CABEE: A PEER-TO-PEER RIDE HAILING PLATFORM FOR NORTH CYPRUS

**A THESIS SUBMITTED TO THE
ENGINEERING FACULTY
OF
NEAR EAST UNIVERSITY**

**BY
HARUN MOHAMED**

**IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF BACHELOR OF SCIENCE
IN
SOFTWARE ENGINEERING**

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DECLARATION

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original, to this work.

Harun Mohamed

Signature………………………………………… Date…………..…………………

ACKNOWLEDGEMENTS

The completion of this study would not have been possible without the guidance of my supervisor Research Assist. Oluwaseun P. Olawale. I would also like to thank Assist. Prof. Dr. Mohammad Momenzadeh for his expertise in Probability and Statistics in helping me successfully come up with the regression model for the Price Estimation Algorithm.

Above all, my heartfelt gratitude to my parents for their great confidence in me.

To my parents….

ABSTRACT

Ride-Hailing systems play an instrumental role in helping a society keep moving. However, price allocation for such systems is quite complex. Ride-Hailing platforms such as Uber have achieved explosive growth and reshaped urban society. Their success can not only be attributed to their gamified systems and one click convenience in hailing a ride but also largely in part to their solving the Chicken and Egg problem that is price estimation.

On one hand consumers are always looking to pay the least amount possible for a ride while drivers are looking to earn more since their livelihood depends on it. The fundamental aim of this thesis is to establish a price equilibrium; a middle ground favorable for both parties involved and to develop a convenient cross platform mobile application called CABEE using React Native for the user interface, Firebase for the backend and Google Maps APIs for the mapping functionality.

The Price Estimation Algorithm (PEA) developed is used to quote prices to both riders and drivers. It calculates ride prices based on two rudimentary principles; minutes spent in the car during the ride and kilometers covered during the ride. When a user requests a ride, the most proximal driver in the vicinity gets a notification and the ride price is quoted to both parties before the ride starts. The driver can then accept the ride request and share their live location with the user who requested the ride.

This system will hopefully serve to establish an optimal pricing model for all parties involved and also reduce wait times due to its instantaneous nature of requesting rides

Keywords: CABEE, Ride-Hailing, Rider, Driver, Price Estimation Algorithm (PEA)

ÖZET

Ride-Hailing sistemleri, bir toplumun ilerlemeye devam etmesine yardımcı olmada önemli bir rol oynar. Ancak, bu tür sistemler için fiyat tahsisi oldukça karmaşıktır. Uber gibi araç çağırma platformları hızlı bir büyüme elde etti ve kentsel toplumu yeniden şekillendirdi. Başarıları sadece oyunlaştırılmış sistemlerine ve tek tıklamayla bir sürüşü selamlamanın kolaylığına değil, aynı zamanda büyük ölçüde kısmen fiyat tahmini olan Tavuk ve Yumurta problemini çözmelerine de bağlanabilir.

Bir yandan tüketiciler her zaman bir yolculuk için mümkün olan en az miktarı ödemeye çalışırken, sürücüler geçim kaynakları buna bağlı olduğundan daha fazla para kazanmak istiyorlar. Bu tezin temel amacı, ilgili her iki taraf için de uygun bir fiyat dengesi oluşturmak ve kullanıcı arayüzü için React Native, arka uç için Firebase ve haritalama işlevi için Google Haritalar API'leri kullanarak CABEE adlı uygun bir platformlar arası mobil uygulama geliştirmektir.

Geliştirilen Fiyat Tahmin Algoritması (PEA), hem binicilere hem de sürücülere fiyat teklif etmek için kullanılır. Yolculuk fiyatlarını iki temel ilkeye göre hesapladı; yolculuk sırasında arabada harcanan dakika ve yolculuk sırasında kat edilen kilometreler. Bir kullanıcı bir yolculuk talep ettiğinde, civardaki en yakın sürücü bir bildirim alır ve yolculuk başlamadan önce yolculuk fiyatı her iki tarafa da verilir. Sürücü daha sonra sürüş talebini kabul edebilir ve canlı konumunu sürüşü talep eden kullanıcıyla paylaşabilir.

Bu sistem umarım dahil olan tüm taraflar için en uygun fiyatlandırma modeli oluşturmaya hizmet edecek ve ayrıca sürüş talep etmenin anlık doğası nedeniyle bekleme sürelerini azaltacaktır.

Anahtar Kelimler: CABEE, Selamlama, Binici, Sürücü, Fiyat Tahmin Algoritması (PEA)

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LIST OF ABBREVIATIONS

API: Application Programming Interface

ETA: Estimated Time of Arrival

GPS: Global Positioning System

HTTP: Hypertext Transfer Protocol

PEA: Price Estimation Algorithm

TL: Turkish Lira

CHAPTER 1: INTRODUCTION

With the advent of the COVID-19 pandemic all across the globe, people all over have had to rethink and redesign their lives around this new way of living. Businesses and economies at large have had to acclimatize to this new normal standard of living. Social distancing has resulted in the rise of remote working, the surge in use of video conferencing software and a spike in use of food delivery services (Tiruchelvam, 2021). However, public transport sector has been greatly stifled and suffered the most. Since the imposition of night time curfews and inter-district travel restrictions withing North Cyprus, the public transport sector has grinded to a halt.

Residents of North Cyprus without cars have had to increasingly rely on the use of taxis for their day-to-day transport. This has only served to expose the problem that is at the core of the taxi industry in North Cyprus; the absence of a fair pricing model for taxi rides. This thesis focuses on the development of a Price Estimation Algorithm (PEA) to amicably solve the pricing problem at the heart of taxis in North Cyprus and the development of a ride hailing platform with the pricing model we've established embedded within it.

1.1 THESIS PROBLEM

Taxi pricing is a problem almost everyone has experienced in North Cyprus. Drivers charge a base fare of 30 Turkish Lira regardless of the ephemerality of the trip. Moreover, ride prices for longer trips are not only determined without any due criteria but are also fully dependent on the driver's whim. For a trip from Near East University to Ercan Airport, I surveyed multiple taxi drivers whose quotations for this exact trip varied from 110 Turkish Lira up to 180 Turkish Lira. This is a margin of up to 70 Turkish Lira on just one trip. Moreover, some taxi drivers do not possess Point of Sale terminals and riders sometimes have to divert their trips to the closest Automated Teller Machines (ATMs) to withdraw cash. This could not only increase the price of the trip significantly for the rider but the rider could moreover incur additional waiting charges levied by the driver for this minor inconvenience. The wait times for trips also pose a significant challenge for the rider. Out of 51 people surveyed, 54.9% stated that they wait for more than 10 minutes after calling their cab for the driver to show up. An additional 31.4% stated that they wait for at least 10 minutes and only 2% of the respondents stated that their driver arrives in less than 5 minutes.

1.2 THE AIM OF THE THESIS

The primordial aim of this thesis is to come up with a fair pricing model for both parties involved and an easy-to-use platform for users to hail cabs and drivers to build their clientele and generate more revenue. As earlier stated, riders wish to pay the least amount possible while drivers livelihood depend on a better pricing model. I aim to come up with a middle ground that satisfies both parties. Moreover, I will propose solutions to the long wait times experienced by riders and absence of card payment terminals by drivers.

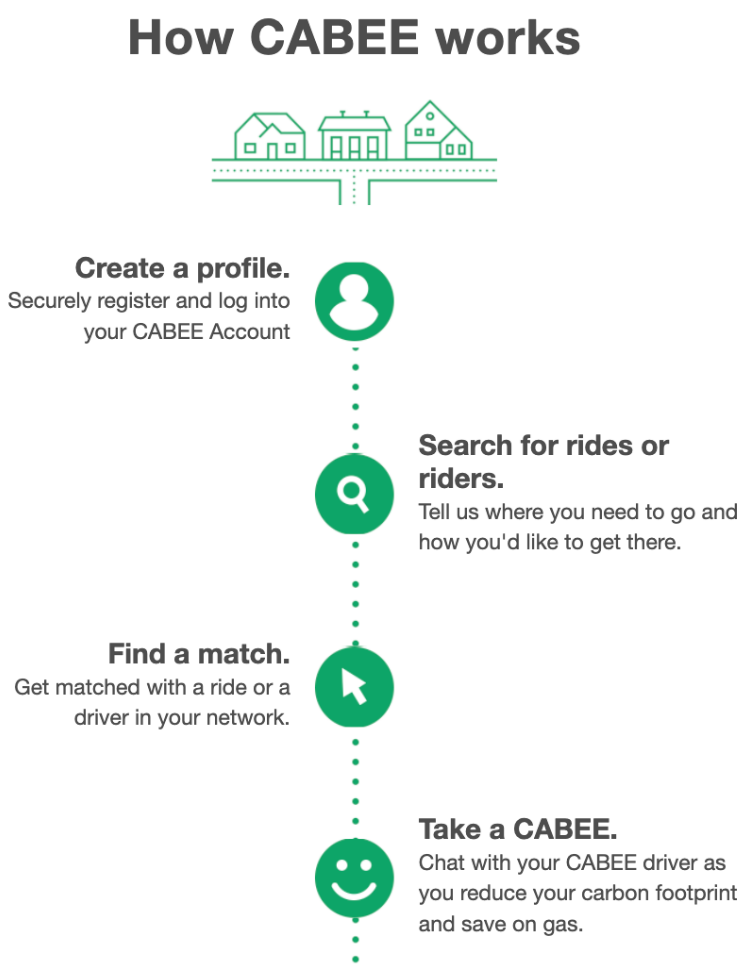

Figure 1: How CABEE works

1.3 THE IMPORTANCE OF THE THESIS

CABEE as a platform is significant since it will establish a fair pricing model for both riders and driver using the Price Estimation Algorithm. It is worth noting that out of 51 people surveyed which makes up for 0.1% of all international students in North Cyprus, 47 or 92.2% stated that they would want to use a platform like this in the event of its existence. This proves that there is a significant niche for a product like this. CABEE as a peer-to-peer ride hailing platform will not only improve pricing for taxi rides, but will also greatly reduce wait times, increase ride frequency for drivers, and in the long run reduce traffic and carbon emissions through carpooling.

