SWERVE by
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A Senior Project submitted in partial fulfillment
of the requirements for the degree of Bachelor of Science in Industrial Engineering

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Abstract

Carpooling yields great benefits environmentally, socially, and economically for carpooling, however there is no easy to use, safe, and enjoyable application for people to connect with others who are both close in proximity and have schedules that match currently. By creating a database and visual mock ups, our senior project creates the basis for an application called Swerve that matches users by location and schedules and has social and economic incentives. Our research allowed us to further understand the social, environmental and economic benefits and incentives of carpooling. We also looked into current carpooling websites and applications and could not find a successful platform for carpooling that involves both matching and social profile components. Through surveys and interviews we confirmed our belief that there is a great student interest in a social carpooling application as well as gain an understanding of what users would want and need in the application. Based off of all of this knowledge we were able to build an Access database that matches drivers and passengers based off of location and schedules and a visual mock up of the application screens that show how the social matching would work.

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I. Background

Today the majority of the population in the United States is not taking advantage of the numerous benefits of carpooling. There are not only environmental benefits, but monetary and social benefits as well. The environment is suffering from the pollution that is emitted by cars each day, which is an undeniable cause of poor health in our country. Furthermore, with gas prices as high as they are, each year more and more of Americans' paychecks are being designated to get them to and from the office. Also, car maintenance is also a huge factor that goes into total cost of commute that many fail to think of. Finally, as we grow increasingly secluded and more involved in the virtual world of our phones, we are missing the valuable chance for human interaction that occurs during carpooling.

As mentioned previously, transportation is the largest single source of pollution in the United States. Unfortunately, the amount of pollution that cars emit is only increasing each year instead of improving. In 2013, transportation contributed to more than half of the carbon monoxide and nitrogen oxides, as well as a quarter of hydrocarbons in the air. Cars pollute the air so much that nearly 150 Americans, which is about one half, live in areas that do not meet federal air quality standards. There are various health risks that go along with this pollution. Air quality is directly linked to respiratory problems such as asthma and bronchitis, as well as more serious conditions such as cancer.

According to the US Energy Information Administration, the average American spends around $2,500 each year to fill their tanks. According to The Union of Concerned Scientists, most Americans are likely to spend the same amount that their car cost to buy as they do on gasoline over the span of the car's life. Over a period of 15 years, the cost of fueling one's car equates to purchasing a new one. It is no secret that every American would like to be spending that money in other places, and carpooling is the easiest way to do that. By carpooling with just one other person, Americans can easily reduce their commute spending by one half.

The social benefits that society is ignoring are also a concern for those in favor of carpooling. By opening oneself up to commuting to work or school with those that live nearby, valuable connections can be made. Due to the fact that these two people already share the common factor of working at the same office or attending the same school, the likelihood increases that a friendship can be formed. In a world of decreasing face-to-face interactions and an increase of human to computer interactions, it is crucial that we take every opportunity to make connections. A carpooling partner can offer relief in stressful traffic, and reduce the anxiety that one feels making the long drive to the office each day.

The problem that we currently plan to solve with the framework of our carpooling application is that students do not have an easy to use, safe, and enjoyable way to meet peers to carpool to campus with that is based on location proximity, schedule matches and social interests. In the future, we hope to solve the greater problem by expanding the scope to include other campuses and offices so that not only students reap the various benefits of carpooling.

II. Literature Review

Driving Factors Behind Successful Carpool Formation and Use
Authors: Buliung, Ron N., Kalina Soltys, Catherine Habel, and Ryan Lanyon. Publication year: 2009
Publication: Transportation Research Record: Journal of the Transportation Research Board 2118.1

A transportation agency of the Government of Ontario called Metrolinx based out of Toronto, Ontario obtained a program called Smart Commute in 2008 that focuses on helping commuters travel via "smarter" ways. One of these alternatives is called Carpool Zone that is a web-based application that connects potential carpoolers. Smart Commute completed a logistical regression analysis on data collected about carpool use and formation and found that accessibility to matches and other socio-demographic factors had more of an influence on carpooling than availability of carpool infrastructure, environmental and cost concerns.

This article was great in supporting our belief that social factors, i.e. meeting and connecting with fellow students, is a huge driving factor in the formation and use of students carpooling. Our senior project builds the basis to provide an easy, safe way for students to meet each other. This article and our survey show that the Cal Poly community has the potential to see an increase in carpool use with this socially based carpooling application which will yield benefits to both students and the environment.

A variable neighborhood search algorithm for the optimization of a dial-a-ride problem in a large city
Authors: Muelas, Santiago, Antonio LaTorre, and José-MaríaPeña. Link:
http://www.sciencedirect.com.ezproxy.lib.calpoly.edu/science/article/pii/S0957417413002522
Publication year: 2013
Publication: Expert Systems with Applications Volume 40 Issue 14

A study conducted at the Universidad Politécnica de Madrid proposed an algorithm that provides the optimal public transportation routes that satisfy multiple customer requests while decreasing costs while respecting constraints regarding maximum pick up time, maximum ride duration and maximum load per vehicle. They saw the need for a demand-responsive transportation system due to the traditional public transportation not being able to meet the public's ever changing public transportation needs and individual transportation services being too expensive for the public.

This article was helpful in supporting the argument that there is a need for transportation that is both flexible and low in cost. It also helped us think about what was necessary to include when creating the database and visuals that our application would use. However, the use of medium size vehicles does not pertain to our application as we are expecting the students to use their own cars that will range in size. Additionally, for our first targeted customer segment, Cal Poly students, we are assuming that all students will be either starting from a variety of locations and all going to Cal Poly or going from Cal Poly to a variety of locations. This is different from the DARP, which assumes that their customers will be traveling to different destinations.

Dynamic ridesharing: A simulation study in metro Atlanta
Authors: Agatz, Niels AH, Alan L. Erera, Martin WP Savelsbergh, and Xing Wang. Link: http://www.sciencedirect.com.ezproxy.lib.calpoly.edu/science/article/pii/S0191261511000671
Publication year: 2011
Type of publication: Transportation Research Part B: Methodological Volume 45 Issue 9

A study based out of Atlanta used optimization methods to match drivers and riders while minimize the total system vehicle miles and minimizing costs yielding personal, environmental and cost benefits. They stressed the importance of matching their customers automatically and with the ability to do so on short notice. Once the user puts in their availability, a pre-agreement is required, meaning that the driver and the rider have to agree to carpool together. They also differentiated dynamic ride-sharing from traditional carpooling in the sense that dynamic ride- sharing is for users that do not want a long term commitment of traveling to the same place, at the same times, with the same people and instead want the flexibility that comes with non- recurring arrangements. By using simulations, they were able to provide a system that allows new drivers and riders to enter and leave the system as they wish.

This article had many aspects that are applicable to our project. This article helped us think about everything to consider regarding the user's need for flexibility, pre-arrangements, decrease in travel times and decrease in overall costs.

Saving time, money and the environment - vHike a dynamic ride-sharing service for mobile devices
Author: Stach, Christoph Link:
http://ieeexplore.ieee.org.ezproxy.lib.calpoly.edu/xpls/abs_all.jsp?arnumber=5766904&tag=1
Publication year: 2011
Type of publication: Pervasive Computing and Communications Workshops (PERCOM Workshops), 2011 IEEE International Conference on.

This article discusses some of main concerns people have when it comes to carpooling. They found that most people don't carpool due to the difficulty of organizing and scheduling rides, a current lack of flexibility and safety fears. There is currently some software that provide carpooling arrangements, but the ones discussed were all for long-time, repetitive use. Regarding the safety issue, a rating system was discussed as providing a reliable source of information. In order to increase they found that switching from basing pick-ups around time, they should be organized based off of location.

Based off of the concerns they found in the community and studying what previous approaches to carpooling solutions, they came up with a list of requirements as follows: web-based, community based, privacy, trust and insurance.

This article also discussed the features and services of vHike that can be seen in Figure 1.

