RIDESHARING: Fair Cost Distribution

MTP Report submitted to

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of

B. Tech

by

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under the guidance of

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CERTIFICATE OF APPROVAL

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Faculty Advisor

CERTIFICATE

This is to certify that the thesis titled **Ridesharing: Fair cost distribution**, submitted by **Kumar Ashutosh**, to the Indian Institute of Technolog, Mandi, is a record of bonafide work under my (our) supervision and is worthy of consideration for the award of the degree of **B. Tech** of the Institute.

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DECLARATION BY THE STUDENT

This is to certify that the thesis titled **Ridesharing: Fair cost distribution**, submitted by me to the Indian Institute of Technology Mandi for the award of the degree of **B. Tech** is a bonafide record of work carried out by me under the supervision of **Dr. Siddhartha Sarma**. The contents of this MTP, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.

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Kumar Ashutosh

Abstract

Cab companies like OLA, Uber etc have come up with ride sharing as a solution to the increasing traffic congestion around the world. Ride sharing resulted in decrease in the number of vehicles which resulted in less carbon footprint. This makes ride sharing that is all the more desirable from sustainability perspective. The major motivation for cab companies to provide ridesharing services is attributed to the fact that ridesharing leads to cost savings for the service consumers and savings for the cab company due to less no of vehicles.The companies have different cost sharing schemes but most of them calculate costs on the basis of the distance covered by a passenger. But none of them take the inconvenience faced by the passengers during the ride into account while calculating the costs for a ride. So we are providing a modified cost sharing scheme which also accounts for the inconvenience caused to a passenger.

Keywords: *Individual Rationality, Sequential Individual Rationality*

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Abbreviations

IR	- Indiidual Rationality
SIR	- Sequential Individual Rationality
MPMD	- Multiple Pickup Multiple Drop
MPSD	- Multiple Pickup Single Drop
SPMD	- Single Pickup Multiple Drop
IC	- Inconvenience cost
OC	- Operational cost

Symbols

DU	- Disutility
OC	- Operational cost
IC	- Inconvenience cost
f	- Cost function

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Chapter 1

Introduction

Ridesharing has become a popular choice among people as well as the taxi service providing companies as it provide monetary benefits to the customers as well as the companies. But there are some shortcomings of ridesharing services. It introduces the problem of detours caused by passengers due to the different locations of pickups and drops. It increases the inconvenience passengers face during the ride. Although this problem is inevitable in ridesharing there are ways to compensate for the inconvenience a passenger suffer. One of such way is to provide monetary compensation to the passengers for the inconvenience they face. This can be done by modifying the cost sharing scheme used by the companies to distribute the cost among passengers. Our motivation comes from the idea that there is a possibility of a more user friendly cost sharing framework.

Our aim is to come up with an efficient cost sharing framework for real-time ridesharing and demonstrate the effectiveness of this scheme using simulations. In order to do this the concept of Sequential Individual Rationality (SIR) is introduced according to which the inconvenience is taken into account every time a passenger is picked up or dropped.

The scope of this project is limited to the modification of cost sharing framework for multiple pickup and multiple drop scenario. Routing aspect of the problem is out of scope of this project. The simulations to demonstrate the effectiveness of the cost sharing scheme try to depict the use of proposed scheme in real ridesharing scenario with some assumptions to reduce the complexity problem we are trying address.

Chapter 2

Background and Related Work

In the current scenario, company providing ridesharing services have cost sharing scheme suchthat the total cost is shared among the passengers proportional to the distance they travel.Even though the benefits of ridesharing are good for the society, many individual com-muters are reluctant to embrace ridesharing, despite the cost savings that would result. Severalfactors such as reliability, privacy, security, and delays contribute to the inconveniences due toridesharing. Therefore, for the average commuter, it may be easier to stick with their existingroutine that they are comfortable with, when faced with an often challenging decision processto determine whether the cost savings is worth the inconvenience.In order to increase the adoption of ridesharing, the routing, pricing, and cost sharingschemes must provide some benefits in order to compensate for the additional delay and costsavings in a way that ultimately incentivizes them to participate in ridesharing.

2.1 Related work

Individual rationality (IR) is a concept in ridesharing that requires that passengers are better off ridesharing than not, but by taking into account their disutilities only at the end of their ride. In that sense, it is a static property. To encourage wider adoption of ridesharing, we need to address the pain points of ridesharing passengers during the ride as well. An important class of such pain points is when the vehicle undertakes detours to pick up and drop off other passengers. In order to address this problem a stronger property that requires

that IR hold at every stage of the ride, that is, every time a new passenger is picked up has been proposed by Gopalakrishnan, Mukherjee and Tulabandhula in their paper titled " The Costs and Benefits of Ridesharing: Sequential Individual Rationalityand Sequential Fairness " [1]. This property is called sequential IR (SIR). This model for cost sharing explicitly takes into account the inconvenience costs experienced by passengers due to detours they endure as a result of other passengers being picked up and dropped off. SIR and some other notions given in their paper has been described in detail in this section.

