

## ***Preparing for the Future of Public Transportation with a Real-Time Application***

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**Abstract** — *The use of public transportation offers a lot of benefits to a city and to its citizens in terms of: economy, health, accessibility and manage of emergency, but some cities don't inform their citizens or tourists of the different types of public transportations available. This idea consists in the implementation of a real-time application that can inform every user of public transportation about which alternatives they have in that matter. Users will also the ability to track vehicles movements in real time to determine their location and where they are headed. This application will help users adapt their lifestyle to use public transportation to any area they go. A native iOS application was created as a prototype which uses the phones GPS receiver to track the current location of the user and the vehicles. With the prototype, a user could track public transportation vehicles at real time, locate their stations, and request a ride to a taxi. The application showed huge potential to impact the use of public transportation and also, be able to adapt to the future to include self-driven car.*

**Key Terms** — *GPS, iOS, Real-Time, Self-Driven.*

### **INTRODUCTION**

As the economy grows, the need for more transportation escalates since we need more places to go and be. Public transportation plays a huge role in the future of the economy and as citizens, we need to adapt to this movement and encourage the use of public transportation because it brings many benefits to a city and to the world. Some of the benefits public transportation offers to a city are: health, economy, accessibility and emergency response. Per example, public transportation allows reducing air pollution since the more people use it; the fewer vehicles are on the road. This helps produces 95 percent less carbon monoxide (CO), 90

percent less in volatile organic compounds (VOCs), and about half as much carbon dioxide (CO<sub>2</sub>) and nitrogen oxide (NO<sub>x</sub>), per passenger mile, as private vehicles [1]. By reducing air pollution, we can provide a city with better life quality and have lower rates of respiratory and heart disease. In terms of economy it has been proven that investing in public transportation leads to huge profit. In fact, it has been estimated that every \$10 million in capital investment in public transportation, yields \$30 million in increased business sales, and every \$10 million in operating investment in public transportation, yields \$32 million in increased business sales [2]. New jobs are available with an investment in public transportation. It is said that every \$1 billion of federal investment in the nation's transportation infrastructure, supports and creates 47,500 jobs [3]. Using public transportation lowers a person's expense, which would be used to buying, maintaining and operating cars. One of the main reasons citizens use public transportation is because of how accessible it is to go to a location they want without the need to drive or the hassle of looking for parking. That's why public transportation helps with the accessibility of a city helping people from different ages reach their location. Also, for those who don't have the means of personal transportation, being able to have public transportation is an alternative. As mentioned before, the rise of public transportation means fewer cars on the road which helps enormously with traffic congestion. The TTI report stated that public transportation services in America's most congested cities saved travelers 1.1 billion hours of added travel time [4]. Those who prefer to use their own car, will also benefit from public transportation with less traffic congestion when they are traveling. Finally, in terms of emergency response, when Americans face natural or man-made

disasters, America's public transportation system provides comfort, safety, security and rescue.

As you can see, there are a lot of benefits to public transportation, and those mentioned above are a few of them. The problem lies in cities that don't invest in public transportation or don't inform their citizen of the public transportation in the area. For tourists, it is very difficult to visit a new area and be able to move from one location to another in public transportation, because they lack the knowledge of what alternatives they have and which of those can help them reach their destination. Some popular applications like Uber or Lyft offer tourists a way to reach their destination but cities do not benefit from these private companies. We need to make public transportation as efficient as these applications. By having software that tracks all means of public transportation a city offers. This would help the citizens and tourists move from one location to another as efficiently as possible while the city is being benefited.