1.4 LIMITATIONS OF THE STUDY

As at the time of my writing, the world is still in the midst of the COVID19 pandemic. This has greatly limited the scope of my research. Originally, I intended to survey a significantly larger group of people and collect more unbiased data and opinions. I only managed to survey 51 people and collect 12 data points for the regression model of the Price Estimation Algorithm. However, due to the linear nature of the data involved, I was able to extrapolate the findings and come up with the coherent inferences initially intended.

1.5 OVERVIEW OF THE THESIS

The thesis will begin by discussing the previous works carried out in the field of ride hailing including dynamic ride matching systems and pricing models including the single and double bidding systems. It will then go over data and inferences inferred from the 51 respondents surveyed for the purpose of this thesis. Later, I will discuss the price estimation algorithm and how I came up with it mathematically as relevant to the scope of this thesis. Finally, I will go over the integration of the price estimation algorithm and the technical and system design for both the rider and driver mobile applications.

CHAPTER 2: RELATED RESEARCH

2.1 PREVIOUS WORK IN THIS FIELD

2.1.1 SINGLE BIDDING SYSTEM

This system was proposed to establish an alternative pricing strategy for ride hailing systems. Once a user requests a ride, they are able to quote the amount of money they are willing to pay and the driver accepts or rejects the ride based on how satisfied they are with the price (Gupte, 2018)

2.1.2 AUCTION PRICING MODEL

This model was used by DiDi Dache in China before being ceased as a result of government intervention. It allowed users to bid in fixed increments on top of the base ride cost, thus increasing the likelihood of getting a ride when demand outstrips supply. The user could request a ride and state the amount they were willing to pay. The app would then display on the screen the likelihood of the user getting the ride based on stated price. The user could then increase their price to increase their chance of acceptance. This model worked like an auction where the highest bidder got the ride (Loke and Jia, 2017).

2.1.3 UBER DYNAMIC PRICING MODEL

Uber, which is a pioneer in ride hailing and sharing technology, employs a dynamic pricing model for their rides. Ride prices are primarily determined by the length and duration of the ride. Moreover, a base fare is applied on the ride and a minimum ride fare too if the price of the ride is less than the minimum fare price. Uber also charges waiting fees and cancellation fees on occasion. But the most interesting aspect of their pricing model is the surge price which is at the core of its dynamic pricing model.

When a user requests a ride, Uber considers the current rider-to-driver demand for their service and a surge factor kicks in when there is an offset in this equilibrium. A surge factor is an integer that they multiply with their regular price on special occasions such as when there is high ride demand but not enough drivers on the road or during rush hours such as Thursday and Friday evenings. For instance, if a normal commute from the city center to your home normally costs $5 and the number of riders requesting are significantly more than the drivers, Uber could use a surge factor of 2 making the ride cost $10. This is used to encourage drivers to get on the road and meet the demand.

When more drivers get on the road and demand is quenched, the price is then normalized and returns back to normal. Moreover, dynamic pricing also kicks in during Uber's peak times for example on Thursday and Friday nights, during rush hour after work and when big events and festivals are happening in town.

Dynamic pricing helps to ensure that there are always enough drivers on the road to meet the demand and to ensure smooth operation of their ride hailing service (Uber, 2016).

2.1.4 LIMITATIONS OF THESE SYSTEMS

The above-mentioned systems have their pros and it is not the intention of this thesis to overlook them. For example, the single bidding system and the auction system democratizes the process of ride hailing. The user gets to state their price and the driver can only accept the ride if they are fully satisfied with the price stated. However, the major concern with this model is that it increases wait time significantly particularly when there are not enough drivers on the road. Moreover, some users could blatantly try to undercut the drivers by stating ridiculous prices which would then undermine the system and lead to low turnover rate of rides.

The dynamic pricing model employed by Uber is a rather neat implementation and the Price Estimation Algorithm developed in this thesis draws inspiration from it. The issue with it for the most part is the surge factor which could 3X the ride price sometimes when ride demand is high, in high traffic situation and during peak hours when drivers are scarce like late at night.

North Cyprus consists of a very vibrant student community who are the target demographic for this thesis. Of the students surveyed, most stated that they use taxi services to go to school or home when they miss the school buses, or to go for recreational and leisure activities sometimes late at night. The stated times meet all the requirements for a surge factor to kick in. For instance, late at night when some students are coming from a party, drivers are scarce or early evening in high traffic, since demand and supply is conflicting, the system might be tricked to throw in the surge factor which would hugely inconvenience the rider particularly if the rider is a student as in these examples stated.

2.2 USER RESEARCH CONDUCTED

To fully comprehend the problem at hand and thus come up with an amicable solution, 51 random students from Near East University were surveyed. The set of questions were focused on determining the level of convenience or inconvenience of the taxi experience particularly for students in North Cyprus. The questions were bundled up into a *Google Form* and sent to the email addresses in a Near East University Mailing List. I did not send the survey to my friends because that would potentially affect the authenticity of the data collected. 51 students responded to the survey and the findings will be discussed in the coming sections.

2.2.1 RIDE HAILING FREQUENCY AND PAYMENT MEANS

In this section, I discuss user responses to how often they hail a taxi in a week, where they most often go to and what means of payment, they use to pay for their taxi rides. Most students stated that they call taxis mostly to go home or to school. A significant chunk also stated that they go to restaurants.

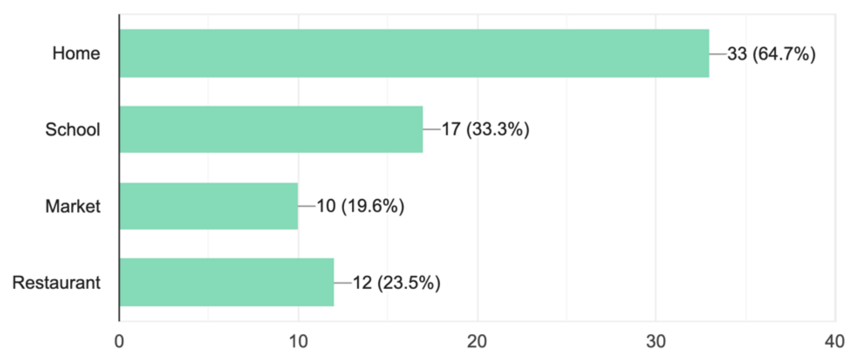

Figure 2: Where do you go most when you call a taxi?

When asked how often users call a taxi in a week, 4% stated always, 40% stated often, 38% stated more than once and 18% stated that they never call a taxi at all in week

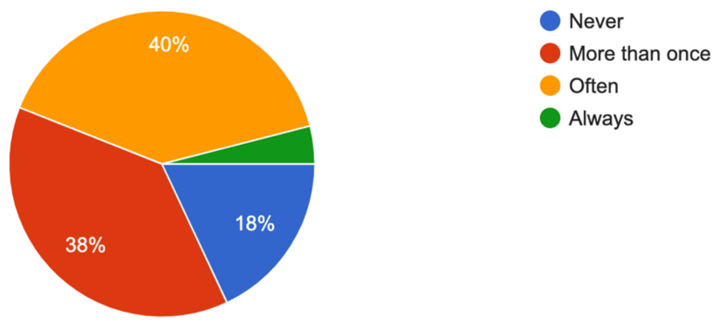

Figure 3: How often do you call a taxi in a week?

During this data collection phase, I also managed to interview a taxi operator who happens to also be a friend of mine and he told me that it is the standard to charge 30 Turkish Lira (TL) for all rides within the city of Lefkoşa and for shorter rides between the towns of Gonyeli and Yenikent. I therefore modeled the survey form to establish the median price paid by students for shorter rides for instance from their houses to school. An overwhelming 84.3% stated that a ride of this nature costs 30TL.

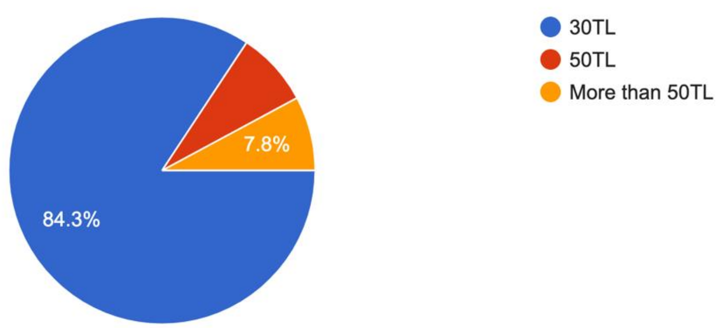

Figure 4: Taxi Ride Cost from Home to School

74.5% of users surveyed stated that they use cash as their primary means of payment for their rides.