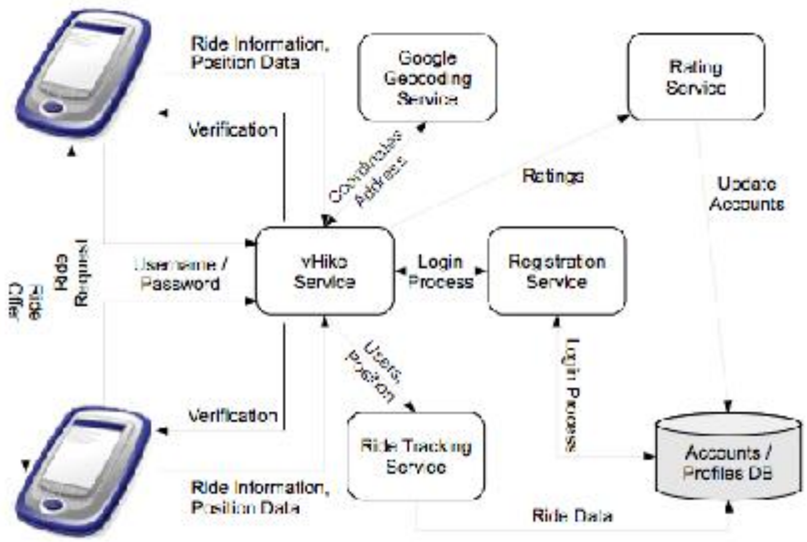

Figure 1: vHike Logic

This article was helpful for us by showing what the main concerns of our targeted customer segment are and how others have thought about fixing them in order to provide an application that students will actually use. By reviewing the design and features of the vHike application, we were able to think our how our application would be built.

Interaction, Privacy and Profiling Considerations in Local Mobile Social Software: a Prototype Agile Ride Share System

Authors: Ghelawat, Sunil, Kenneth Radke, and Margot Brereton.
Link: http://dl.acm.org.ezproxy.lib.calpoly.edu/citation.cfm?id=1952307 Publication year: 2010
Type of publication: Proceedings of the 22nd Conference of the Computer-HumanInteraction Special Interest Group of Australia on Computer-Human Interaction.

A ridesharing system created by three professors at Queensland University of Technology in Australia marries social networking with ride sharing. The most interesting find was that a simple profile where simply entering personal information is not as successful as also providing a way for users to communicate and negotiate. They found that by providing this feature in their system, a sense of community evolved virtually and more people were interested in using their system. Examples of this networking are currently found all over different social medias such as Facebook, Instagram, Snapchat and Twitter. They also found that an essential aspect of their system would be to provide a multi-platform based system and be able to be locally customizable.

For the development of their system, they used a Reflective Agile Iterative Design which consists of three main stages: development, use and reflection all while forming and reforming a continuously usable exploratory prototype. By using prototypes, they were able to study their users and their interaction with their system in order to evolve their system to be the most beneficial, efficient and easy to use system as possible. Their first prototype was available to use on any device that could use the internet in order to reach as many participants as possible, however it was at an extremely simple functionality level where users could only send and receive messages regarding ride sharing. After a month of eight users sending messages and an analysis both by looking at the messages and interviewing the users, they understood that by providing a casual way for people to talk, their users felt that they were able to personally connect and were more willing to be flexible. They also discovered the importance of providing the users with an ability to post to their own desired ride groups or all of the users. Finally, they concluded that it is extremely important to ensure that the system is secure privacy wise.

Ridesharing: The state-of-the-art and future directions
Authors:Masabumi Furuhata, Maged Dessouky, Fernando Ordonez, Marc-Etienne Brunet, Xiaoqing Wang,Sven Koenig
Link:
http://www.sciencedirect.com.ezproxy.lib.calpoly.edu/science/article/pii/S0377221712003864
Publication year: 2012
Type of publication: Transportation Research PartB-Methodological Volume: 57 Pages: 28-46 Special Issue: SI

Travelers today typically have a number of transportation modes available to go from their origins to their destinations. In selecting between these different transportation modes, travelers consider a number of criteria, such as cost, travel time, flexibility, convenience, reliability, and perception of security. With the increased adoption of smartphones and social networking tools, large scale information about mobility habits of people, can be easily documented. This lends itself to an increase in ride sharing, however, ridesharing has not increased in recent years. Specifically, ridesharing refers to a mode of transportation in which travelers share a vehicle for a trip and split travel costs. These costs include gas, toll, and parking fees. Consequently, it is crucial that these travelers have similar time schedules.

The demand for convenience is so high in current times, which people shy away from ridesharing because it can seem inconvenient. By coordinating schedules between participants, convenience is increased and adoption of ridesharing will increase. Ride- matching is a problem of optimization. Without matching itineraries, the popularity of ride-sharing will only decrease. Maximizing efficiency of vehicles routes and satisfied passengers is the key to success. Along with these keys to success, is the relevance of minimizing downsides. These include the minimal operating cost and inconvenient stops.

This article was helpful in understanding the factors that were incorporated to encourage ridesharing adoption. It explains downfalls of current ridesharing and explains where improvements need to be made. It was relevant to understand the factors that drive both failure and success in this venture.

Optimization for dynamic ride-sharing: A review

Authors: Niels Agatz, Alan Erera, Martin Savelsbergh, Xing WangLink:
http://www.sciencedirect.com.ezproxy.lib.calpoly.edu/science/article/pii/S0377221712003864
Publication year: 2012
Type of publication: European Journal of Operational Research Volume: 223 Issue: 2
Pages: 295-303

Oil supply is dwindling, and gas prices, traffic congestion, and environmental concerns continue to rise. The annual cost of congestion in the US in terms of lost hours and wasted fuel was estimated to be $78 billion in 2007 and personal car usage is the leading cause of increased carbon dioxide emissions. These issues have sparked the interest in services and products that help people to use personal cars more efficiently. The demand for ridesharing servers has increased in recent years because of all the increases in costs associated with driving one’s own personal car wherever they need to go. Rideshare providers around the world are looking to capitalize on this shift of thought, whether it be for recurring commutes or one time trips. Some companies have even implemented incentives such as restaurant coupons or gift certificates for frequent users.

Effective usage of empty car seats by ride-sharing could substantially increase the efficiency of urban transportation systems. Along with this, reducing traffic congestion, fuel consumption, and pollution. This study focuses on defining objectives for ridesharing. Some of these being that users are looking to save travel expenses when ride-sharing. This means that ridesharing will save users money, making them more mobile by matching users and drivers on short notice. Constraints are also discussed and heavily defined in this article. The most important constraint is the timing of rides. Users are always looking to save time by matching drivers are users that are close by and looking to take a similar route, the most time is saved. Users also want a choice to select their driver or passenger. It makes the process not only more enjoyable, but increases safety. The three key points that this article makes when discussing the factors a successful ridesharing system would need for widespread adoption are optimization, incentives, and choice.

This article was helpful in terms of defining why the idea of ridesharing is important and the impact it can have on our world today. We are wasting valuable resources because we have not all found a way to easily and quickly share safe rides. This article brings up the point of choice, which is a huge factor in if people will adopt a new practice. Everyone wants to feel that they have choices at their disposal. It also discusses constraints and how they can be implemented, which was helpful to our understanding of the system.

A model and a solution algorithm for the car-pooling problem withpre-matching information

Authors: Shangyao Yan, Chun-YingChen Link:
http://www.sciencedirect.com.ezproxy.lib.calpoly.edu/science/article/pii/S0360835211001070
Publication year: 2011
Type of publication: Computers & Industrial Engineering

Volume: 61 Issue: 3 Pages: 512-524

Pre-matching information, including carpool partners and their route have rarely previously been considered. Because of this, a model has not been developed for solving a practical many to many carpooling problems. Sometimes carpooling is considered a person looking for an on demand ride, but ignores creating solutions for people looking for consistent rides to and from the same places. This study divides carpooling into two main types of practice: those without pre-matching information, and those with pre-matching information. Pre-matching information is categorized in several types. One of these is a carpool member group. In this case a carpool member can request to share the same trip with his or her friends, in which case they are treated as a group. Another type of categorization is by user characteristic. These four types are dependent on sex and smoking status: non-smoking female, smoking female, non-smoking male and smoking male. Finally, pre-matching information can rely on the vehicle type that the user is looking for transportation in.