2.1.1 Distance Functions

A routing algorithm $\mathcal{R}$ that, given any subset , will compute a route r_S (an ordered sequence of pickup/dropoff points) that serves all the passengers in S. Thus, the following distance functions can be used:

(1) For any subset $S \subseteq \mathcal{N}$, the total distance traveled along route r_S is denoted by $d(S; r_S)$.

(2) For any passenger $i \in \mathcal{N}$, and any subset $S \subseteq \mathcal{N}$ such that $i \in \mathcal{S}$, the total distance traveled along route r_S from S_i to D_i is denoted by $d_i(S; r_S)$.

2.1.2 Cost Functions

We define the following cost functions:

(1) Operational Cost: The operational cost of a ride involving a set of passengers $S \subseteq \mathcal{N}$, otherwise known as the meter fare, is defined as

$$\mathcal{OC}(S; r_S) = \alpha_{op} d(S; rS) \tag{2.1}$$

(2) Inconvenience Costs: In a ride involving a set of passengers S N, for each $i \in \mathcal{S}$, the inconvenience cost incurred due to other passengers is defined as

$$\mathcal{IC}_i(S; r_S) = \alpha_i(d_i(S; r_S) - d_i(i; r_{\{i\}})) \tag{2.2}$$

Here, $\alpha_{op} > 0$ is the price (in commercial ridesharing) per unit distance, and, for each passenger $i \in \mathcal{S}$, $\alpha_i \geq 0$ is the inconvenience cost of i per unit distance.

2.1.3 Cost Sharing Scheme

A cost sharing scheme f is a function that specifies, for any subset $S \subseteq \mathcal{N}$, how $\mathcal{OC}(S\,; r_S)$ is distributed among the passengers in S. That is, $f(i; S\,; r_S)$ denotes the portion of $\mathcal{OC}(S\,; r_S)$ allocated to passenger $i \in \mathcal{S}$. We set $f(i; S\,; r_S) = 0$ whenever $i \notin S$.

A cost sharing scheme f is budget-balanced if it exactly recovers the operational cost of a ride, that is,

$$\sum_{i \in \mathcal{S}} f(i; S\,; r_S) = \mathcal{OC}(S\,; r_S) \qquad \forall \quad S \subseteq \mathcal{N}. \tag{2.3}$$

2.1.4 Disutility and Individual Rationality

When a subset of passengers $S \subseteq \mathcal{N}$ share a ride, the disutility to a passenger $i \in \mathcal{S}$ is defined as the sum of their monetary payment for the ride and their inconvenience cost due to any detours, that is,

$$\mathcal{DU}_i(S\,; r_S) = f(i; S\,; r_S) + \mathcal{IC}_i(S\,; r_S) \tag{2.4}$$

A cost sharing scheme f is individually rational (IR) on route $r_{\mathcal{N}}$ if

$$\mathcal{DU}_i(N; r_N) \leq \mathcal{DU}_i(\{i\}; r_{\{i\}}) \qquad \forall \quad i \in \mathcal{N}. \tag{2.5}$$

A route $r_{\mathcal{N}}$ is IR-feasible if there exists a budget-balanced cost sharing scheme f that is IR on $r_{\mathcal{N}}$.

2.1.5 Sequential Individual Rationality

Let $i \in \mathcal{N}$ be the i-th passenger to be picked up, in the route $r_{\mathcal{N}}$. Let $\mathcal{T} = \{t_1, t_2, ..., t_n\}$ denote the set of pickup times, that is, t_i denotes the time at which i-th passenger is picked up

according to route $r_{\mathcal{N}}$. Let S(i) = {1,2,...,i} denote the set of passengers that have been picked up upto time t_i. Route $r_{\mathcal{N}}\ t$ denotes the route identical to $r_{\mathcal{N}}$ up to time t, but thereafter does not pick up any more passengers, and proceeding only to drop the remaining passengers.

The disutility of a passenger $i \in \mathcal{N}$ at time $t_j \in \mathcal{T}$ is defined as

$$\mathcal{DU}_i(t_j) = \begin{cases} \mathcal{DU}_i(\{S(j); r_{\mathcal{N}}(t_j)\} & \forall \quad i \in S(j). \\ \mathcal{DU}_i(\{i\}; r_{\{i\}}) & otherwise \end{cases} \tag{2.6}$$

A cost sharing scheme f is *sequentiallyindividuallyrational* (SIR) on route $r_{\mathcal{N}}$ if

$$\mathcal{DU}_i(t_j) \leq \mathcal{DU}_i(t_{j-1}) \qquad \forall \quad 2 \leq j \leq n \quad \forall \quad i \in \mathcal{N}. \tag{2.7}$$

A route $r_{\mathcal{N}}$ is SIR-feasible if there exists a budget-balanced cost sharing scheme f that is SIR on $r_{\mathcal{N}}$.

Chapter 3

Work Done

The simulation of the multiple pickup and multiple drop (MPMD) scenario is a complex problem to address which can divided into following two sub problems:

- **Multiple pickup single drop (MPSD) :** All the sources are the sources of MPMD problem and the destination is the destination closest to the last pickup
- **Single pickup multiple drop (SPMD) :** The single source is the last source of the multiple pickup single drop problem. All the destinations are the destinations of MPMD problem in rearranged in the following order :
  - First destination is the destination closest to the single source.
  - Consecutive destinations are the destination closest to the preceding destination.