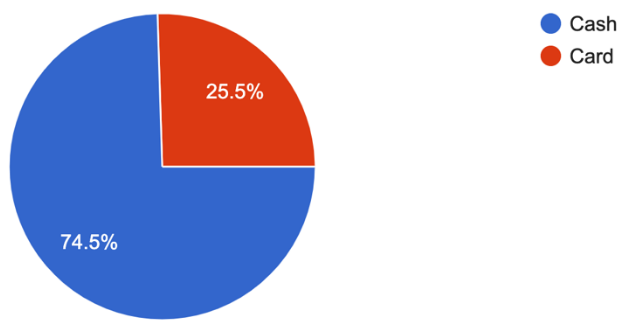

Figure 5: Payment means for Taxi Rides

2.2.2 EXPERIENCE RATING

When asked to rate how fair they think the pricing of taxis is on a 5-point Likert Scale, only 2% of users stated that they thought the pricing was fair

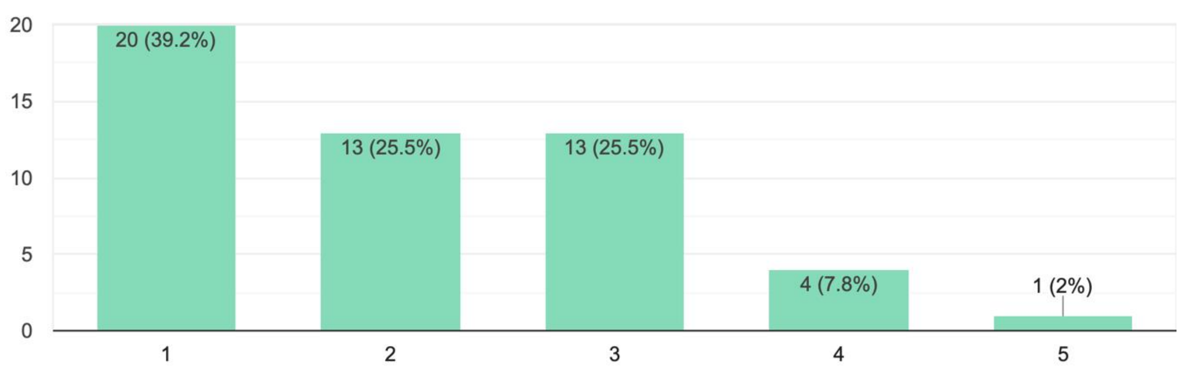

Figure 6: Fairness of Taxi Pricing in North Cyprus

86.3% of all respondents also stated that they wait for at least 10 minutes or more for their taxi driver to show up after calling them.

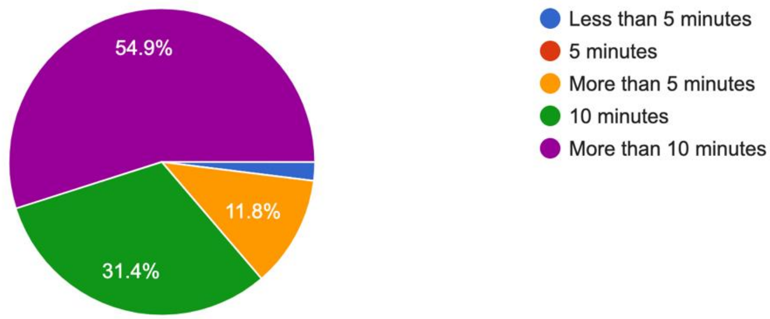

Figure 7: Taxi Wait Times

It is worth noting though that most respondents stated that they feel very safe in taxis in North Cyprus with only 5.9% of respondents stating that they don't feel safe at all and 29.4% stating neutrality.

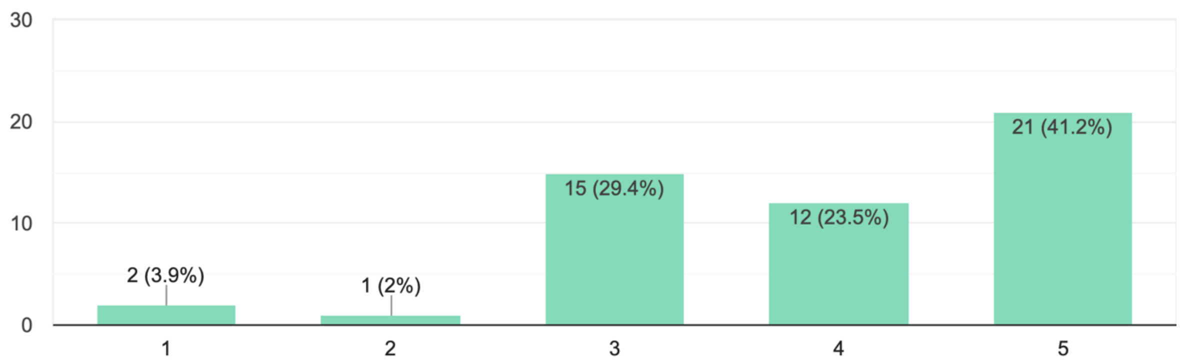

Figure 8: Safety in Taxis in North Cyprus

When asked to rate their experience with taxis, an overwhelming 52.9% chose neutral.

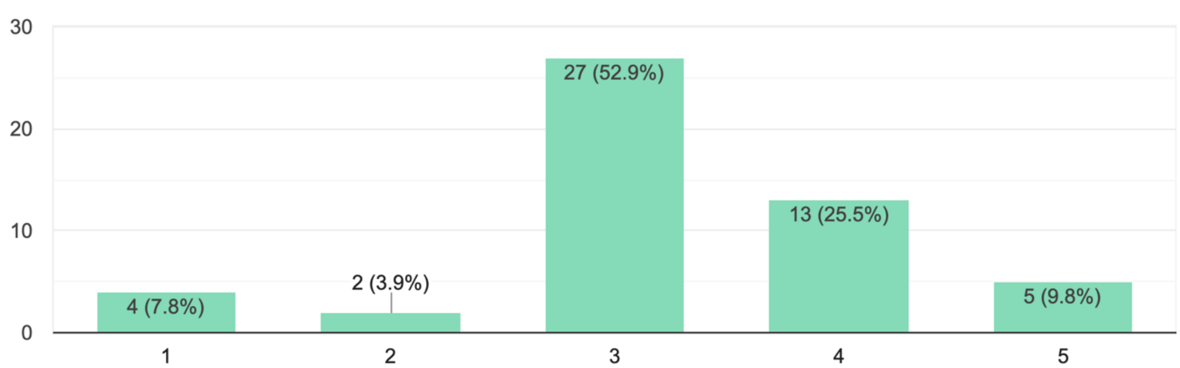

Figure 9: Experience Rating of Taxis in North Cyprus

Among the things users disliked most about taxis in North Cyprus, poor pricing was the biggest problem, with language barrier coming second.

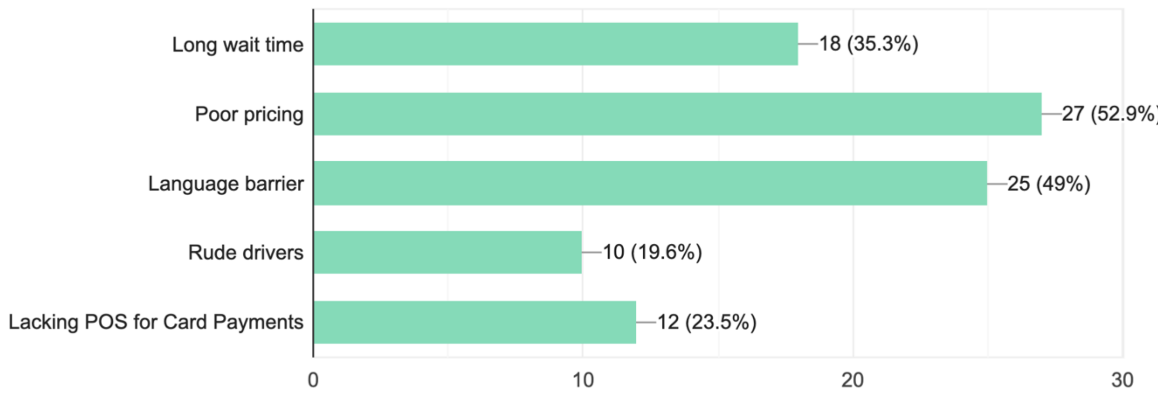

Figure 10: Dislikes about Taxis in North Cyprus

2.2.3 CABEE ADOPTION PROSPECTS

When asked if they have ever used a ride hailing service before, 76% of respondents stated that they have and 24% stated that they had no experience with ride hailing services.