This article was helpful in understanding other types of pre-matching data. While we did match by class schedule, this article makes it clear that other types of data can be used for matching carpools in the general public. It keys in on why matching people allows for better carpooling and the benefits that are achieved by pre-matching based off of the database we built.

Investigating ride sharing opportunities through mobility data analysis

Authors: Nicola Bicocchi, Marco MameiLink:
http://www.sciencedirect.com.ezproxy.lib.calpoly.edu/science/article/pii/S1574119214000868
Publication year: 2014
Type of publication: Pervasive and Mobile Computing Volume: 14 Pages: 83-94 Special Issue: SI

Smart phones and social networking tools allow for simple collection of data about the mobility habits of most people through GPS. In this study, the goal is to use this data to support sharing and coordination of mobility by integrating a recommendation system into smartphones, tablets, and vehicles for convenient ride sharing.

The world has suffered an ecological toll because travel has expanded and become such a great part of daily life. In response to this, improvements are needed in vehicle to vehicle coordination. This work looks to collect mobility information, identify routine behaviors via smartphone data, identify sharing opportunities between users, and recommend mobility alternatives. The key difference between this work and many ridesharing systems today is that this work determines the system should be fully autonomous. Users do not enter their needs and availabilities explicitly, because users are busy and have many reasons to not take the time to do so. Instead, sharing opportunities are automatically identified by analyzing people's travel patterns and the user is noticed when suitable conditions arise. This hands off proactive approach could improve effectiveness because of its unobtrusive and simple to use nature.

The first step is to identify the places most visited by the user by clustering location traces to hypothesize about what places are relevant to the user. Routes would be identified and labeled.

An algorithm would be set where each routine that is typically followed by a user on some days of the week can be factored in as coordinates of the travel source, destination, and time of day. The algorithm selects all the routes performed by users on select days and notes the method of transition. The algorithm then scans for all possible transitions that match the route and suggests possibilities.

This work was helpful in getting our minds to think out of the box about how users like to adopt new applications. The fact that this work suggests that a fully automated suggestion should be given to the users is interesting and was helpful in building our project.

Towards privacy-driven design of a dynamic carpooling system

Authors: Jesus Friginal, Sebastien Gambs, Jeremie Guiochet, Marc-Olivier KillijianLink:

http://www.sciencedirect.com.ezproxy.lib.calpoly.edu/science/article/pii/S1574119214000856
Publication year: 2014
Type of publication:Pervasive and Mobile Computing Volume: 14 Pages: 71-82 Special Issue: SI

Dynamic carpooling is known as a service that arranges a single time, shared ride on short notice. This new type of carpooling relies on navigation devices to determine a driver's route and arrange the ride. Smartphones are used for the traveler to request a ride and social networks are in place to establish trust between drivers and passengers. However, dynamic carpooling raises many safety and privacy concerns that cannot be ignored. First of all, personal information that can be used to identify users is exchanged in this system. Data regarding where an individual is traveling on a regular basis can be used to track his habits, to find information about his interests, and to detect changes from his normal behavior.

Dynamic approaches to carpooling require a major exchange of data between the passenger and driver, increasing the risk that attackers can find private information of both participants. The recent advancements in carpooling applications has exposed the privacy drawbacks. The fact that collection of personal data can be harvested and used against users and drivers during the ride or in the future, is a huge threat. The problem becomes increasingly overwhelming when messages are exchanged across a dynamic carpooling application where attackers are equipped to hack the wireless medium.

This study was helpful to our project because it was one of the most notable concerns regarding privacy we came across in our research. Privacy was not compromised in our project, because safety goes along with that. This article helped us realize the importance of creating the basis of our application that maintains privacy for Cal Poly students.

III. Application Research

UberPop

Link: http://www.rudebaguette.com/2014/02/04/uberpop/

On February 5, 2014 Uber launched a peer-to-peer ride-sharing service Paris. The service reduces ride costs in comparison to UberX by 50%. The service allows for individuals to register their own car and sharing rides with other users. This is a change from the original use of Uber by allowing users to contact other users directly, instead of a taxi like system where drivers are employed by Uber.

Carticipate

Link: http://www.carticipate.com/Home.html

Carticipate was founded in 2008 and is a location based based social network for ride-sharing. First, users get on Carticipate to post where they are going and when. The website then connects you to other other users who have expressed the same travel agenda. However, there are some glitches with the system, such as a bug with the time picker so users are required to schedule their rides at least 8 hours in advance. There is also an issue with entering users entering their phone numbers. A "+" and their country code is required before the number. Although the website has been around for 7 years, it has not taken off. This is likely due to to inflexibility that users feel when they are required to plan all trips over 8 hours in advance. Although some have caught on to Carticipate, we recognize the value users see in scheduling flexibility.

Carma

Link: https://carmacarpool.com

Carma works my matching users with nearby people who want to share trips. Users can look through profiles, send messages and invite friends to join Carma as well. The main feature of this Android and iPhone application is that the cost of the drive is shared. For distances 0 to 1 miles it costs the users $1, from 1 mile to 15 miles it costs $0.20, and for 15 miles and above it costs $0.08. Drivers register with Carma and are paid 85% of the trip fee. The other 15% of the payments goes to Carma. All payments are made through the application on your profile.

Zimride

Link: https://www.zimride.com

Users who wish to use this ride-sharing application sign up for free through their Facebook account, which creates a profile for them on a website. However, only people who go to certain universities or work for certain businesses can sign up for Zimride. The founder of Zimride felt that the main reason carpooling has failed so far was because of people not trusting strangers with their safety and comfort. By only allowing users who work for the same company or go to the same school to connect with each other, that fear is eliminated. This is a concept that we have agree with wholeheartedly and are incorporating into our senior project.

On top of eliminating distrust, the automatic profile allows for users to gain a deeper understanding and connection with other users in their community. Additional information can be added to a user's profile such as music and smoking preferences. The system uses an algorithm that accounts for the distance to pick someone up and the time for detouring to a passenger drop-off point. The site then ranks the options and assigns a score to the best matches. The drivers decide on their own what to charge their passengers. Zimride is quite successful and has over 350,000 registered users today and has saved over $50 million in vehicle operation expenses.

Flinc

Link: https://play.google.com/store/apps/details?id=org.flinc.app&hl=en

Similar to Zimride, Flinc incorporates a social aspect intro ridesharing. It is designed with smartphones and social networks in mind. It was launched for trial in Germany in 2010 for android phones with the intention of making ridesharing easy in order to avoid pricey cab fares. With this application, those seeking a ride can just put in an order at their GPS location. Then these orders are sent out to drivers. Drivers can easily accept or reject the opportunity for pickup from their phones. A ratings system is included in the customer order so they can define their preferences when placing their order. The most suited drivers will get the order first and if they reject it, the order will continue down the line. Drivers and passengers both rate the service at the end of the trip, and drivers are paid directly through the Flinc smartphone application.

The College Carpool

Link: http://thecollegecarpool.com

If a user is a student at one of about thirty colleges in the US, he or she can register online for The College Carpool. When registering, the user is initially prompted to add their college information. Once the user is logged in, they can access their school's "travel board" where other users have posted ride requests. Drivers are free to accept whichever of these ride requests they would like, as well as decide the rate they will charge their passengers.

This site also provides the opportunity for users to post about other travel opportunities. For example, if a student has purchased a train ticket, but is no longer able to make that ticket, they can post on their school's travel board and see if there are any other users who are would like to purchase this ticket part or pull price. The College Carpool looks to open a free forum where students feel comfortable to communicate about transportation. Although it is less complex than other carpooling applications, it is one interesting solution to college students need for ridesharing.