3.1 Multiple Pickup Single Drop scenario

3.1.1 Model for Cost Sharing in Ridesharing

The distance functions and cost functions for the MPSD scenario are defined in following sections.

3.1.2 Distance Functions

A routing algorithm $\mathcal{R}$ that, given any subset , will compute a route r_S (an ordered sequence of pickup/dropoff points) that serves all the passengers in S. Thus, the following distance functions were used:

(1) For any subset $S \subseteq \mathcal{N}$, the total distance traveled along route r_S is denoted by $d(S; r_S)$.

(2) For any passenger $i \in \mathcal{N}$, and any subset $S \subseteq \mathcal{N}$ such that $i \in \mathcal{S}$, the total distance traveled along route r_S from S_i to D_i is denoted by $d_i(S; r_S)$.

3.1.3 Cost Functions

We defined the following cost functions:

(1) Operational Cost: The operational cost of a ride involving a set of passengers $S \subseteq \mathcal{N}$, otherwise known as the meter fare, is defined as

$$\mathcal{OC}(S; r_S) = \alpha_{op} d(S; rS) \tag{3.1}$$

(2) Inconvenience Costs: In a ride involving a set of passengers S N, for each $i \in \mathcal{S}$, the inconvenience cost incurred due to other passengers is defined as

$$\mathcal{IC}_i(S; r_S) = \alpha_i(d_i(S; r_S) - d_i(i; r_{\{i\}})) \tag{3.2}$$

Here, $\alpha_{op} > 0$ is the price (in commercial ridesharing) per unit distance, and, for each passenger $i \in \mathcal{S}$, $\alpha_i \geq 0$ is the inconvenience cost of i per unit distance.

3.1.4 Cost sharing scheme

The cost function for our scheme has following 3 components:

(1) The operational cost of each segment of the ride is equally distributed, among the ridesharing passengers at that time.

$$\mathbf{f_1(i, S(j))} = \alpha_{\mathbf{op}}\Big(\sum_{\mathbf{k=i+1}}^{\mathbf{j}} \frac{\mathbf{S_{k-1}S_k}}{\mathbf{k-1}} + \frac{\mathbf{S_jD}}{\mathbf{j}}\Big), \quad \mathbf{1 \le i \le j \le n}. \tag{3.3}$$

(2) Total amount for any passenger i after compensating all $'i-1'$ passengers due to the detour it takes.

$$\mathbf{f_2(i, S(j))} = \alpha_{\mathbf{i}}\mathbf{(i-1)(S_{i-1}S_i + S_iD - S_{i-1}D)}, \quad \mathbf{1 \le i \le j \le n}. \tag{3.4}$$

(3) Total monetary benefit received as a compensation by the i-th passenger due to the inconvenience caused to him during the ride.

$$\mathbf{f_3(i, S(j))} = \sum_{\mathbf{k=i+1}}^{\mathbf{j}} \alpha_{\mathbf{k}}\mathbf{(S_{k-1}S_k + S_kD - S_{k-1}D)}, \quad \mathbf{1 \le i \le j \le n}. \tag{3.5}$$

Cost function that takes into account all the above mentioned costs:

$$\mathbf{f(i, S(j))} = \mathbf{f_1(i, S(j)) + f_2(i, S(j)) - f_3(i, S(j))}, \quad \mathbf{1 \le i \le j \le n}. \tag{3.6}$$

3.2 Single Pickup Multiple Drop scenario

The distance functions and cost functions for the MPSD scenario are defined in following sections.

3.2.1 The distance and cost functions

$D(j) = \{1,2,...,j\}$ denotes the set of passengers that are to be picked up from a single pickup point denoted by {S}. Let $\{D, D_2, ..., D_j\}$ denotes the set of drop locations for each of the picked up passenger. The distance functions become:

$$d(D(j)) = S\,D_1 + \sum_{k=1}^{j-1} D_k D_{k+1}, \qquad 1 \le j \le n. \tag{3.7}$$

$$d_i(D(j)) = SD_1 + \sum_{k=1}^{i-1} D_k D_{k+1}, \quad 1 \le i \le j \le n. \tag{3.8}$$

The cost functions become

$$\mathcal{OC}(D; r_D) = \alpha_{op} d(D(j)) = \alpha_{op}\Big(SD_1 + \sum_{k=1}^{i-1} D_k D_{k+1}\Big), \quad 1 \le j \le n. \tag{3.9}$$

$$\mathcal{IC}_i(D(j)) = \alpha_i(d_i(D(j)) - d_i(i)) = \alpha_i\Big(SD_1 + \sum_{k=1}^{i-1} D_k D_{k+1} - SD_i\Big), \quad 1 \le i \le j \le n. \tag{3.10}$$