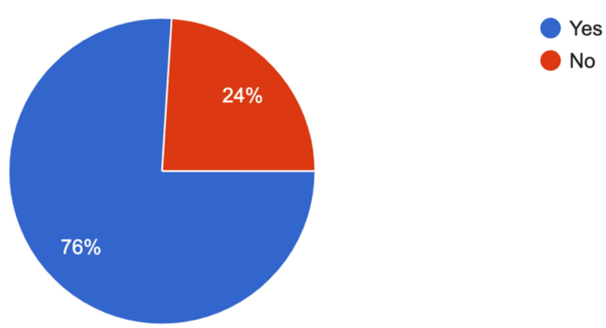

Figure 11: Ever used a ride hailing app before?

When asked if they would ever use a ride hailing service in North Cyprus, 92.2% of users stated that they would most certainly use it.

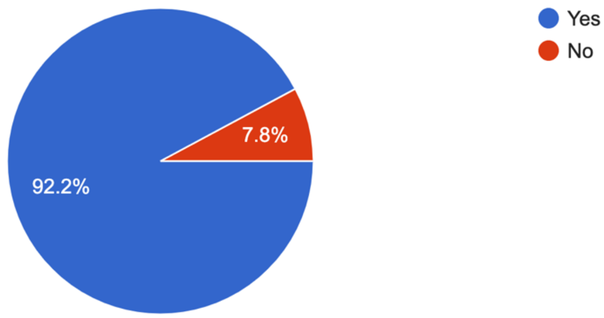

Figure 12: Would you want to use a ride hailing app in North Cyprus?

To aid with designing an amicable solution to the taxi problem in North Cyprus, I asked the respondents to state what would improve their taxi experience the most. 76.5% stated that better pricing would do the trick for them. Respondents also suggested an option to select driver based on language spoken and if they possess a point-of-sale terminal to accept card payments. A significant chunk of the respondents also suggested to reduce the waiting time

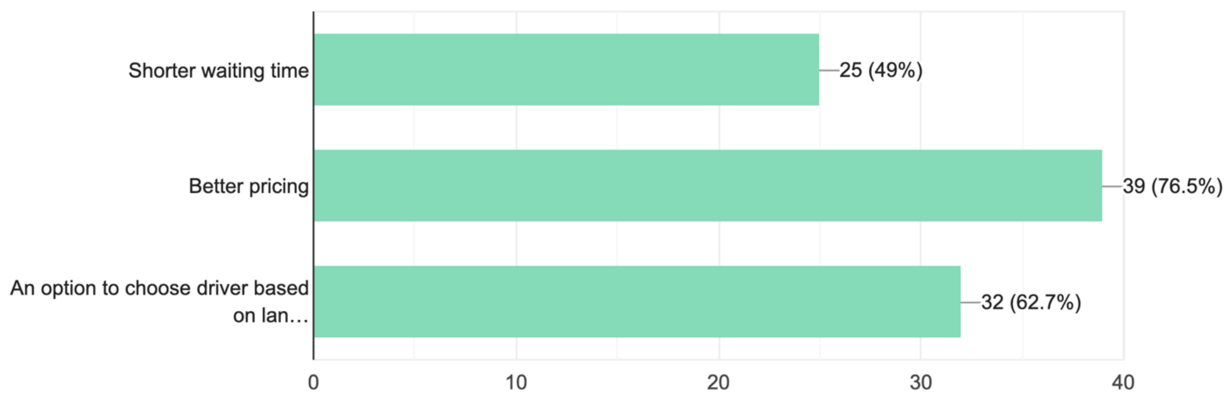

Figure 13: What would improve taxi experience in North Cyprus

2.3 INFERENCES FROM USER RESEARCH

From the above data, we can infer the following points which will help us understand user experience with taxis and further establish a fair pricing model and develop an efficient mobile application that serves the fundamental purpose of getting the user to their destination and keeping a smile on the driver's face with the good wages;

a. Most students' destination when hailing a taxi is home
b. Students call a taxi at least once in a week

c. Primary means of payment for taxi rides is cash
d. The average wait time for a taxi is more than 10 minutes
e. Students believe that there is great room for improvement in the pricing model for taxis
f. Most students have experience using a ride hailing application
g. Students would overwhelmingly use a ride hailing service if launched in North Cyprus

From this inferred data, we can then come up with the price estimation algorithm in the following chapter.

CHAPTER 3: PRICE ESTIMATION ALGORITHM

3.1 DEFINITION

Taxi pricing in North Cyprus is fairly uncomplicated; which is the beauty of it and like a two-edged sword, its detriment. Most prices within the town are 30TL with longer distances for example from Hamitkoy to Lefkoşa ranging from 50 to 60 Turkish Lira. Longer distances can often range from north of 100TL to just shy of 200TL. From this, we can now easily establish that prices are directly proportional to the distance of the ride with a minimum ride price of 30TL for shorter distances.

The latter is the premise of this chapter; the very assumption that all shorter distances regardless of distance covered should be 30TL. For example, a trip from Yakın Doğu Üniversitesi to Dr. Fazıl Küçük Bulvarı which is the first bus stop from the university is 2.9KM. Moreover, a trip from Yakın Doğu Üniversitesi to Martı Sokak in Gönyeli where I live is 7.2KM. Both these trips would cost the rider 30TL.

The Price Estimation Algorithm (PEA) is meant to come up with a rational way to determine ride prices devoid of all the guess work. In the coming sections, we will examine trip data and infer conclusions that will aid in coming up with the formula for the price estimation.

3.2 RESEARCH

To come up with conclusive data to develop a pricing model, I decided to survey several taxi drivers whenever I would take a taxi ride. My core intention was to know how they price different trips. I would ask them how much a trip would cost for example from point A to point B and they would state the price off head.

I would then ask what justifies the price and they would mostly state the distance in kilometers of the. trip. Later, I input the trip details into *Google Maps* and got the distance in kilometers and how many minutes the trip would take on average.

Table 1. Pricing Data from Taxi Drivers

FROM	TO	PRICE	MINUTES	KILOMETERS	PRICE/KM
NEU	CITY CENTER	30	11	8.4	3.57
NEU	GONYELI	30	8	5.4	5.55
NEU	CHINA BAZAAR	30	9	6.5	4.62
NEU	ERCAN AIRPORT	120	27	24.6	4.88
NEU	GIRNE	150	20	22.3	6.73
GONYELI	MAGUSA	250	49	57.5	4.35
LEFKOSA	LEFKE	180	75	66.9	2.70
CIU	LEFKOSA	60	38	22.2	2.70
GONYELI	KUCUK KAYMAKLI	40	14	9	4.44
GONYELI	HAMITKOY	40	14	9.3	4.30
HAMITKOY	ORTAKOY	35	12	6.4	5.47
LEFKE	GIRNE	300	66	73.7	4.07
		Σ = 1265		Σ = 312.2	Σ = 4.45

From this data, it is evident that the relationship between the price, duration and distance of the trips is linear. Average price for every kilometer traveled during these rides was 4.45TL. For a total of 312.2KM covered, the average price per kilometer was 4.05TL.

It is rather anomalous to notice that the price per kilometer for shorter trips within the city is significantly higher. For example, a trip from Near East University (NEU) to Gonyeli which took 8 minutes had a price per kilometer of 5.55TL. Moreover, a trip of 12 times the distance; from Lefkosa to Lefke had a price per kilometer of 2.70TL

3.3 ESTABLISHMENT OF COEFFICIENTS

It is now evident that the Price Estimation Algorithm (PEA) will be a linear function with two constants; duration *(X)* and distance *(Y).* The formula will thus take the following form considering the two factors;

$$P(X, Y) = aX + bY$$

I intentionally avoided factoring in a surge factor for several reasons; North Cyprus is a relatively sparsely populated island and is thus not affected by the malignant traffic experienced in densely populated cities. Moreover, by making the pricing dynamic and provisional, it is exposed to possible manipulation by drivers who could create artificial scarcity thus messing with the demand and supply equilibrium and trick the system into pricing rides extravagantly. (Yan et al, 2018)

Static pricing also works equally as well in our target market since it does not yield any less performance return than dynamic pricing. Dynamic pricing lets platforms optimize their static pricing even with imperfect knowledge of the system parameters (Riquelme et al, 2017). This is luckily not a problem we have to deal with since using just the duration and distance of the trip as system parameters and their linear relationship with regard to ride price, we can systematically come up with prices with a degree of certainty using static pricing that would barely be points off if we factored in any other dynamic data such as traffic and ride demand.

To establish the coefficients a and b for the formula, we will determine the covariance and correlation coefficient (r) of our data. If r is $\{ r \mid -1 \leq h \leq 1 \}$, we could then use multiple regression to predict the criterion variable in this case the value of the price (P) based on the duration *(X)* of the trip and the distance *(Y)* of the trip

Table 2. Regression Analysis for the Price Estimation Algorithm

	DURATION(X)	DISTANCE(Y)	X^2	Y^2	XY
1	11	8.4	121	70.56	92.4
2	8	5.4	64	29.16	43.2
2	9	6.5	81	42.25	58.5
4	27	24.6	729	605.16	664.2
5	20	22.3	400	497.29	446
6	49	57.5	2401	3306.25	2817.5
7	75	66.9	5625	4475.61	5017.5
8	38	22.2	1444	492.84	843.6
9	14	9	196	81	126
10	14	9.3	196	86.49	130.2
11	12	6.4	144	40.96	76.8
12	66	73.7	4356	5431.69	4864.2
	$\Sigma X = 343$	$\Sigma Y = 312.2$	$\Sigma X^2 = 15{,}757$	$\Sigma Y^2 = 15{,}159.26$	$\Sigma XY = 15{,}180.1$

From this table, the correlation coefficient *(r)* is **0.9666** which is close to 1 confirming the linearity of our variables. I then applied multiple regression to come up with the coefficients for X and Y

Using the above-mentioned procedure, we can establish the optimum coefficients *a* and *b* for variables *X* and *Y* to be **0.54** and **3.44** respectively.