Wheelie

Link: https://wheelie.me

With Wheelie, users use the website to build a profile that can also be linked up to their Facebook and Twitter accounts. This feature allows users to feel more trusting of fellow users and keep in touch with users you liked. Wheelie has also provided some general safety tips that they hope their users will use. Wheelie is more reliant on the social profiling aspect of their website, and less on speed or monetary savings. They look to draw users in by having users connect with each other. Although the website is not necessarily quicker or more cost efficient, users are beginning to flock to it with the hopes of finding a n enjoyable carpool companion.

The current version that is up is their minimal version prototype to see how their users are interacting with them website and themselves. So far they have over a thousand users and over five hundred trips created.

Bandwagon

Link:
http://www.nj.com/news/index.ssf/2015/04/newark_airport_climbs_on_the_bandwagon_taxi_sharing_app.html

Bandwagon is an environmentally friendly rideshare app that achieves success by saving fuel and wasted space in taxis. The app pairs individual riders getting taxis who are going in the same direction. To use the application, users enter where they would like to go, browse available seats, and book their ride. Before booking, users can see prices and pick up times so they have the ability to know the fare beforehand. Bandwagon also has a feature in which users can schedule trips ahead of time, often at a reduced price.

Sidecar

Link: https://www.side.cr

With Sidecar, anyone can be a driver. Drivers choose their rates, which are posted for users to see. Along with fare rates, passengers can view a small bio, picture, and ratings. When users go to book a ride, they can pick and choose the ride experience they are looking for based off of several criteria. All possible rides show the quality of the vehicle, driver rating, estimated pickup time and amenities offered. By giving users more control of the style and options of their ride, they make passengers feel comfortable, and therefore more inclined to ride with Sidecar.

Hitch

Link: http://www.takehitch.com

Hitch is a ridesharing app that uses logistics to not only match passengers with a driver, but with other passengers. The interface is very similar to Uber and Lyft; users request a ride and the car comes to pick you up. However, the key difference is that by filling all seats in the car, the cost is much lower.

The way that sharing the car with others works is that instead of users telling the app where to be picked up, they tell it where they are looking to be dropped off and the app uses GPS to find the start point. The app also asks how many riders are in that user's' party and gives an up front cost estimate. If another user nearby has requested a ride at the same time along the route, the app will book the ride for both. Hitch then brings in a social aspect by allowing users to learn more about who they are sharing a ride with by showing each other’s mutual Facebook friends and likes so they have topics to talk about. At the end of the ride, passengers rate the driver and each other so that the app to collect data about which users are best suited to ride together.

IV. Methodology

Due to this project being a unique and never done before idea, our methodology and project schedule was crucial to the success of our project. The first step was to clearly define our objectives and deliverables so that we had a clear vision on what we wanted to produce. Our objectives were to provide the database that would fulfill the need of Cal Poly students to carpool to campus at the times they have class and to create the visual interface that allows students to safely get to know each other through profile matching. The deliverables were a functional database and a complete set of visuals. The next step was to research both scholarly articles and current technology to gain a better understanding of what we need to consider when building the framework of our application. We also conducted multiple rounds of surveys and interviews to zone in on what our customers need and want. Once we analyzed the results of our research and survey, we outlined exactly how we wanted our Access database to run and they flow and design of all of the visual screens. We also set weekly goals in order to ensure that the visuals and the database would be built, tested and revised in a timely manner. As we built the database we constantly tested the tables, queries and forms to ensure everything was running smoothly. There were two rounds our creating the visual screens. In the first round we used everything we learned from the research, surveys and interviews to create a prototype mock up that included all of the features we thought the users would want and need. We then conducted surveys with multiple Cal Poly students where we explained the concept of our application and had the students go through the screens and make comments on what they thought of the flow, design and features and asked them if there was any additional features they would like to see. Based off of their answers, we went back and modified the visual mock ups to create a final version of the visual mock up.

V. Visual Mockup

A. Design

Phase one of designing the visual mockup was based of an analysis of our survey results and human computer interface methods. The survey consisted of questions that were not only targeted to help us decide how the logic of the application would work, but also the interface. Both literature reviews and additional research went into further analyzing the best human computer interface methods and how our target audience would respond to certain screen layouts, color choices, and logic flow.

Our survey results were obtained from over one hundred Cal Poly students and gave a great deal of insight into the visual aspect of the project. One of the initial questions that was the most beneficial was why that student would be hesitant about carpooling with others. About 80% of students answered that they would not feel comfortable riding with others that they do not know. This fed into a question that asked if they would be more likely to carpool if they could select people from profiles that let them see information about their potential carpool matches. Over 80% of students answered that this would indeed sway them to carpool. This initial data led to the big picture design of the visual mock up, which was that the app would be functional but also, intentionally social. With the need for a social aspect solidified, the visual design was decidedly centered on profiles and the optimal way to present matches.

One of the most insightful questions was what information students would like to be included in the profiles. The results were as followed: 85% of students felt it was important that a picture was included, 60% wanted to know each other's' birthdays and hometowns, and 57% wanted major to be included. It was also interesting to see that 45% of students wanted to know each other's smoking habits and 35% wanted to be able to see what hobbies or clubs, and organizations the other user is affiliated with. Surprisingly, only 18% of students felt that music taste would weigh in on their decision. The questions greatly impacted the design of the application. It was determined that the profile and the ability to express specific profile elements was highly desired by students, there fore those were incorporated into the design.

The key principle of human computer interaction that was employed in the visual mockup was learnability. Learnability is the ease with which new users can begin effective interaction and achieve maximal performance. Factors that make an interface learnable are predictability, synthesizability, familiarity, and generalizability. Predictability is considered the support for the user to determine the effect of future actions based on past actions on the interface. For example, predictability is key when using terminology, color, and shape of buttons on each screen. In Swerve, users can locate the "next" button and instantly predict that it will also say "next" on the same screen in the same colors, font, and format, making it effortless to learn. Synthesizability is when the user can tell why they have arrived based on past operations that have led them to that interface. This means that the screens flow in a way that the user understands how to navigate, which was a key component to Swerve. Familiarity is the extent to which a user's experience in either the real world or other computer domains can be useful when interacting with the new system. For example, most users are familiar with entering in their credit card information in a certain order and format. By employing familiarity and keeping this screen similar to what one would expect, we ensured that the user is likely to learn how to navigate more quickly. Finally, generalizability is considered support for the user to extend specific knowledge from application to application. An example of an application that users will generalize with Swerve is Tinder. By using Tinder, users have become familiar with the opportunity to see a small profile with pertinent information about someone and quickly decide yes or no if they would like to start a conversation with that person. Similarly, in Swerve users would be able to quickly decide if they would or would not like to match to carpool with another user and message them to coordinate ridesharing. All of the aforementioned data and principles were the basis used to design the visual design mock up. The first screens of Swerve are kept clean (Figure 1, 2, and 3).

Figure 2: Welcome Screen

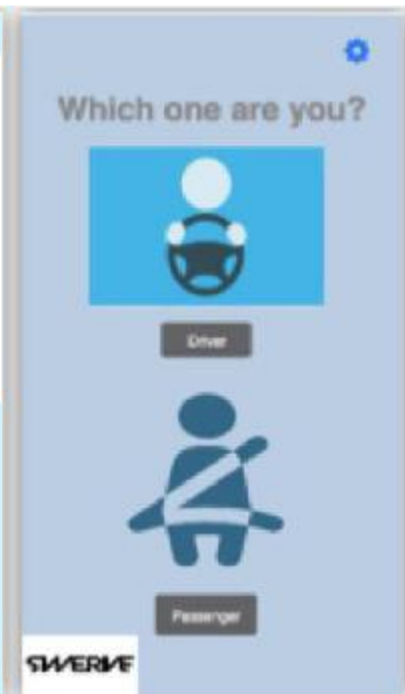

Figure 3: Driver or Passenger Screen

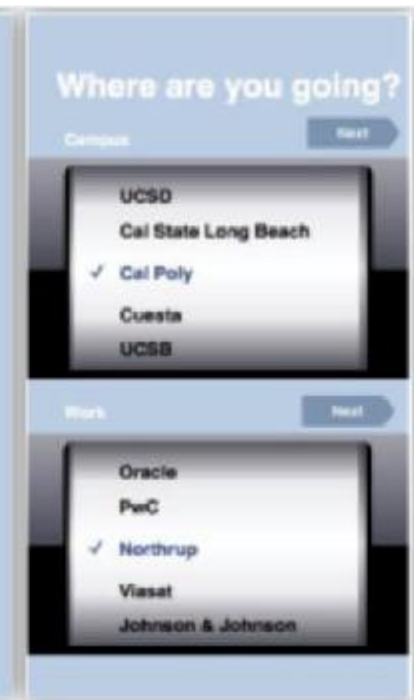

Figure 4: Location Screen

The first page is vibrant and allows the user to familiarize themselves with the application's layout and color scheme. On these screen users are prompted to either register for an account or login if they are an existing user. If they are registering, they are taken to the second screen where they are asked if they would like to sign up as a driver or a passenger. Next, they are taken to a screen where they are asked to select the campus or workplace they will be carpooling to.