The disutilities are given by

$$\mathcal{DU}_i(D(j)) = f(i, D(j)) + \alpha_i\Big(SD_1 + \sum_{k=1}^{i-1} D_k D_{k+1} - SD_i\Big), \quad 1 \le i \le j \le n. \tag{3.11}$$

3.2.2 Cost Sharing Scheme

A fair cost sharing scheme similar to the scheme for MP-SD is described as follows:

1. Dividing the operational cost of each segment equally, among the ridesharing passengers.

$$f_1(i, D(j)) = \alpha_{op}\Big(\frac{SD_1}{j} + \sum_{k=1}^{i-1} \frac{D_k D_{k+1}}{j-k}\Big), \quad 1 \le i \le j \le n. \tag{3.12}$$

2. A passenger i, compensating all $'j - i'$ passengers due to the detour taken for it takes.

$$f_2(i, D(j)) = \alpha_i(j-i)(SD_i + D_i D_{i+1} - SD_{i+1}), \quad 1 \le i \le j \le n. \tag{3.13}$$

3. The compensation that the i-th passenger receives due to the inconvenience caused to it.

$$f_3(i, D(j)) = \sum_{k=1}^{i-1} \alpha_k(SD_k + D_k D_{k+1} - SD_{k+1}), \quad 1 \le i \le j \le n. \tag{3.14}$$

A cost sharing scheme for SP-MD scenario becomes:

$$f(i, D(j)) = f_1(i, D(j)) + f_2(i, D(j)) - f_3(i, D(j)), \quad 1 \le i \le j \le n. \tag{3.15}$$

3.3 Multiple Pickup Multiple Drop scenario

As stated earlier we are analyzing the the problem of MPMD by breaking it into two sub problems (which are mentioned in the above sections). This means we are handling the issue of detours due to pickups and drops seperately.

3.3.1 The disutility of passengers

In case of MPMD, the disutility of a passenger at any stage t_j of rideshare can be given by the sum of disutilities of the passenger in the subpaths MP-SD and SP-MD, at that stage

$$\mathcal{DU}_i(t_j) = \mathcal{DU}_i(S(j); r_S(t_j)) + \mathcal{DU}_i(D(j); r_D(t_j)) \quad i \in S(j) \tag{3.16}$$

Sequential Individual Rationality requires that the disutility of each passenger should not increase at any stage of ridesharing. This means that the disutilities of the passengers should not increasee in the two subpaths upon addition of a passenger in ridesharing. It follows that their sum would also not increase at any stage of ridesharing.

3.3.2 Cost Sharing Scheme

The cost shares of the passengers can be obtained by adding their shares in the two subpaths, and handling the operational cost of the segment which is common to both subpaths, only once.

1. Dividing the operational cost of each segment equally, among the ridesharing passengers.

$$f_1(i, t_j) = f_1(i, S(j)) + f_1(i, D(j)) - \alpha_{op}\left(\frac{S_j D^1_{x_1}}{j}\right), \quad 1 \le i \le j \le n. \tag{3.17}$$

2. A passenger i, compensating all $'j - i'$ passengers due to the detour taken for it takes.

$$f_2(i, t_j) = f_2(i, S(j)) + f_2(i, D(j)), \quad 1 \le i \le j \le n. \tag{3.18}$$

3. The compensation that the i-th passenger receives due to the inconvenience caused to it.

$$f_3(i, t_j) = f_3(i, S(j)) + f_3(i, D(j)), \quad 1 \leq i \leq j \leq n. \tag{3.19}$$

Overall cost shares for $i^{(}th)$ passenger at the stage in which j passengers participate in ridesharing:

$$f(i, t_j) = f_1(i, t_j) + f_2(i, t_j) - f_3(i, t_j), \quad 1 \leq i \leq j \leq n. \tag{3.20}$$

Chapter 4

Exerimental Studies and Results

In order to depict the real world scenario of ridesharing we are using a grid which represents a city like model. Now, the passengers are generated randomly throughout the grid i.e., random pickup and drop points associated with passengers are generated. Following are the generalized steps followed to generate the SIR feasible path to accommodate the randomly generated passengers.

(1) For every passenger as a source passenger check for every other passengers as potential next passenger.

(2) If it gives a SIR feasible point, then select the point.

(3) After considering all passenger select the passenger which minimizes the Inconvenience Cost of previous passenger.

(4) repeat step (2) and (3) until 4 passengers have been picked up, or all passengers have been considered and none of them gives SIR feasible route.

(5) Now the SIR feasible routes are sorted in descending order of number of passengers. If two routes have same number of passenger choose the one with higher operational cost, to maximize the service providers revenue.

(6) Remove the passengers of the selected route from the passenger space, and start from step (1) until all the passengers are assigned a cab.

The program has been run several times to get the data set of different costs associated with the passengers.

4.1 Results for Multiple pickup single drop scenario

4.1.1 SIR feasible region

Following is the route for which SIR feasible region is shown.