All findings are then charted in the following table with the old pricing on one side, and the new price as established by the formula

Table 3. Contrasting old cab fares with new prices from the Price Estimation Algorithm

FROM	TO	DISTANCE IN KM	OLD PRICE	PEA PRICE
NEU	CITY CENTER	8.4	30	34.84
NEU	GONYELI	5.4	30	22.90
NEU	CHINA BAZAAR	6.5	30	27.22
NEU	ERCAN AIRPORT	24.6	120	99.20
NEU	GIRNE	22.3	150	87.51
GONYELI	MAGUSA	57.5	250	224.26
LEFKOSA	LEFKE	66.9	180	270.64
CIU	LEFKOSA	22.2	60	96.89
GONYELI	KUCUK KAYMAKLI	9	40	38.52
GONYELI	HAMITKOY	9.3	40	39.55
HAMITKOY	ORTAKOY	6.4	35	28.50
LEFKE	GIRNE	73.7	300	289.17
			Σ = 1265	Σ = 1,259.2

It is worth noticing that the total amount paid for both models remains fairly constant hence earnings for a driver who took part in all 12 trips would be the same. However, the price adjusts proportionally to the distance of the trip. For a shorter distance like Near East University which would've previously cost 30TL now costs 22.90TL. Moreover, for a longer distance like Lefkosa to Lefke, the trip cost increases from 180TL to 270TL for good reason too.

In future updates of this model, I will factor in other variables such as terrain of the trip particularly in long distance trips and fluctuations in the price of fuel to further improve the price estimation formula.

CHAPTER 4: SYSTEM ANALYSIS

4.1 SYSTEM FEATURES

CABEE as a platform will be divided into two mobile applications; the rider and driver apps.

The rider application will contain the following features;

1. Sign up and login
2. A booking interface
3. The price estimation algorithm abstracted from the user view
4. Payment gateways
5. Tracking API to check on ride status
6. Push notifications
7. Profile page with trip history

The driver application will contain the following features;

1. Sign up and login
2. Driver verification screen
3. Trip Data view for booked trips
4. Estimated Time of Arrival Screen
5. Payment acceptance gateways
6. Push notifications

Through the CABEE rider application, a user can;

1. Create an account
2. Enter their destination
3. Meet their driver
4. Monitor trip statistics
5. Rate the trip

4.2 SYSTEM CONTEXT DESIGN AND DEVELOPMENT

To analyze the problem, I used the Soft System Methodology to design context diagrams. I then use Rich Picture for problem domain identification. Rich Picture is a method of developing a preliminary mental model using express diagrams to explore, acknowledge and define a situation.

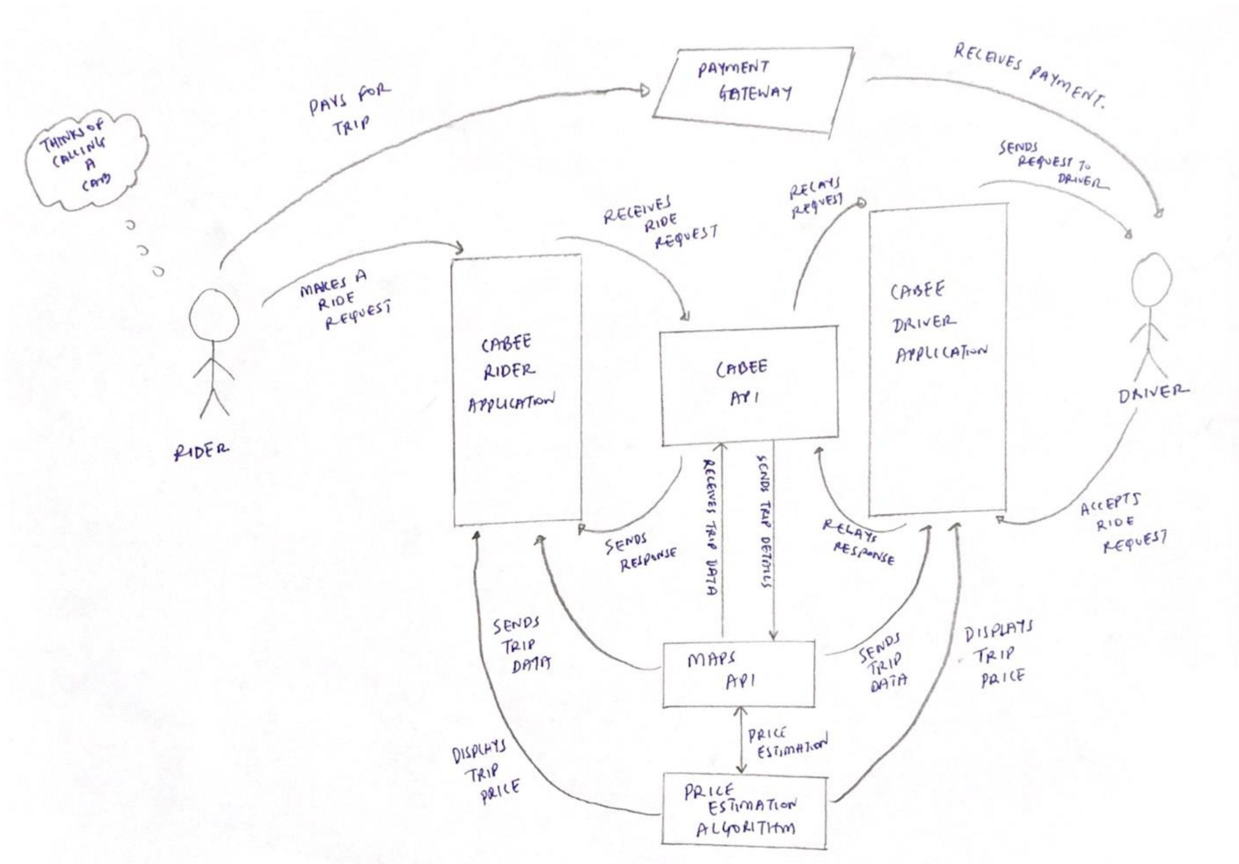

Figure 14: CABEE Platform Rich Picture

From this illustration, we can then derive the different functional and non-functional requirements, key actors and actions. We can then come up with a use case diagram for the system context design that is more understandable.

4.3 USE CASE DIAGRAM

The use case diagram is used to specify system requirements to make the platform functional and useful to the end users and functionality offered to the end users with regard to what the system can do.

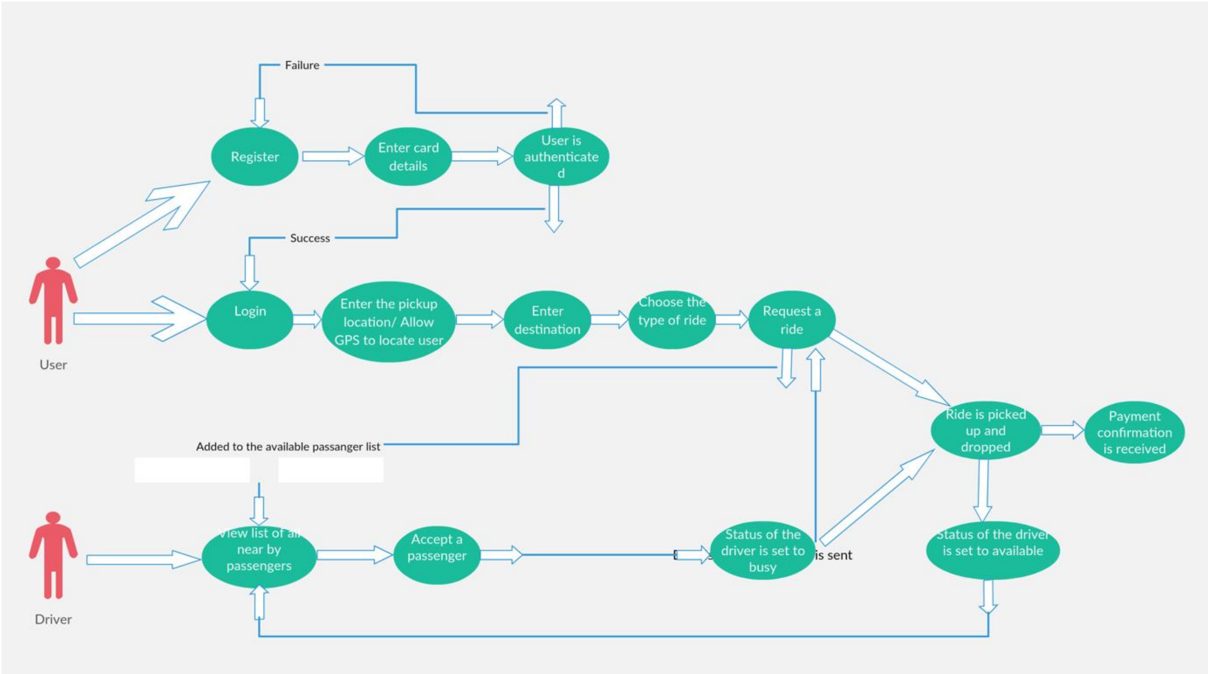

Figure 15: CABEE use case diagram

4.4 ENTITY RELATIONSHIP DIAGRAM

The entity relationship diagram is a graphical representation of all system relationships including people, objects, concepts and system events. It is made up of three basic components;

