how to ride a skateboard. That said, this high level design will focus primarily on the wireless communications aspect of the project, because it represents the crux of the solution and is the more difficult part to implement.

Problem Statement and Proposed Solution

The problem is that there is currently no way to quickly and conveniently travel distances which are too short for cars but too far for walking. This distance, which normally ranges from roughly one to five miles, is a common distance that needs to be traversed at universities and in urban cities. Although cars are the more common choice for these distances, parking can be tricky, and there are more efficient ways to get from point A to point B, especially when sidewalks can be factored into the equation. So, some type of small vehicle that can be locked safely when not in use is the perfect solution to the problem. That said, the vehicle needs to be able to connect to cellular towers in order to complete transactions and communicate with mobile phones. Our solution to this problem is a small microchip that has a GSM SIM card which is connected to a microprocessor that controls the locking mechanism.

System Requirements

In order for our shareable skateboard service to be successful, there are a variety of system requirements that we must first meet. Because our project is centered around the creation of a working cellular based interface between the user, board, and third party (company), we will focus the system requirements on the success of the three parts of this system rather than the actual requirements of building a working skateboard.

As previously mentioned, the root of our project relies on the interconnectivity of three different parts via a cellular network. Because this is an integral part of the project, we will begin by listing the requirements to create this network.

- We need to provide a reliable and secure way to send and receive signals from a user's cellphone to a device on the board. We also must be able to communicate from the board to the company device in order to complete the three pronged network. For this we have chosen to use the cellular network already established by companies such as AT&T, T Mobile, ect…
- Two microcontroller devices (shield and microcontroller), one pair that will act on the skateboard and one that will act as our company billing system. Both of these must be working, and they must be able to receive signals via cellular network.
- Cellphone that will act as the user interface for accessing said skateboard
- Software platform that can interact with the microcontroller on the board.
- Software that can interact with the "company" microcontroller, and register when a signal is sent to it.
- Interface to link between the two softwares we have previously mentioned: (ex: Communication ability between board software and company software)

Going more in detail into the hardware that we have chosen to build our project, we have chosen the adafruit FONA 800 shield in order to be able to receive data from the cellular network. This chip also has some hardware requirements listed below:

- 2G GSM Sim card to ensure cellular network connection
- Micro-USB cable
- GSM/Cellular Network Quad Band Antenna (3dBi)
- 500mA Lipo battery
- Wires

Another piece of hardware that will bring in some challenges for our project will be the actual device that we plan to put on the skateboard. Although this device already includes one of the Microcontrollers that we have previously mentioned, we also need to ensure that this device can not only receive a signal, but also act on that signal and flip some sort of switch (open a lock) in response to its input signal. For this device, we have chosen the adafruit Metro Mini 328 Microcontroller. This device should:

- Connect to the FONA 800 shield
- Process the input of a signal and be able to respond to it with an action of its own

Another aspect of our device will include the software that will store and process all of the signals that we will be attempting to send between our microcontrollers. Overall, we two different kinds of software. The first kind will be the microcontroller software. This piece of code should be able to :

- Communicate directly with the microcontroller and control give it instructions/record its inputs
    - Record if a signal has been received
    - Direct microcontroller to “unlock” once it has received signal
    - Communicate to Database software that signal has been received and “board is in use”
    - Maintain a steady state as it is waiting for signal to come through
- Can communicate to the Database software

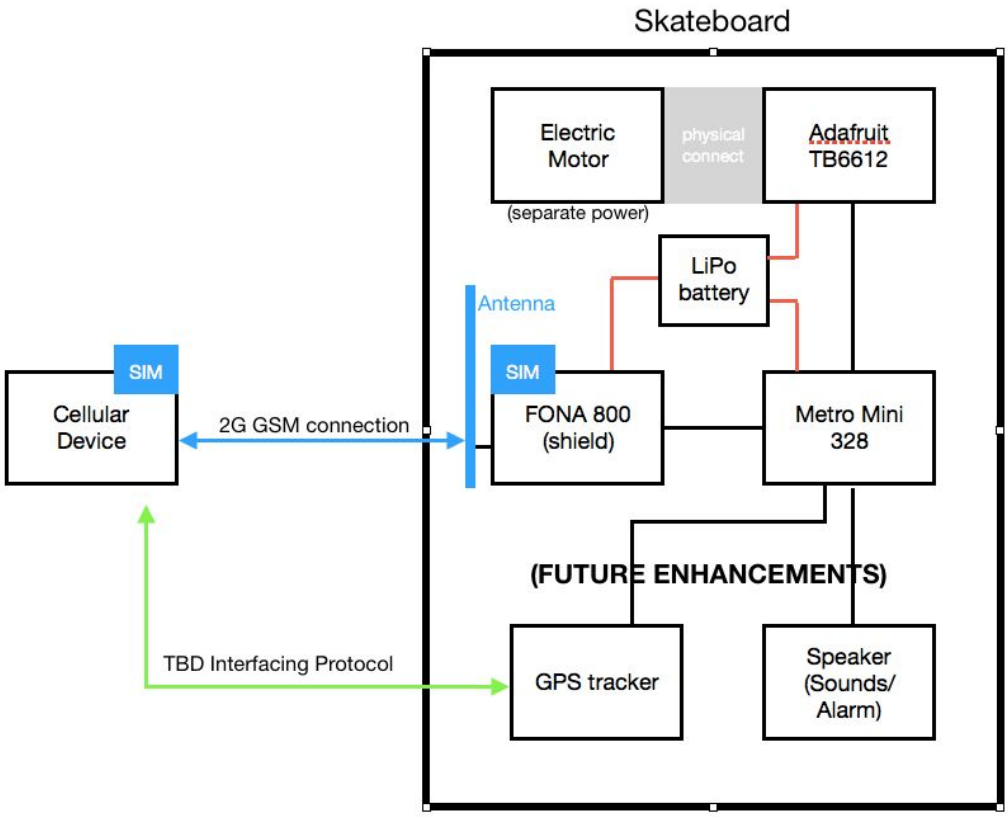
The second kind of software that we want to implement is what we refer to as our “database” software. This part of the project should:

- Maintain a record of the board microcontroller
    - Be able to comment on its status “in use” or available (aka locked or unlocked)
    - Receive a signal from the company microcontroller and be able to determine it needs a payment or not
- Communicate with both the skateboard microcontroller and the billing microcontroller

System Block Diagram

Overall System:

Diagram:



Subsystem and Interface Requirements:

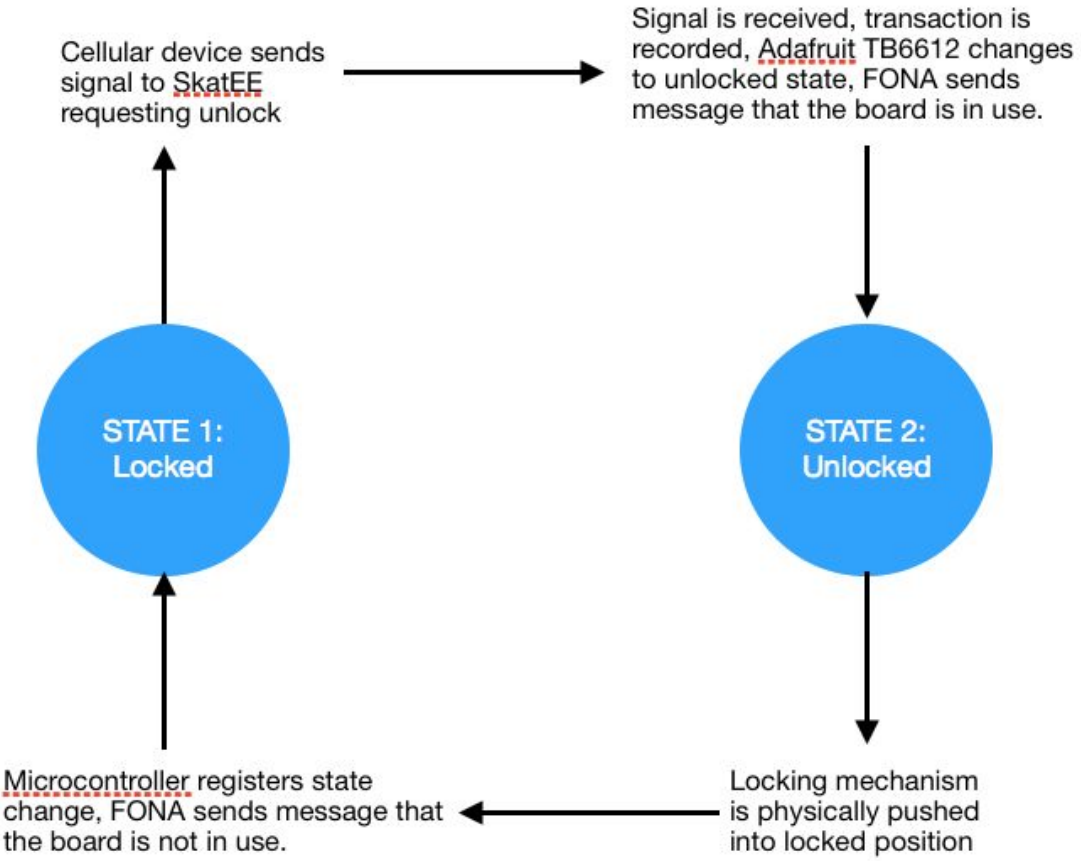
Electric motor: The skateboard that we will be building our system on top of will be a fully-functioning electric skateboard in its own right, and not directly as part of our design requirements. However, we will need to use the existing hardware in the skateboard to create a suitable locking mechanism that can be controlled by the Adafruit TB6612.