Route: $(62, 10) \rightarrow (49, 11) \rightarrow (33, 10) \rightarrow (29, 10) \rightarrow (9, 12)$

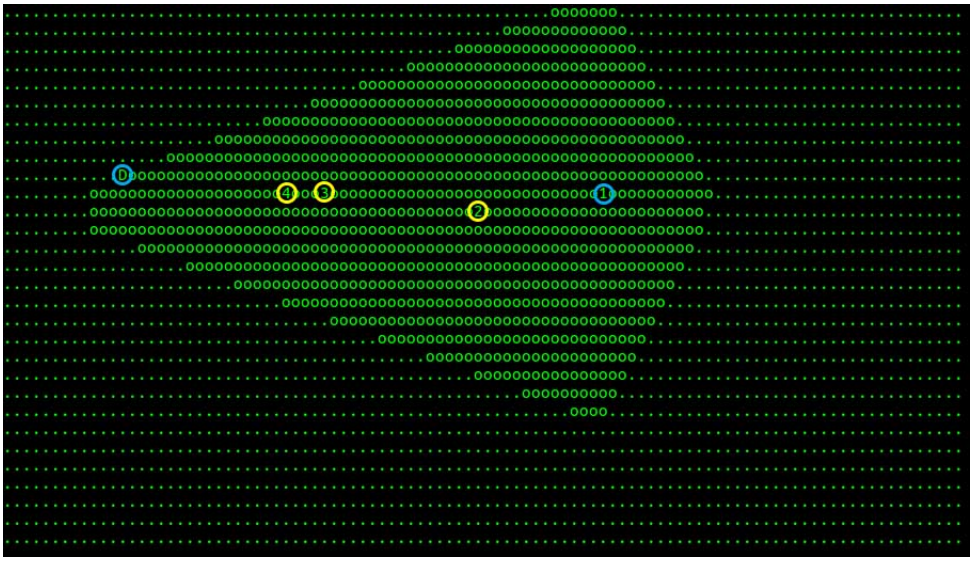

Fig. 4.1: SIR feasible region for first passenger

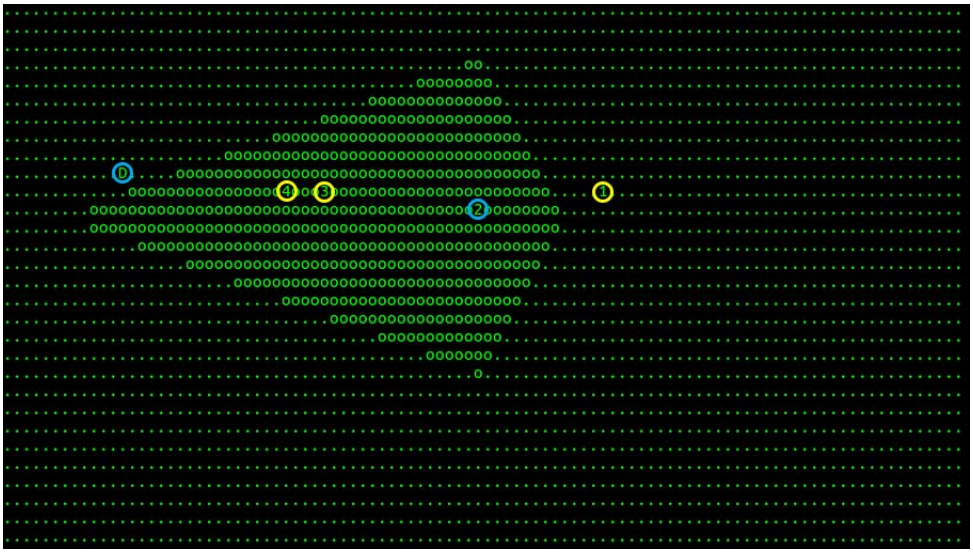

Fig. 4.2: SIR feasible region for second passenger

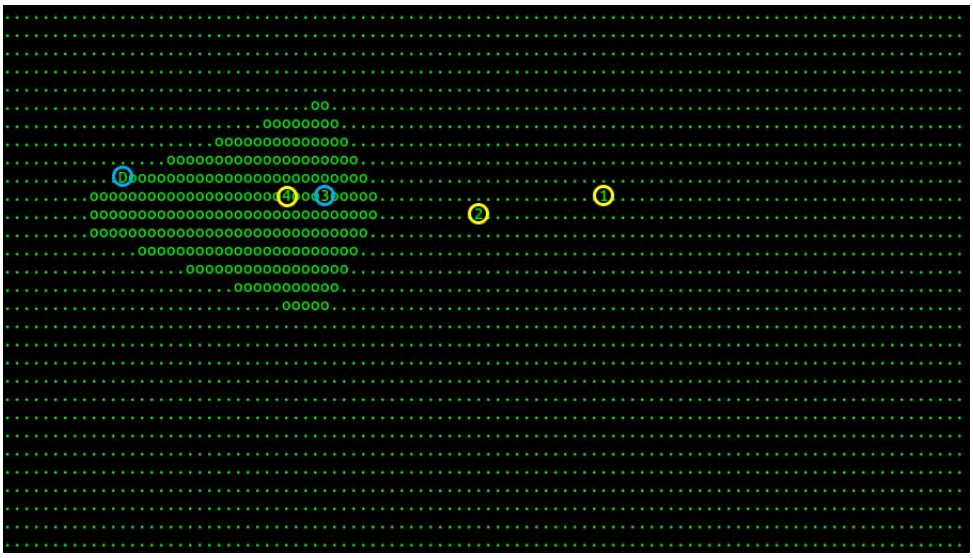

Fig. 4.3: SIR feasible region for third passenger

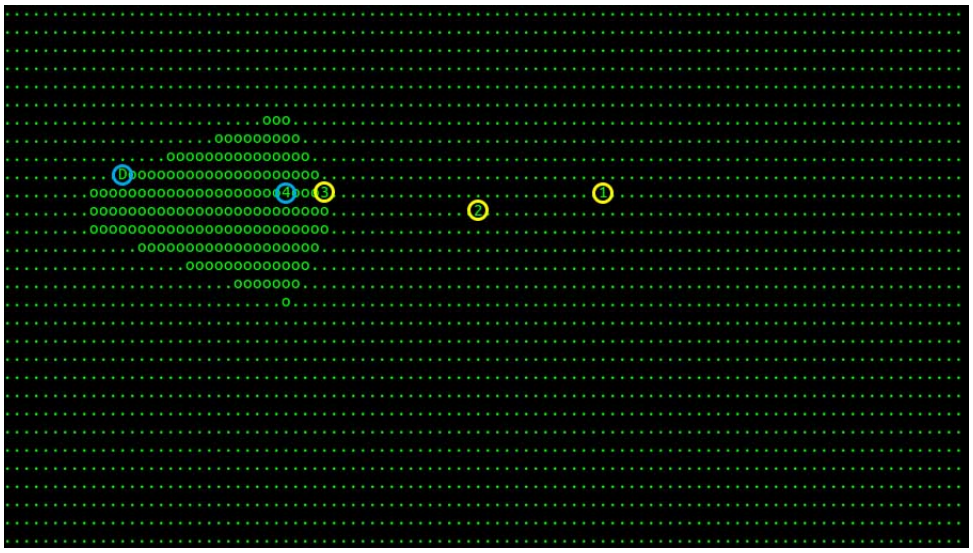

Fig. 4.4: SIR feasible region for fourth passenger

From above figures we observe that the shape of the SIR feasible region given a passenger and a destination