1. Entities: objects or concepts
2. Attributes: characteristics and properties of entities
3. Relationships: information between entities

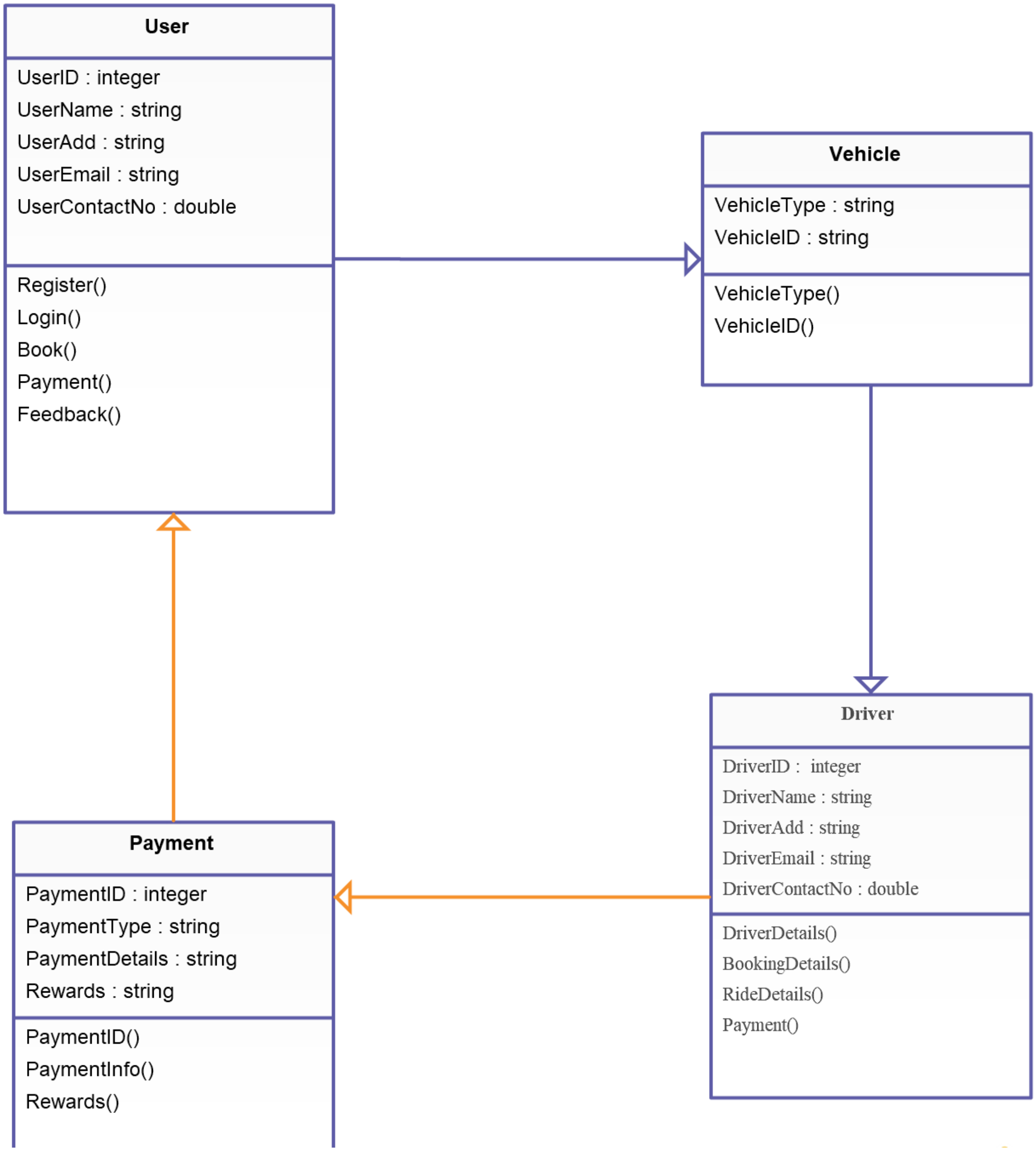

Figure 16: CABEE Entity Relationship Diagram

4.5 ACTIVITY DIAGRAMS

Activity diagrams are used to modeling the logic of a single use case scenario. I will highlight three scenarios in the following activity diagrams; ride request handling, during the ride and payment process