The next screen the user is taken to is create their profile screen, seen in Figure 5. On this screen the new user must upload a photo, input their address, birthday, hometown, major, and any club, sport, or Greek affiliations they would like to include. Finally, an optional short description is included. Based on the survey, these criteria were crucial to Cal Poly students in determining whether they would like to carpool with each other.

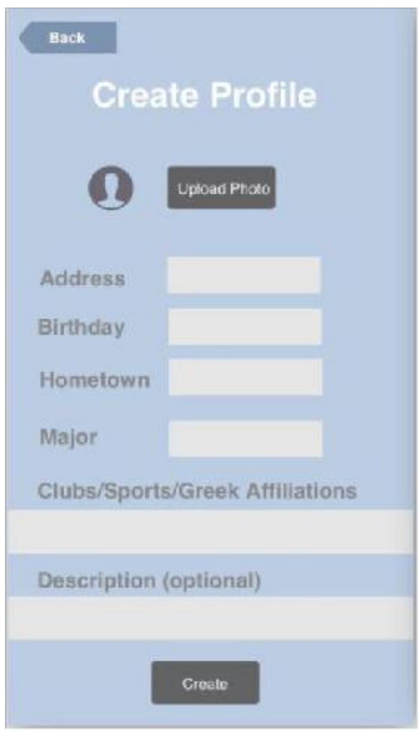

Figure 5: Create Profile Screen

Next, drivers are asked to input their schedules so that they can be matched with passengers looking for rides at the same time (Figure 6).

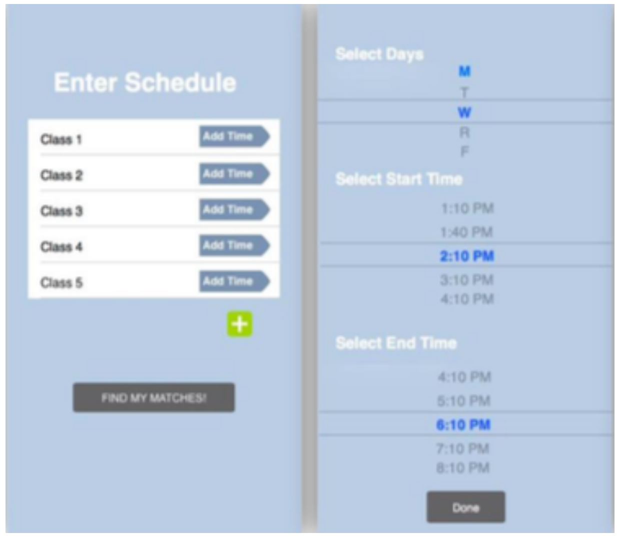

Figure 6: Driver Class Schedule Screens

Passengers are prompted to select if they would like to carpool to or from campus. After entering in the time that they are looking to rideshare at, both drivers and passengers click to find their matches (Figure 7).

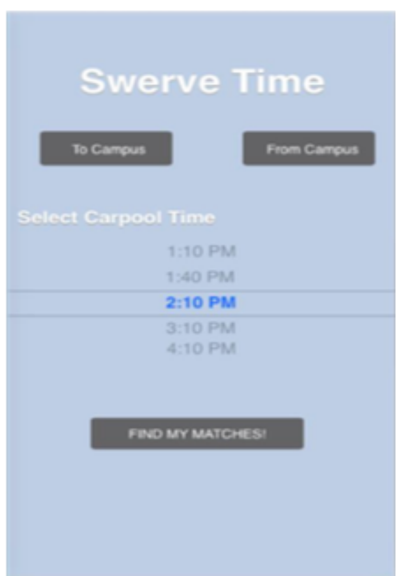

Figure 7: Passenger Time Screen

Users are then presented with their matches (Figure 8). For drivers and passengers this screen shows all of the matches that are looking to carpool at the same time that they have signed up for. They can each see each other's user names, photos, and a short profile description. By clicking on the user's bolded name, they can view each other's complete profiles, other than address, and can click on the blue message icon if they would like to arrange carpooling with that user. If both the passenger and the driver have clicked on the blue message icon on each other, they are notified that they are a match, and their phone numbers become visible to each other in the description area.

Figure 8: Original Matching Screen

B. Testing

After surveying responses to our original design, feedback was positive. However, there were some small adjustments and new features that were introduced as a result of the testing.

If the user had registered as a passenger, it was decided that they should be taken to a screen where they could enter payment information (Figure 9). Responses to our design were that some drivers would be encouraged to use the application if they were to receive compensation for their efforts. While some drivers found that they would like to carpool just for the social benefits, a significant number of students responded that they would like the option of matching with passengers that are willing to pay for rides. Students did not want the payment to be as large as ride services such as Uber or Lyft, but instead just a small payment so that the driver could accrue enough to pay off their parking permit over the course of the quarter. Although, since not all drivers found payment to be important, it was decided that the passenger payment information screen was optional.

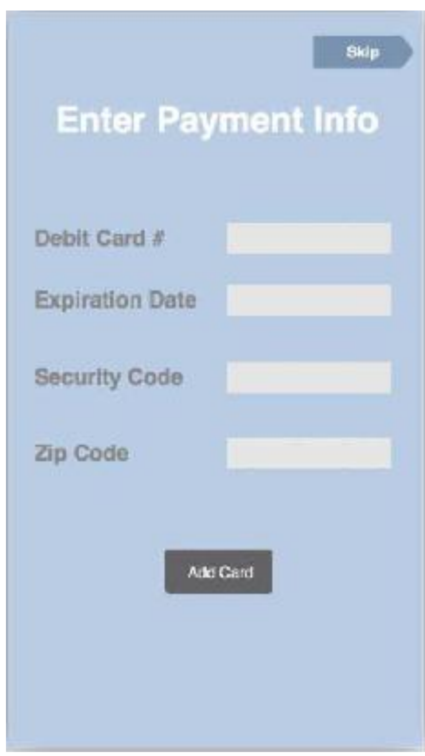

Figure 9: Payment Information Screen

Another change that was implemented after testing was that instead of giving users each other's phone numbers, messaging is now done only within the app. Not only is this only to protect user's safety, but also it is more convenient. In the original design, users could see each other's personal phone numbers and were free to text or call as they pleased. Some users expressed concern with giving out their phone number freely. To eradicate this concern, we changed the design of Swerve to allow for messaging in the application.

Finally, after testing, we realized that users need to be able to go back to edit their profiles after they have created them. To fix this, a settings icon was added to each of the screens, which takes users to their profile (Figure 10). An "update" button was added on this screen as well as an option to change from a driver to a passenger or vice versa. It is not only likely that users would like to change their personal information from time to time, but if they decide that one quarter they would like to buy a parking permit and become a driver although they were originally a passenger, the application needed to support that.

Figure 10: Profile Screen

C. Results

After the initial design phase and testing, the end result of the visual design of Swerve is cohesive, user friendly, learnable, and enjoyable. The application solves the problem that we were looking to solve by giving students a safe and fun way to meet peers to carpool to campus with based on proximity, schedule matches, and social interests.