Locking mechanism (Adafruit TB6612): This system has a controlled relay that takes a signal from the microcontroller and runs a tiny motor to slide the locking mechanism into place. The locking mechanism itself will be some sort of physical object that will keep the electric motor on the skateboard from running and/or the wheels from turning. This will have two states a LOCKED mode, for when the skateboard is not in use and an UNLOCKED mode where the motor can run freely when the skateboard is in use via the SkatEE system.

Cellular communication module (FONA 800 shield): This handles the incoming and outgoing communication to send and receive signals over the 2G GSM network. It works a slave to the microcontroller, fulfilling the functions that it is told by the Metro Mini 328.

Microcontroller (Metro Mini 328): This is the microcontroller that we will program to hold the code for our device operation.

Here's a FSM diagram, describing how the Arduino code operates:



Lithium Polymer (LiPo) Battery: This gives power to all the subsystems that need it, and is rechargeable.

Future Enhancement Requirements

GPS tracker module: Connected to microcontroller, can send location information and interface with the cellular device. Unsure about power requirements, must make sure microcontroller has enough comm ports to support this feature.

External Speaker: Plays sounds at the , possibly including a sound for locking and unlocking (like the LimeBikes), or a burglar alarm when locking mechanism is forced into the unlocked without having been sent a signal from the cellular device. Must make sure the microcontroller has open comm port, and speaker is properly powered.

High Level Design Decisions

The microcontroller we will be using is on the Adafruit metro mini 328 and is called the Atmega 328. This will have the GSM FONA 800 shield attached for use of cellular services. The shield will not work without the GSM antenna. In order to write to the microcontroller we will most likely be using Putty and using the Arduino software for the rest of our coding needs.

We will be powering the microcontroller and the cellular shield with a lithium ion battery that we found in the senior design room that is the correct voltage and has reasonable capacity. A potential action later on in the project may be to order a battery that is ideally suited to our system. The microcontroller itself is being directly powered while it feeds power to the shield through the header pins. We will be able to align the clock of the FONA and the mini easily with the SoftwareSerial library provided by Arduino.

We may also need a bus bar and circuit protection hardware but these systems are dependent on what kind of electric skateboard kit we purchase and will most likely have minimal code. The only change to our current design is if that kit does not provide a motor controller of some kind in which case we would simply buy one and wire it to our mini.

Open Questions

One rather crucial unknown as of now is the operating interface from the customers end. So we know that we will be having our device usable via phone or some cellular service but whether that is an app, a website, or somehow a texting service remains unclear. Another unknown related to this issue is if we do decide to build an app whether or not we will have to enlist some third party software for billing and the financial questions this raises. Finally, I am not sure if our system can support secure billing and money transactions but we may buy another microcontroller for this purpose and to act as a database for the skateboard.

We also do not have a method of charging the board's battery or our lipo battery without disassembling the board. For our final prototype we will hopefully have figured out an elegant means of charging the battery whether that be metal contacts on the bottom of the board or a waterproof port.

Major Component Costs

The following is a table outlining the costs of the main parts that we will need in order to get our project working. This is what we currently estimate that our project will cost, and it is subject to change for we must ensure to meet the 500$ budget. Keep in mind that we are currently leaving out the costs for the assembly of our electric skateboard, since our project is more centered around the cellular network and connectivity of these IoT components rather than the actual assembly of the board. Also, we may need to order multiple pieces of each of the equipment, in order to test and ensure that we have a working product.

Major Component	Cost (in US dollars $)
Adafruit Metro Mini Microcontroller	$12.50
Adafruit FONA Mini Cellular GSM Breakout uFL Version	$39.95
Slim Sticker-type GSM/Cellular Quad-Band Antenna - 3dBi uFL	$2.95
Adafruit TB6612 1.2A DC/Stepper Motor Driver Breakout Board	$4.95
Lithium Ion Polymer Battery - 3.7v 500mA	$7.95
2g GSM SIM card	$20.00

Conclusions

In conclusion, we are extremely excited to present a potential solution for the gap that exists in modern transportation today. We realized that our passion for riding a skateboard and learning about electrical engineering do not need to be mutually exclusive, and our design project could reflect that passion. Although not everyone rides a skateboard, a working microchip that has cellular capabilities could theoretically be applied to any transportation device, so it could be applied to things which are easier to ride. Our more ambitious goal is to incorporate the electric component of the skateboard into the project, and we definitely know how to implement it. Unfortunately, this part of the project does not start us closer to the finish line, so it will be a later consideration if we are efficient and do not run into too many hurdles. Although there are indeed other ways to tackle this problem, such as electric scooters, we believe that a locking skateboard with cellular functionality is a breakthrough idea which has the potential to change the landscape of both modern transportation and IOT.