4.5.1 RIDE REQUEST HANDLING

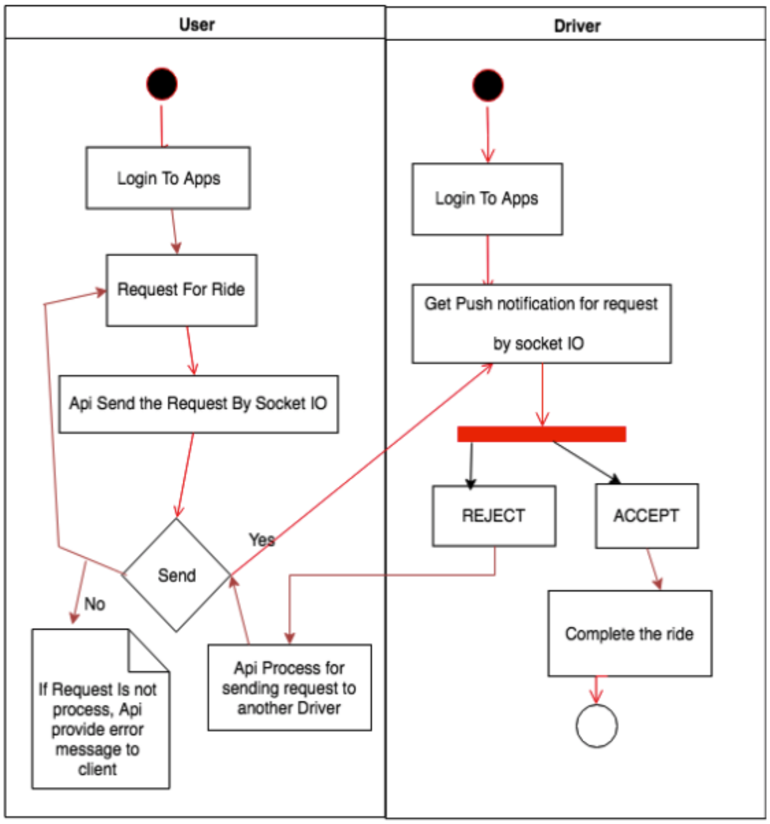

Figure 17: Ride Request Handling activity diagram

4.5.2 RIDE DURATION

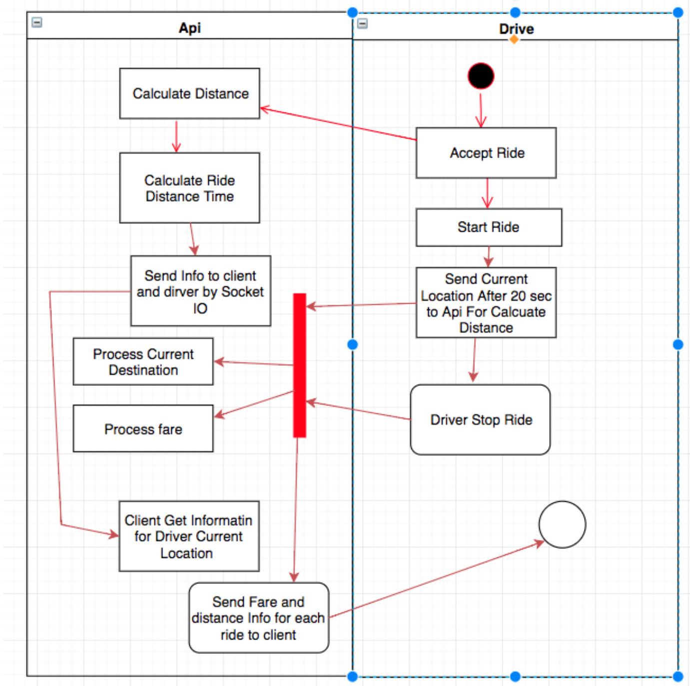

Figure 18: Activity diagram during the ride

4.5.3 PAYMENT PROCESS

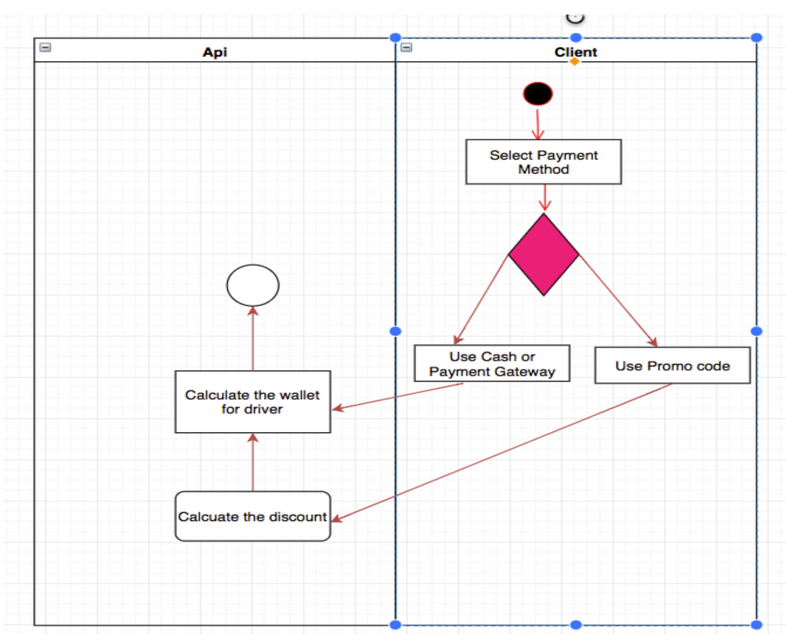

Figure 19: Activity diagram for payment gateway

CHAPTER 5: SYSTEM IMPLEMENTATION

5.1 WEBSITE USER INTERFACE

CABEE's landing page is hosted on GitHub and is developed using HTML, CSS, JavaScript and Bootstrap. The purpose of the landing page is to display the product description and redirect the user to download the app upon its completion.

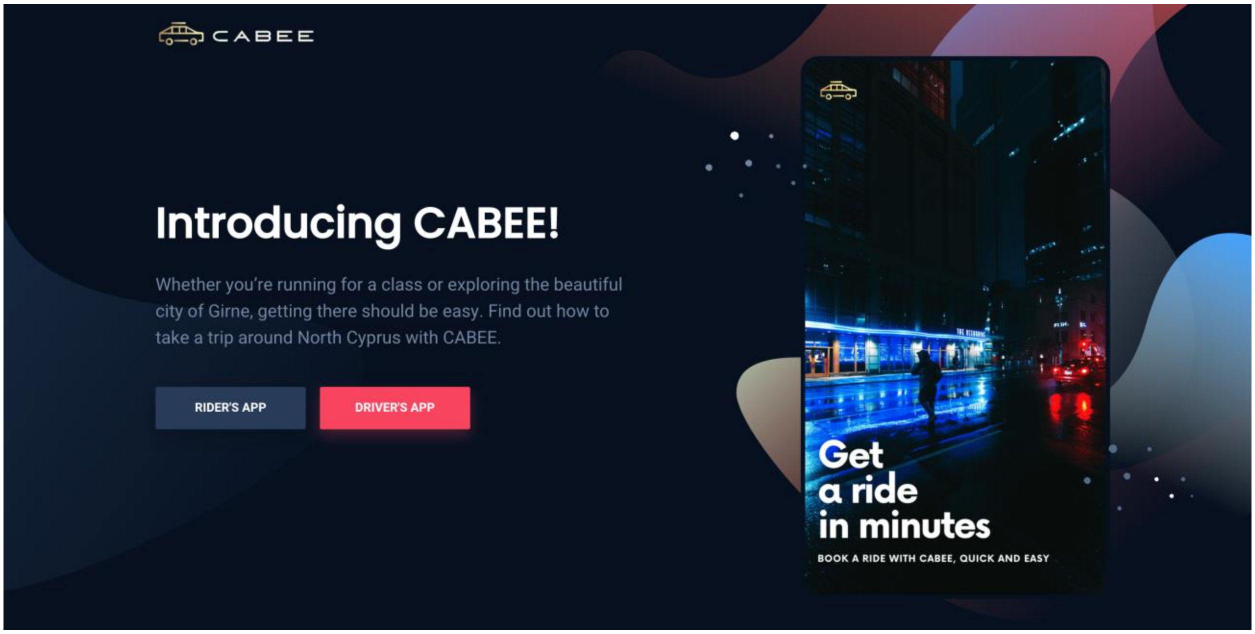

Figure 20: CABEE Landing Page

5.2 MOBILE APPLICATION USER INTERFACE USING REACT NATIVE

The initial version of the CABEE application was developed in Flutter early in April 2021. However, the null safety update that was rolled out soon after broke some key components in the application and I had to reevaluate the technology stack that I was using. I decided to develop the new applications in React Native for 2 reasons specifically;

1. React Native is now one of the most starred open-source projects on GitHub. It is developed by Facebook and makes it easy to develop beautiful user interfaces using widgets. Its hot reload feature and live expo server also makes it simple to compile and test the application without having to waste any time.
2. React Native is a cross platform mobile development framework which allows for the development of both the Android and IOS versions of CABEE using a single codebase.

The benefits of using React Native for a project of this nature is;

1. A single codebase speeds up the development process
2. User Interface screens are rendered in lightning speeds of up to 60 frames per second (fps)
3. Extensive catalogue of libraries that incorporates Material UI and Cupertino to create striking and expressive designs that are platform native
4.
5. Hot reload enables rapid testing and development and bug fixing in real time

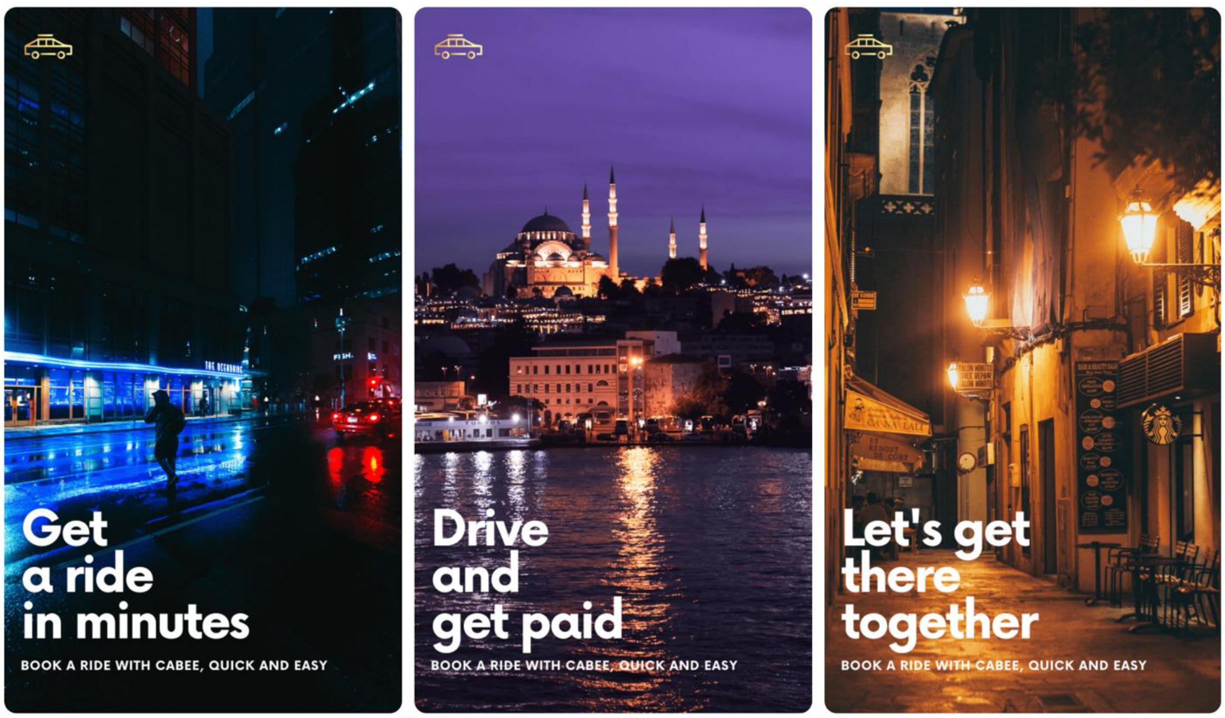

Figure 21: CABEE splash screens

All the screens for both the rider and driver mobile applications are developed in Flutter and simple logic such as onclick events are handled using Dart programming language

5.3 BACKEND USING GOOGLE FIREBASE

CABEE does not heavily rely on the backend as all transactions are handled in real time hence little activity logging happens in the background. Firebase is used in the application to handle user data such as rider and driver details used for authentication when signing up and logging in.

Firebase handles the authentication, real time database and storage of data. It is also used in this project to take care of push notification and to provide crash reports that happen at runtime when the platform is in use.

5.4 GOOGLE MAPS APIS FOR GEOLOCATION AND GEOCODING

CABEE heavily relies on *Google Maps* APIs for its core functionality. Since most of the app features such as searching for destination, displaying trip route and calculating the estimated time of arrival rely of maps, it is safe to say that *Google Maps* API is the backbone of CABEE.