Because of the feedback to add a payment feature, this resulted in a change in the matches screen of Swerve. Now, when a driver views their matches, a blue check mark is seen next to those passengers who have added payment information (Figure 11). Passengers are presented with their matches in the same way and the only difference is that the blue checkmark payment indicator does not exist.

Additionally, because of the decision to add a messaging feature in the application itself, a change in that icon is present as well. The change in the visual mock up is that once two users have both clicked the blue message icon on each other's names indicating their interest in carpooling, the blue icon changes to a green message bubble (Figure 11). That green message bubble opens a conversation window so that the two users can message freely in the app to arrange carpooling without needing to exchange phone numbers.

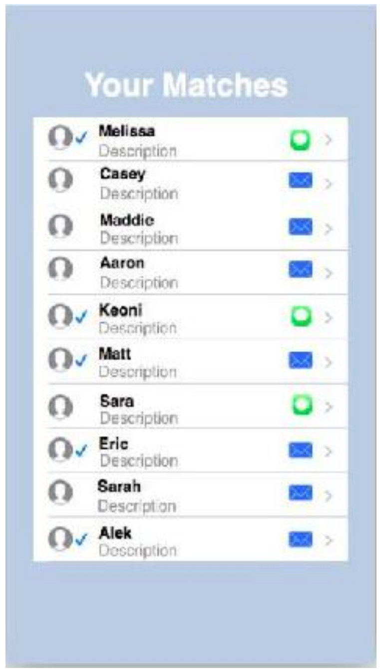

Figure 11: Updated Matching Screen

As a result of the literature reviews surrounding human computer interface, learnability, and other applications, the overall design of Swerve was well received. The design is sleek and allows all users to quickly learn how to navigate the application. Because the design is so simple and pleasing to the eye, it allows for predictability, synthesizability, familiarity, and generalizability. Users are already familiar with not only the type of data input the application asks for, but also the general information manipulation methods. By surveying users, a second time after improvements were made, we were able to receive feedback that users enjoyed the application's features, and consistent design, and direct logic flow.

VI. Database

A. Design

We wanted to match the drivers and passengers based off of their location and times they were going to or from school so we built our database to run these matching functions. We used the drivers' class schedules to use as the times that they would be driving. On the passenger side, we saw that it would be more beneficial to have them be able to input whatever time they wanted rather than class schedules. We understood that allowing them to input any time they entered would encompass both the times they have class and the scenarios that they need to go early or stay late. The users' locations were built the same for both the driver and the passenger. We broke San Luis Obispo into major areas that all have subareas. A major area table was built with locations such as Hathaway area, Madonna area, and North Downtown area. A sub area table was also created, seen in Table 1. This allowed for the database to match students that were located close to each other. On the driver and passenger forms that we built, we had a combo box, which acts as a drop down list, which listed all of the major areas. We then built a set difference query that allowed for only the sub areas that corresponded with their designed major area to show in a second combo box. We coded the sub area combo box to refresh each time a new major area was selected.

SubareaID	Subarea Name	MajorAreaID	MajorArea Name
A	NE Madonna Area	1	Madonna Area
AA	N of Foothill	9	Mustang/Pine Creek/Cedar/Murry Area
B	NW Madonna Area	1	Madonna Area
BB	S of Foothill	9	Mustang/Pine Creek/Cedar/Murry Area
C	SE Madonna Area	1	Madonna Area
CC	Library Area	10	On Campus
D	SW Madonna Area	1	Madonna Area
DD	UU Area	10	On Campus
E	South of Santa Rosa	2	North Downtown Area (Mill/Palm)
EE	Dorms	10	On Campus
F	North of Santa Rosa	2	North Downtown Area (Mill/Palm)
G	Carpenter/Hathaway/Bond	3	Hathaway Area
H	Longview/Albert/Chaplin	3	Hathaway Area
I	Stafford/Taft	3	Hathaway Area
J	N of Highland and E of Jeffery	4	Highland/Foothill Area
K	S of Highland and E of Jeffery	4	Highland/Foothill Area
L	N of Highland and W of Jeffery	4	Highland/Foothill Area
M	S of Highland and W of Jeffery	4	Highland/Foothill Area
N	McCollum/Slack/Hays	5	Grand Ave
O	N of 101 and E of Grand	5	Grand Ave
P	S of 101	5	Grand Ave
Q	N of High and E of Broad	6	South Downtown/Train Station Area
R	S of High	6	South Downtown/Train Station Area
S	N of Islay and W of Broad	6	South Downtown/Train Station Area
T	S of Islay and W of Broad	6	South Downtown/Train Station Area
U	Johnson N of Sydney	7	Broad/Johnson St
V	Johnson S of Sydney	7	Broad/Johnson St
W	Broad N of Orcutt	7	Broad/Johnson St
X	Broad S of Orcutt	7	Broad/Johnson St
Y	E of Broad	8	Foothill Plaza/North Chorro St Area
Z	W of Broad	8	Foothill Plaza/North Chorro St Area

Table 1: Sub Area Table

In the Access database we built a driver's form with tables and queries to support it in order to get the driver's side of the application to run proper matches (Figure 12).