## **A REAL-TIME APPLICATION FOR PUBLIC TRANSPORTATION**

To help citizens know the types of public transportations a city offers and to what areas they reach, I'm proposing a real-time application that will provide real time information of all the types of public transportations available. The idea consists that if a person who has no knowledge of the city wants to go to certain place, the application will inform the person what alternatives they have in order to reach their destinations. Also, those locals who have knowledge of the city can verify the routes they take to determine if it's best to look for a bus stop or search for a train station to reach their destination. The application audience is not limited to tourists as mentioned before, it is also for those who are aware of the public transportation a city offers but don't know the routes, time and when they are working. A group of researchers surveyed users of San Francisco's Muni transit system, to learn not only about how transit users adapt to unreliability, but also, how experiences on buses

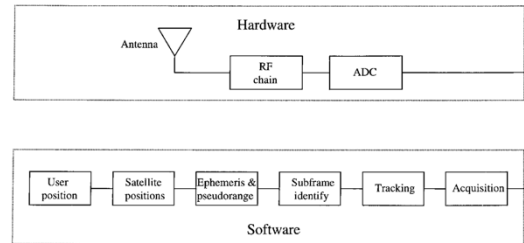
and trains influence people's long-term transportation choices. They found that passengers care about much more than just the time when the bus arrives—a factor traditionally considered influencing perceptions of reliability. Passengers care about the types of delays they endure and when in the trip, they occur [5]. Giving schedule of arrival and departure is not sufficient for a citizen to be informed. This happens because when the delay occurs once they are waiting to be picked up, they can't do anything but wait, so a key feature of the application must be to be able to track at real time all the public transportation a city offers. This will inform the user if a bus or train is working, if they are nearby or delayed. With this feature to the application, the user can decide if it's viable to use public transportation and arrive at a given time or take an alternative. The main idea is to create an application that can inform users as much as possible of public transportations. This will help them be aware of what alternatives they have, the schedule, the routes and where they are.

## **ADAPTING TO THE FUTURE**

We have mentioned some of the key features of the application, but this application must be able to adapt to the future so it can be useful. One feature the application will have is the ability to call a taxi. This means that a taxi driver could use this application to accept nearby passengers and take them to their destination. Taxi drivers have been in battle with new technology, associated with the sharing economy like Uber and Lyft due to their accessibility. Since these types of services arrived, it has been found that wage-employed drivers experienced declining earnings, which were in part offset by increases in hourly incomes among self-employed drivers. In other words, vindicate survey evidence showing that self-employed Uber drivers in the U.S. typically exhibit higher hourly earnings than their counterparts [6]. To help taxi drivers be more competitive with these services, they could use the application to offer the same service of their competition. As new technologies emerge, the

application can adapt to these changes so public transportation stays relevant and the user is aware of new changes in the public transportation of the city and how beneficial they can be.

Offering services to taxi drivers is a feature that is adapted to the present, but the application must be prepared for the changes that are coming for the future of public transportation which could be self-driving cars. Self-driving cars offer some great benefits to a city. Major companies are already testing their autonomous car and some of these companies are: Google, Nissan, Toyota and Volvo. The reason why many companies are working at it is because as mentioned before, self-driving cars offer great benefits regarding the saving of gasoline. Each year, public transportation is saving 1.4 billion gallons of gasoline, representing 4 million gallons of gasoline per day [7]. When self-driving cars appear on the market, this number is expected to decrement since self-driving cars are expected to be electrical. A shift from gasoline station to electrical energy is to be expected and this will help the environment. It's expected that self-driving cars are going to be safer since they're going to be built with sensor to monitor throughout all their surroundings, including other vehicles and traffic lights. The advantage of self-driving cars is that they can be tracked using global positioning system (GPS). A self-driving car will have a transmitter that will be in contact with a GPS satellite. Through the radio frequency (RF) chain the input signal is going to be amplified to a proper amplitude and frequency. An analog- to-digital converter (ADC) is used to digitize the output signal. In terms of the application, once the signal is digitalized, the tracking program is used to find the phase transition of the navigation data. This will be used to obtain the user position which can be calculated for the satellite positions and the pseudoranges [8]. Once the application is able to calculate these self-driving cars, a user could track them so they can monitor and use them. This way the technology can be promoted and used as much as possible.