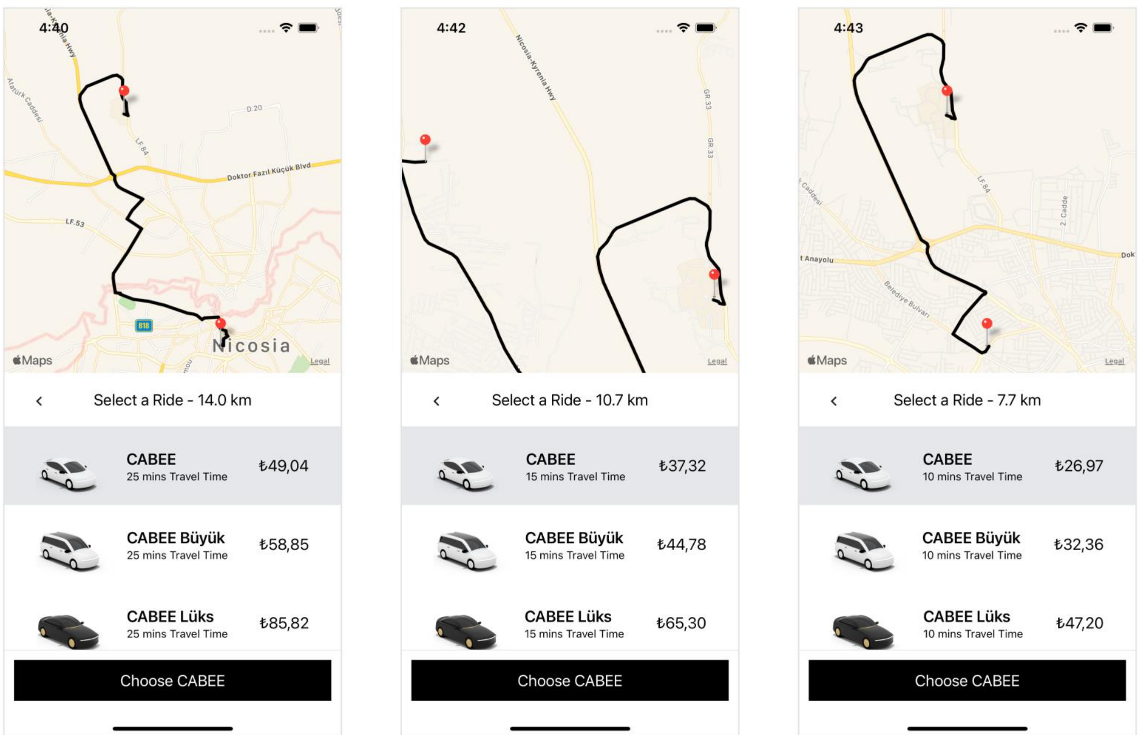

Figure 22: Trips happening in real time

CABEE uses the following *Google Maps* APIs for the following functions:

1. *Geocoding API* to convert addresses that are in human readable form to geographic coordinates like latitudes and longitudes which can then be used to place markers on the map. Reverse geocoding is also applied to convert geographic coordinates sent by the API into human readable addresses for the rider and driver

2. *Places API* returns information about places searched using HTTP requests. Definition of places within this API occurs in the form of geographic locations, establishments, or prominent points of interest.
3. *Geolocation API* is used to return the location of both entities involved with an accuracy radius.
4. *Directions API* is used to provide turn by turn directions for the trip

   CABEE uses the real time data provided by the *Google Maps* APIs mentioned to improve its pricing calculation, accurately determine the estimated time of arrival of the driver and optimize driver allocation in high traffic areas.

   Google Maps APIs greatly improve the user experience of CABEE by;

   1. Making it easy for the rider to hail a cab, calculating the estimated time of arrival of the driver, suggest the most cost effective and accurate route and recommend effective pickup points.
   2. Providing turn by turn directions and live traffic data.
   3. Maximizing fleet efficiency and optimizing dispatch by selecting the best driver for each trip requested.

5.5 USER STORY FROM START TO END OF A TRIP

All drivers registered on CABEE are tracked by geolocation using their latitude and longitude and their location is updated every 4 seconds and sent to the Firebase backend for logging and dispatch optimization.

When a rider requests a cab, the system draws a circle and filters out all nearby cabs by GPS coordinates. The coordinates of all available drivers are then sent to the Maps API to compute the Estimated Time of Arrival (ETA) and further sort out the ETA. Once sorted, the closest driver is offered the ride. The driver then receives the request through web socket and the location of the rider is tracked using GPS. The driver application then sends back the location and car details of the designated driver to the rider app for the rider's display.

The estimated duration and distance of the ride is then sent from the Maps API to the Price Estimation Algorithm and the price of the ride is then computed and displayed to both the rider and the driver before the trip starts.

The closest pickup point is then calculated and a pin is set on the map for the preferred access point. The driver's location is then tracked and updated on the rider's screen to see how close the driver is to the rider.

The trip billing only starts when the rider is in the car. Upon arrival, the trip ends and the rider can then pay the driver with their preferred means of payment. The rider and driver can then later on rate each other's experience on a five-point scale in the application

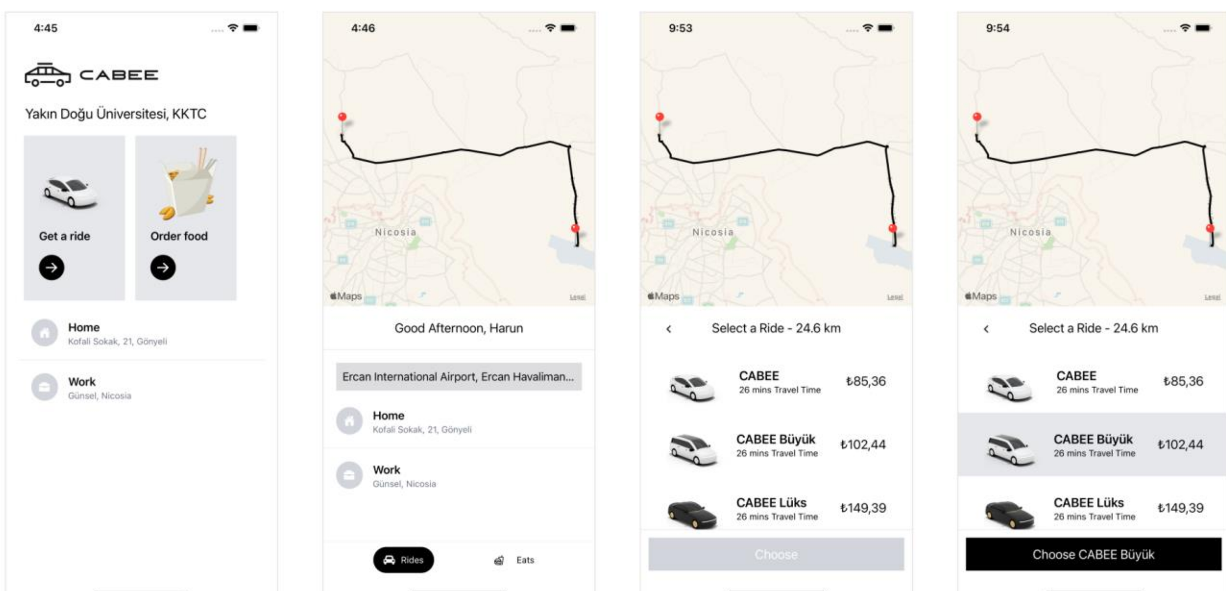

Figure 23: CABEE User Interface

It is worth noting that the ETA is calculated based on the road system and not geography. When a rider requests a ride, the system not only factors in available drivers, but also drivers close by who are about to finish a trip.

The entire road network is mapped by *Google Maps* and graphed to calculate the ETA. It uses graph theory or a simple *Dijkistra Algorithm* to find the best route. On the graph, *Google Maps* uses nodes to represent available cars and edges to represent roads. We can then find the best route using the *Dijkistra's Search Algorithm*.

The use of the *Dijkistra's Search Algorithm* optimizes driver utility and serves to minimize ETA of drivers to their requesting riders. Moreover, it significantly reduces driver's travel distance to their requesting riders and saves them gas fees that isn't factored into the ride pricing.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 FUTURE WORK

These are some research possibilities that can be included in further versions of CABEE;

1. Ability to schedule rides for a later time
2. An admin panel to manage platform statistics
3. Optimize pricing using trip data collected
4. Onboarding more drivers to increase platform utility
5. A group car sharing feature to allow trip sharing

Since CABEE is a peer-to-peer platform, I did not intend to levy a cut on the ride price for the platform owners for now. The only actors in this proposal are the rider and the driver and whatever the rider pays, the driver gets. In future versions when scaling up the project, applying a percentage cut on every trip might be a feasible option to assist in platform maintenance.

6.2 CONCLUSION

In this thesis, I presented a new way for users in North Cyprus to hail taxis and proposed a mathematical approach to coming up with the prices of said rides. Moreover, CABEE is fully peer to peer and does not include a middle man hence what the rider pays, the driver gets. This project demonstrated a fix to the pricing problem of taxis in North Cyprus. I believe that the adoption of this model will greatly enhance the experience of taxi riders in North Cyprus and concurrently improve earnings for drivers.

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APPENDICES

APPENDIX 1: USER MANUAL

CABEE is a cross platform mobile application developed by the author. It aims to provide users in North Cyprus particularly university going students with a platform to quickly and conveniently hail a taxi. Its implementation is based on both the Android and IOS operating systems.

Getting and Installing the application

Both rider and driver applications will be available upon completion on the Google Play Store and Apple App Store. The user can then install the application and begin using the platform.