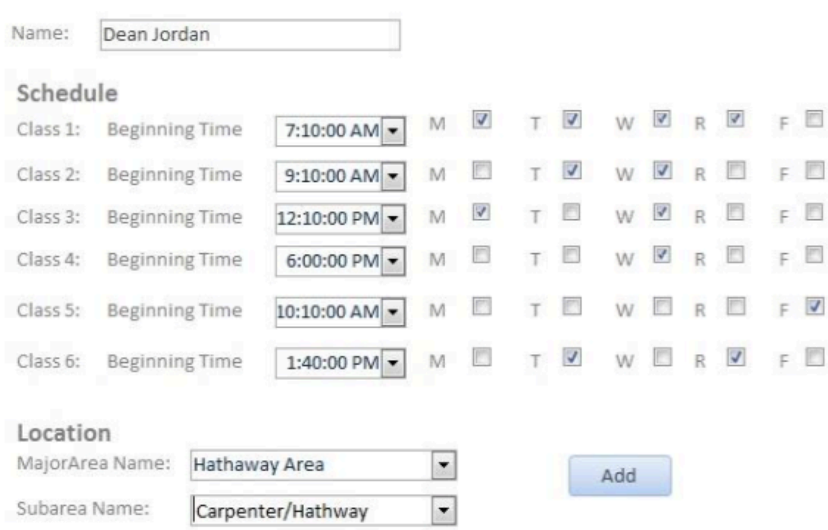

Figure 12: Driver's Form

In order to get the driver's form to work properly, we first we built a table that would include all of the drivers' student ID, name, classes that they input, and their home location. The driver's student ID was the primary key, therefore each student would have a unique record in the table. The driver form was then created that would allow the drivers to input this information into the driver table. We built a time mark table that included all possible start times of classes as well as end times. Next, we built beginning time combo boxes for each class which showed all of the values from the time mark table. Then we built a query for each class end time that selected the time mark values from the time mark tables with the criteria >[Forms]![Driver_Form]![ComboBoxXX]. By creating this query, we could build end time combo boxes that only showed times after the selected beginning time. For days of the week that the class was, we used check marks. We coded the check marks to be unchecked when the form loaded by added the code Check.ValueXX = 0 under the private sub Form_Load() to eliminate complications that would occur with having the check marks have three values. The check marks originally have the values of -1 meaning default, 0 meaning unchecked and 1 meaning checked. By telling the database that the value of the check mark is unchecked, the only possible values that the checks could have is unchecked, it eliminated the default value. This way the check mark values in the table would be only unchecked and checked, corresponding to yes they have class that day or no. The major area and sub area combo boxes were also placed on the form as well as a text box where the user could write their name. We used the ADO code in to add the information into the driver table when the user pressed the add button (Figure 13).

```
Private Sub btn_add_Click()

 Dim rst As ADODB.Recordset
    Set rst = New ADODB.Recordset

    rst.Open "ALL_DRIVER_INFO", CurrentProject.Connection, adOpenDynamic, adLockOptimistic
    rst.AddNew

    rst("FName") = Name.Value
    rst("1_BEG_Time") = Combo1B.Value
    rst("1_END_Time") = Combo1E.Value
    rst("1M") = Check1M.Value
    rst("1T") = Check1T.Value
    rst("1W") = Check1W.Value
    rst("1R") = Check1R.Value
    rst("1F") = Check1F.Value
    rst("2_BEG_Time") = Combo2B.Value
    rst("2_END_Time") = Combo2E.Value
    rst("2M") = Check2M.Value
    rst("2T") = Check2T.Value
    rst("2W") = Check2W.Value
    rst("2R") = Check2R.Value
    rst("2F") = Check2F.Value
    rst("3_BEG_Time") = Combo3B.Value
    rst("3_END_Time") = Combo3E.Value
    rst("3M") = Check3M.Value
    rst("3T") = Check3T.Value
    rst("3W") = Check3W.Value
    rst("3R") = Check3R.Value
    rst("3F") = Check3F.Value
    rst("4_BEG_Time") = Combo4B.Value
    rst("4_END_Time") = Combo4E.Value
    rst("4M") = Check4M.Value
    rst("4T") = Check4T.Value
    rst("4W") = Check4W.Value
    rst("4R") = Check4R.Value
    rst("4F") = Check4F.Value
    rst("5_BEG_Time") = Combo5B.Value
    rst("5_END_Time") = Combo5E.Value
    rst("5M") = Check5M.Value
    rst("5T") = Check5T.Value
    rst("5W") = Check5W.Value
    rst("5R") = Check5R.Value
    rst("5F") = Check5F.Value
    rst("6_BEG_Time") = Combo6B.Value
    rst("6_END_Time") = Combo6E.Value
    rst("6M") = Check6M.Value
    rst("6T") = Check6T.Value
    rst("6W") = Check6W.Value
```

Figure 13: ADO Code

On the passenger side, we created a To_Passenger form for when the passengers wanted to go to school (Figure 14). We also built a From_Passenger form for when the passengers wanted to leave school (Figure 15).

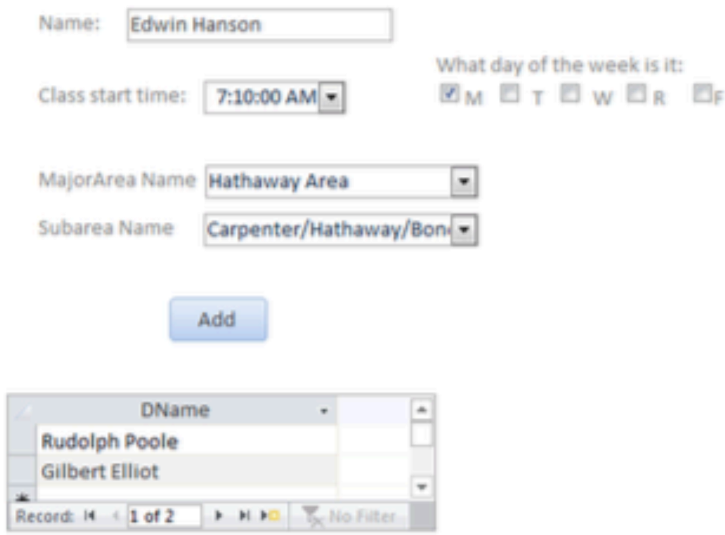

Figure 14: To School Form

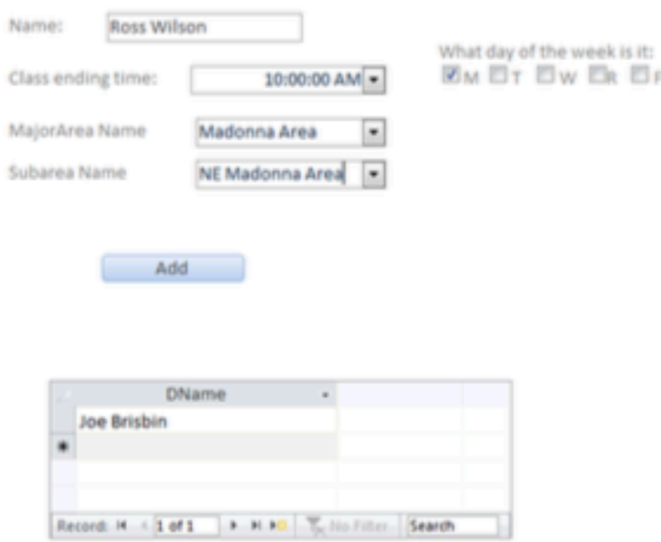

Figure 15: From School Form

By creating two separate forms, it allowed more flexibility for our users. It also allowed for more potential matches by having only one time criteria that they had to match with the driver instead of two time criterias that would occur if the to school time and the leaving school time were on one form. The To_Passenger form and the From_Passenger form were built similarly. On both forms there was a text box where the passenger could write their name, a combo box that showed the time marks from the time mark table, a major area combo box, a sub area combo box, check marks for what day of the week it was, an add button and a subform that show what drivers matched the time, day and location information that the passenger input. The check marks were coded and worked the same way as the driver form. The add button added the passenger's information into the respective To_Passenger table or From_Passenger table. The subforms were built off of queries that checked the passenger time, day and location information against the information time, day and location information in the driver table. It checks all of the check marks, major area, and subarea from the input the passengers put on the form against the information in the driver table. The only difference between the To_Passenger_Subform_Query and the From_Passenger_Subform_Query is that the To_Passenger_Subform_Query checks the selected to school combo box time on the To_Passenger form against the drivers' beginning class times and the From_Passenger_Subform_Query checks the selected from school combo box time on the From_Passenger form against the drivers end of class time (Figure 16).

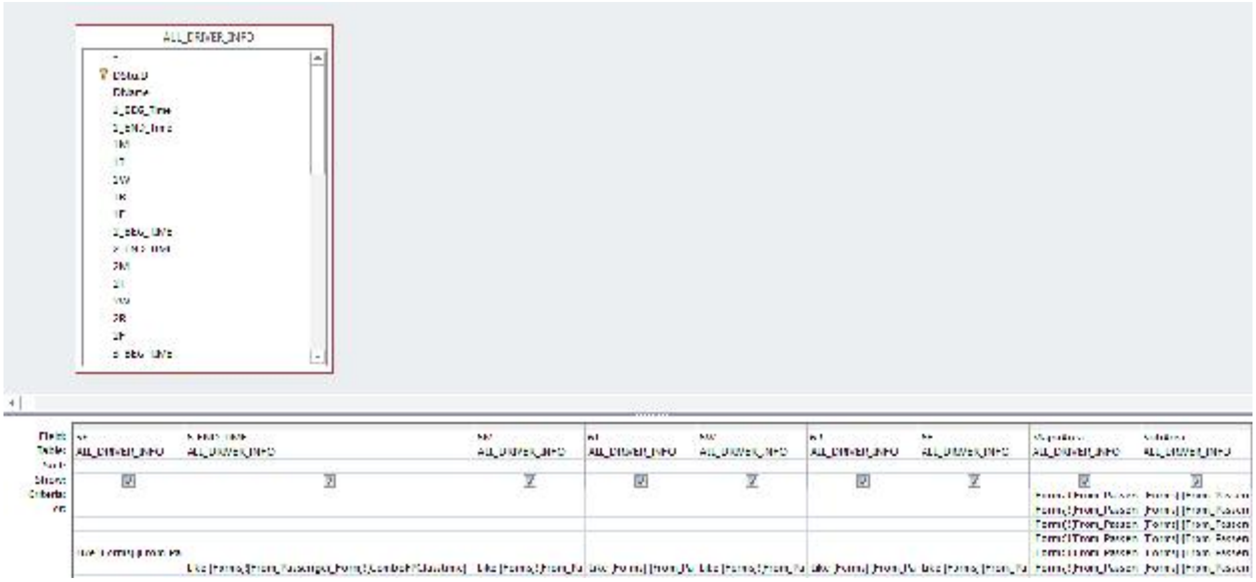

Figure 16: From Passenger Subform Query

B. Testing

Throughout the building of the database, the tables, queries and forms were constantly tested. It was important to ensure that the tables that needed primary keys had them. The queries were tested by looking at the combo box or subform that they were built for. The forms were tested by inputting information and ensuring that the tables and subforms populated correctly. All of the combo boxes were also coded and tested to ensure that they refreshed with every new selection.