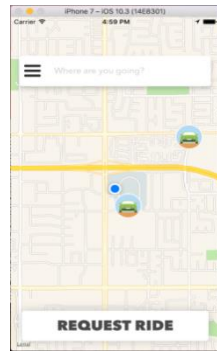
**Figure 1**  
**GPS Process for Transmitting Data**

## THE PROTOTYPE

For the prototype, I decided to create a native iOS application which is written in swift using Xcode. Also, I used Firebase which is a backend-as-a-service. A feature offered by Firebase, which was key for using it, was that it offers a real-time database. We need a real-time database to offer the most accurate information of the vehicles. With Firebase I can connect through a web socket instead of normal HTTP which makes the process of data retrieval faster. The Firebase Real-time Database is a cloud-hosted NoSQL database where data is stored as JSON objects. Another reason that I used Firebase was to implement authentication and Firebase has a built-in email & password authentication system. It also supports OAuth2 for Google, Facebook, Twitter and GitHub but for this application I decided to use email & password authentication. Finally, additional libraries were used to add functionality to the application and to communicate with Firebase. Cocoa Pods was installed for this purpose and because it manages library dependencies for the project and its dependencies are specified in a single text file called a Podfile.

The application consists of a graphical user interface (GUI) of an MKMapView which is an embeddable map interface, like the one provided by the Maps application of an iOS device. In Figure 2, we can look at the design of the Interface for the prototype, which as mentioned, consists of a map that the user utilize to see bus stops, train station and the vehicles moving at real time. Notice that the user is marked as the blue circle which indicates

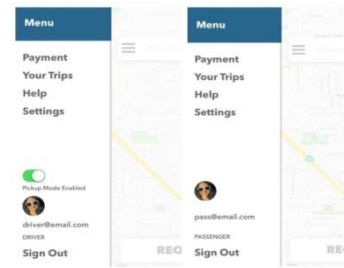
its current location and the car symbol are drivers nearby. At the upper section, the users can search for their destination which obtains its data from the map libraries for iOS. Another function in the main screen is when the user is navigating through the map a “My Location” icon appears which resets the screen to where the user is located.



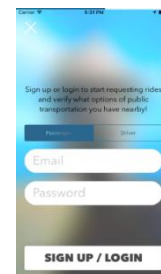
**Figure 2**  
Graphical User Interface of the Prototype

The left panel menu offers the user additional information about the public transportation and about its account. The menu can be accessed by clicking on the menu icon on the left side of the search bar. Notice in Figure 3, that there are two different left panel menus, one for a driver (left) and one for a passenger (right). The main difference is a switch which is titled “Pickup Mode” that only a driver account will have. This switch permits a driver to turn on and off the ability to receive trip request and to appear on other users maps. When the switch is off, the driver will not appear on the map of passenger accounts and this user will be able to benefit from the application as a passenger. At the bottom there is a button which is used to go to the Login/Sign up screen or to logout. The Login/Sign Up screen which is shown in Figure 4 is used for users to create a new account or to login with their existing accounts. Notice that there is a switch to determine which type of account the user wants to create or log in and, as mentioned before, depending if it’s a driver account or a passenger account, different functionalities will be available. The most important difference is that a driver can accept trip requests and the passenger can request

trips. The authentication for this application uses a valid email with a password.

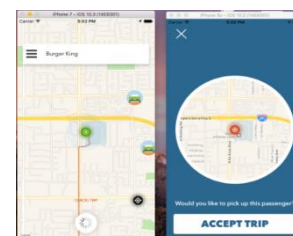


**Figure 3**  
Left Panel menu for a Driver (Left) and a Passenger (Right)



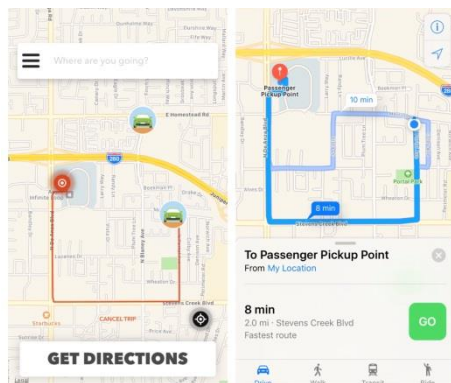
**Figure 4**  
Sign Up and Login Screen

Apart of being able to view stations and vehicles in real time, a key feature of the application, which is implemented in the prototype, is to request a ride. A passenger is able to use the search bar that was mentioned before to locate their destination. Once they choose a location, the map will show direction to their destination and the user has the option to go by themselves or request a ride. When a Ride is requested, all driver accounts that have the “Pickup Mode” enabled will receive a notification with the location of the passenger and the option to accept the trip by clicking the “Accept Trip” button or denying the request by clicking the X on the left superior corner. This event can be seen in Figure 5.