is similar to the shape of a tear drop as shown in fig:1. Also the SIR feasible region for new passenger is a subset of the SIR feasible regions of existing passengers.

4.1.2 Cost comparison between the cost sharing framework for MPSD scenario

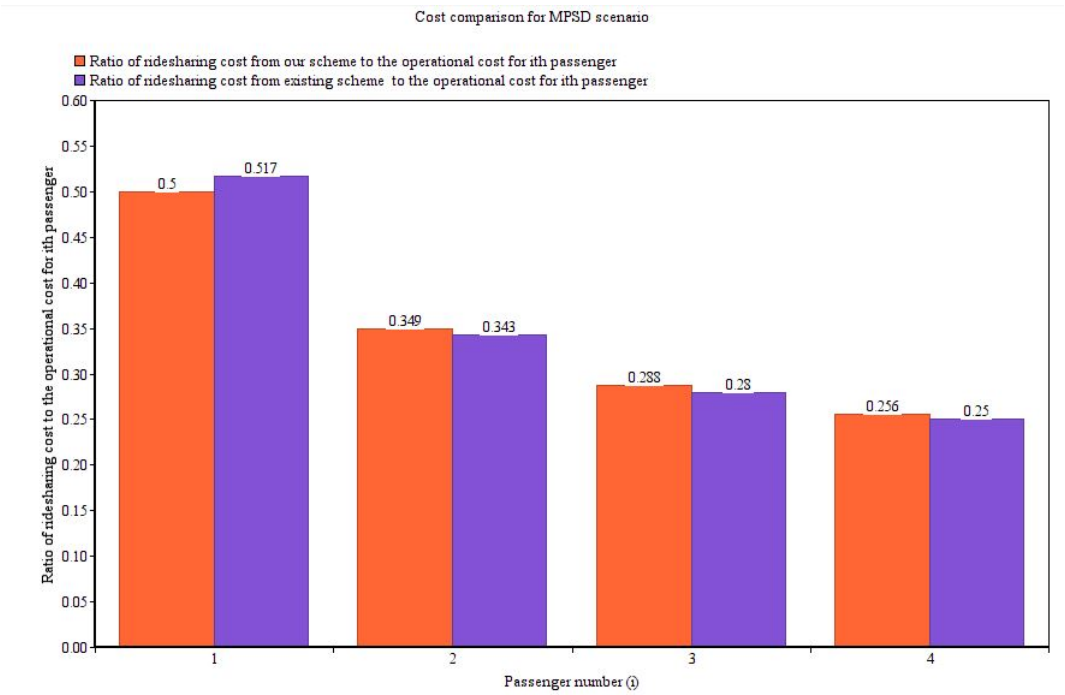

Fig. 4.5: Graph showing the ration of ridesharing costs to the operational cost for every passenger for both the cost sharing scheme for MPSD scenario (for all routes containing 4 passengers)

The above plot does the cost cost comparision between the two cost schemes for MPSD scenario.