C. Results

The subforms on the To_Passenger form and the From_Passenger form show the names of the drivers that match with the passenger that input their information. This is how we would be able to notify the passengers and drivers who match with each other. If there were no names that appeared, that meant that there were no drivers that matched the passengers’ times and locations. However, we believe that with enough users, this would seldom be an issue.

VII. Economic Analysis

When determining the economic impact that Swerve will have for users, we first needed to know how many round trips students who drive to campus take each day (Figure 17).

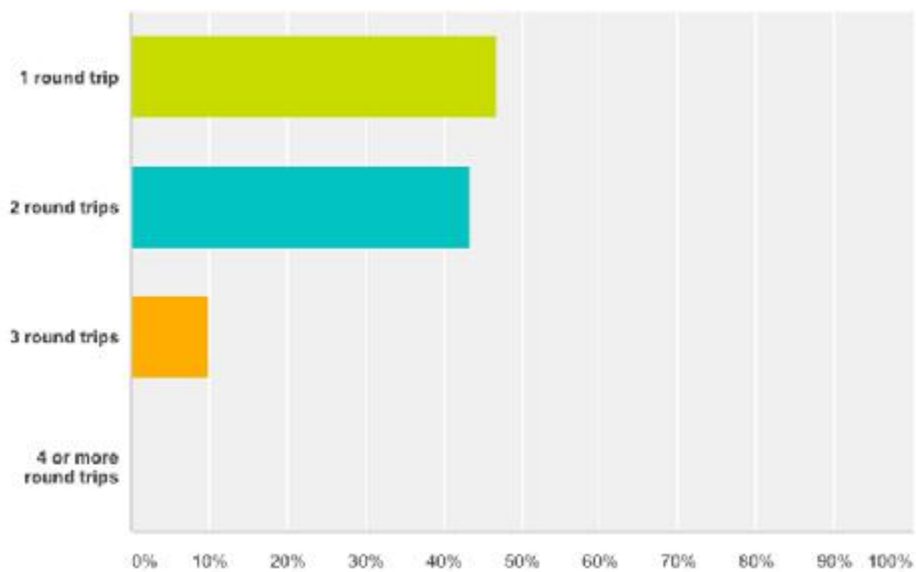

Figure 17: Trips per Day

We calculated this to be an average of 1.63 round trips per day. The cost of student parking permit on campus is $125 per quarter, which is $375 for the academic year. Unfortunately, that is not the total cost incurred to drive to campus. With gas prices as high they are, they cannot be ignored. Recently, the average gas prices in San Luis Obispo have lowered a bit to $3 per gallon. The average car in the United States gets 23.6 miles per gallon and the average mileage a student drives from their house to campus is only 2 miles, making that a 4 mile round trip. At this rate, it costs students about $2.21 per day to drive to campus based on the cost of the parking permit and gas. Because there are 170 school days per year, this translates to an average Cal Poly Student spending $516 each academic year just to drive to campus, assuming they live only 2 miles away (Table 2).

Expenses		
Parking Pass	375	$/year
Gas & Maintenance		
	4	avg. miles to campus
	1.63	roundtrips/day
	3	dollars/gallon of gas
	23.6	avg. car mpg
	0.83	$/day driving to campus
	170	school days/year
	141.1	$/year driving to campus
TOTAL EXPENSE	516.1	$/year to drive to campus

Table 2: Expenses

However, with Swerve, if student drivers choose to charge the small price of only $1 per ride, they can actually be making some money instead of burning through over $500 each year. If a student driver fills their car with an average of just 2.5 people when they drive to campus, the savings are significant. By still driving the average number of round trips to campus per day, 1.63, for 170 school days per year, a driver can make $693. This is an excess of $177 from the current expenditure. Of course, students do not need to charge for every ride or always carpool, and they still are likely to quickly and easily pay off the cost of their parking permit and gas (Table 3).

Savings		
	2.5	avg. people with you to class
	1	$/ride
	1.63	avg. roundtrips/day
	170	school days per year
TOTAL SAVINGS	692.8	$ made per year driving to campus

Table 3: Savings

Passengers are also getting a great deal through Swerve. If the student does not own a car, Swerve clearly solves their need. However, students that do own cars but simply do not drive to campus because of the cost of a parking permit will still be paying less using Swerve to get to campus than they would if they drove themselves. If passengers decided to use Swerve to travel to campus on average 1.63 round trips per day and paid their driver $1 per trip for the 170 academic days per year, which would total a cost of $277. This is less than the $375 the parking permit would cost, without even taking into account the gas savings. However, because many drivers expressed they are not necessarily looking for compensation on every ride, in reality, passengers would actually spend even less than $277. It is undeniable that Swerve would not only be saving the Cal Poly drivers money, but also the passengers, while keeping our overcrowded parking lots less congested.

Because Swerve is not only useful at Cal Poly, we would like to point out the economic benefits it serves on a larger scale as well. According to the DMV, 85 million gallons would be saved per year nationally by carpooling. Currently in America we are saving $1.1 billion dollars by carpooling, based on fuel costing the current national average of $4 per gallon. Although 1.1 billion dollars sounds like a lot, that is only a small percentage of what we could be saving if Americans were educated on how beneficial carpooling truly is. A round trip of 30 miles, which is a common commute distance for many Americans, the cost to drive alone per month is $152 (Table 4).

Round-trip miles	Cost to drive alone (per month)	Cost if 2 people carpool (per month)	Cost if 3 people carpool (per month)
10	$51	$26	$17
20	$102	$51	$34
30	$152	$76	$51
40	$203	$102	$68
50	$254	$127	$85
100	$508	$254	$169

Table 4: Carpooling Costs

By carpooling with two others, that cost drops to $51, a 34% reduction. It is clear that as a nation we are leaving money on the table by not carpooling, and Swerve is looking to put an end to that.

VIII. Conclusion

A. Lessons Learned

Throughout the course of this project, we encountered many challenges, which led to many lessons learned. One of the most important realizations was how crucial project management skills are. By understanding the critical path of the project, the team can decide which task absolutely must be done before other tasks can be started. Without defining our critical path at the start of the quarter, there were several instances that we did not finish something because we were waiting on another portion. This resulted in us changing our project schedule various times, leading to confusion and procrastination. For example, it was difficult to make the visual mock up screens when we had not completely nailed down how the database was going to function. Many visual screens were made that did not get put to use which that was a waste of time and resources.

Another skill we learned to refine was communication. Not only did we need to always be in communication with each other about our schedules and our goals for the project, we needed to make sure that schedule was in accordance with our advisor's schedules.

Hand in hand with the lesson of communication, we soon understood that it is never too early to ask for feedback. By getting input at the earliest stage possible, we can prevent a project from heading down the wrong path, or stop the scope from creeping. Each time we received feedback we realized that it would have been even better to have asked for feedback earlier in the quarter.

Not only did we learn how to plan and execute an idea that we had dreamed up just the two of us, but we refined our IME 303, 312, and 319 skills. There various lessons learned throughout the ride of creating Swerve, but overall, the most valuable are to never underestimate the importance of organization and communication.

B. Future Steps

We have talked about two potential options for what to do going forward. Once is that when we have the time to fully commit to this idea, actually try to make this a successful application. This would entail paying programmers to build a prototype, testing it in the market, and continuously refining and improving our application. We would also need to come up with a business plan and structure. This is definitely an option, but as we are both starting out new careers, we don't see this being a possibility in the near future. However, we are both very passionate about this idea and believe there is a need for this application for both people's social and economic benefits, as well as the great environmental impact it would have. The other option is handing this basis off to a computer science major who would be able to build the application. Obviously with this option we would need to consider what level of control we would want and be able to have over the course of the future of the application.

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