**Figure 5**  
Left: Passenger Screen Requesting Ride; Right: Driver being notified of the Request

When a trip requests is accepted by a driver, the application will generate a route for the driver from him to his passenger and a button for directions will appear, as shown in Figure 6. The “Get Directions” button will give the driver detailed direction and time estimate of the trip to its passenger which is also shown in Figure 6. Once the driver pickups the passenger the “Get Directions” button will change to a “Start Trip” button and once its clicked a new route will be drawn in the map which will lead to the passenger’s destination. Again, the button will change to the “Get Directions” button so the driver can obtain detailed directions and a time estimate to the passenger’s destination.



**Figure 6**

**Left: Route generated from Driver to Passenger; Right: Detailed Directions with Time Estimates to the Passenger**

For the case of a passenger, the button for “Request Ride” will change to “Driver Coming” when the trip is accepted by a driver, to indicate that a driver is coming. Also, the map will generate the route the driver is going to take and will show the driver on its way. The screen will adjust to fit both passenger and driver. When the passenger is picked up, the map will draw the route the driver will take to reach the passengers destination and the text of the button will change to “On Trip”. Once the passenger reaches its destination, the button will change to “End Trip” so the trip can be ended. In any time when requesting ride or on the ride, the trip can be cancelled with a cancel button that is provided when the user is on trip or requesting one. These features and functionalities of the prototype

are the basic of the application. They implement the basic idea which is to guide and inform all users about the public transportation vehicles and their stations, but it can also give directions to their destination and request rides.

## **FUTURE WORK**

For the purpose of this investigation, we were limited to testing the functionality on Cupertino which was the location that was provided by Xcode. Additional test must be done to provide support for others area on the US and outside. To track vehicles, we use the GPS receivers install on the iPhone but we need to find an alternative to be able to track vehicles without the need of a cellphone. This feature is important since the application must be able to adapt the arrival of commercially self-driven car. Study must be done to adapt the GPS receiver of those vehicles with the application. The prototype was written for iOS users but the application must be limited, a counterpart for android and google devices must be created. Finally, the application must be tested with large data set to see how efficient it is tracking multiples vehicles in real time. In terms of the software itself, some additional feature that must be implemented, are giving additional information to the user once a station or a vehicle is selected, so the user can be informed. Authentication support for social media and implementation of an online payment system that supports online money transfers and serves as an electronic alternative to traditional paper methods like checks and money orders must be added. Additional feature to improve user experience and functionality must be investigated so it can be added.

## **CONCLUSION**

Creating an application with all the information regarding the public transportation a city has to offer, will increase the interest of locals and tourists to use it. With all the benefits that public transportation has to offer, citizen are going to support the use and will be willing to learn what

alternatives they have that will make their travelling journeys much easier. An important benefit that will be of the interest of many potential and actual users is the fact that having fewer cars on the road will help the environment by not creating air pollution. They will also have a much cleared driveway since not everyone is going to be driving a personal car. The main idea is to promote the use of these types of vehicles and fortunately, the application can achieve this for all areas. With the prototype that was created, it was achievable that vehicles can be tracked using the GPS receivers of the phones. The prototype was able to track moving vehicles in real time, request ride and inform a user the route to take. When route is given to the user it will include detailed information to how to get to its destination and time estimates. Also, it has email and password authentication which is used to log in and create new accounts. All information in regard of the map is retrieve by Apple maps libraries which is used so the user can search for different destinations, obtain routes to their destination and give detailed directions. For now is only limited for iOS phones, but the goal is to be used by all types of phone.

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