NOTE:

* For every passenger the costs have been normalized with the operational cost for their source and destination i.e., the cost they would have paid if travelled alone.

* The values in the graph are averages of the values from data set.

Color coding :

Orange : Normalised cost from proposed scheme

Voilet : Normalised cost from traditional scheme

The data set used to plot the graph consists of the costs for all paths we got containing **4** passengers after running the program **1000** times.Grid size used was **200 X 200** with **100**

randomly generated passengers.

4.1.3 Histogram showing frequency of no of paths for MPSD scenario

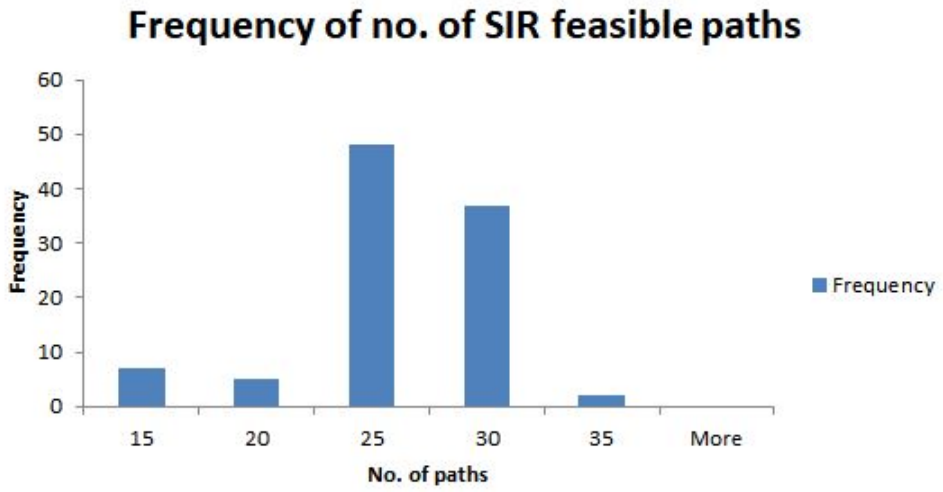

Fig. 4.6: Histogram showing frequency of no of paths for MPSD scenario

The above histogram shows the frequency of the no of routes with (3 or 4 passengers) we get after running the program for 100 times for MPSD. For ex. from the above graph we can see that for around 50 out of 100 times we got 20 to 25 routes containing 3 or 4 passengers

4.2 Results for Single pickup multiple drop scenario

4.2.1 Cost comparison between the cost sharing frameworks for SPMD scenario

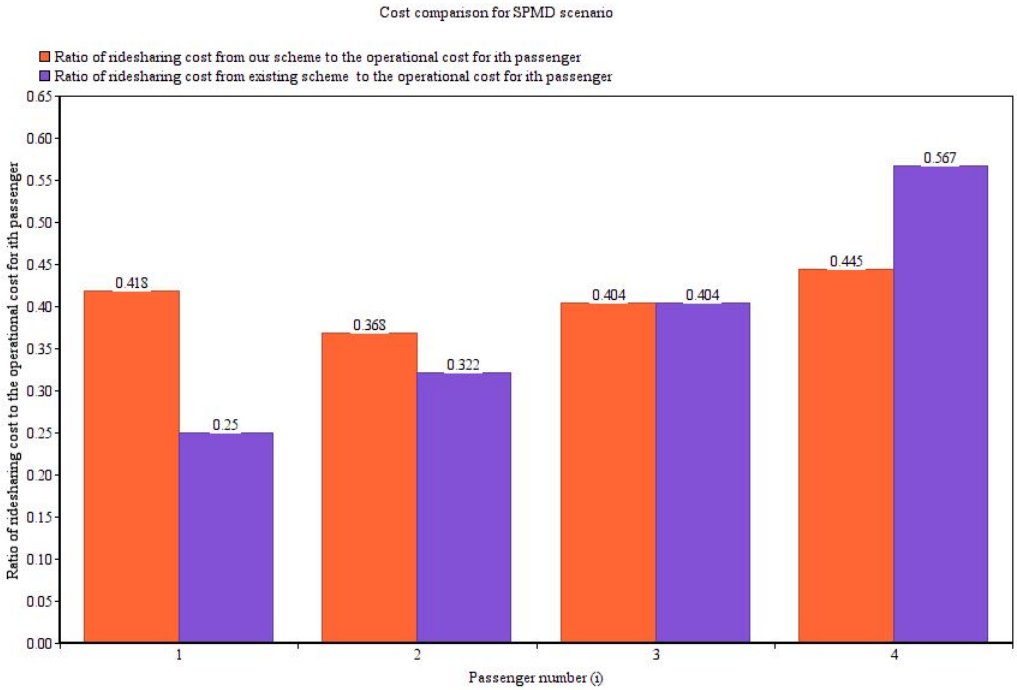

Fig. 4.7: Graph showing the ration of ridesharing costs to the operational cost for every passenger for both the cost sharing scheme for SPMD scenario (for all routes containing 4 passengers)

The above plot does the cost comparision between the two cost schemes for SPMD scenario.
NOTE: *For every passenger the costs have been normalized with the operational cost for their source and destination i.e., the cost they would have paid if travelled alone.
* The values in the graph are averages of the values from data set.
Color coding :
Orange : Normalised cost from proposed scheme
Voilet : Normalised cost from traditional scheme data set used to plot the graph consists of the costs for all paths we got containing **4** passengers after running the program **1000** times.Grid size used was **200 X 200** with **100** randomly generated passengers.

4.2.2 Histogram showing frequency of no of paths for SPMD scenario

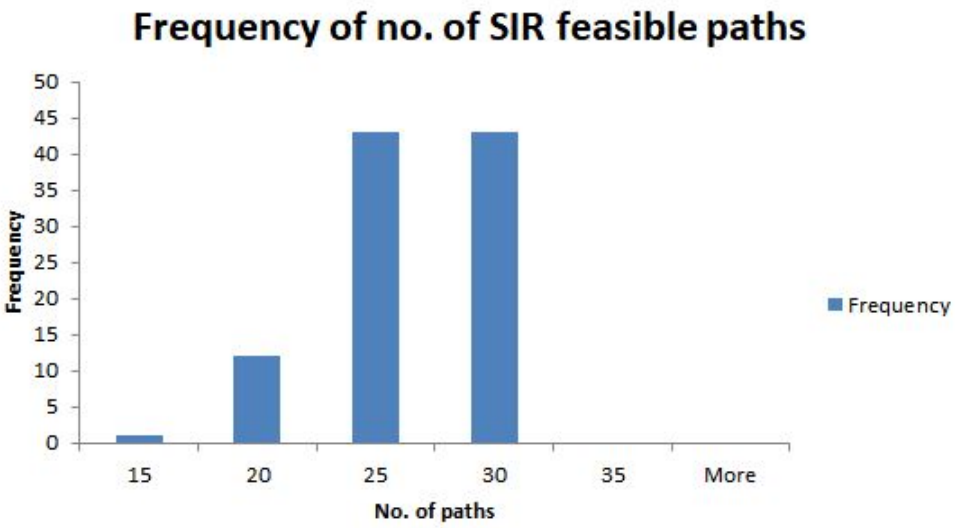

Fig. 4.8: Histogram showing frequency of no of paths for SPMD scenario

The above histogram shows the frequency of the no of routes with (3 or 4 passengers) we get after running the program for 100 times for SPMD.

4.3 Results for Multiple pickup multiple drop scenario

4.3.1 Cost comparison between the cost sharing frameworks for MPMD scenario

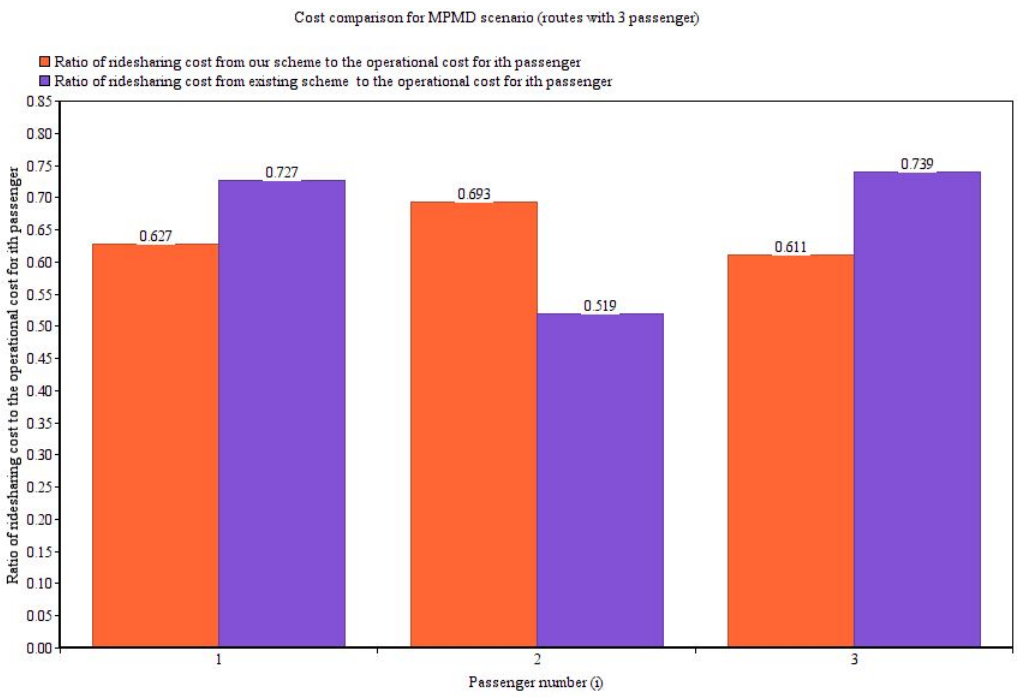

Fig. 4.9: Graph showing the ration of ridesharing costs to the operational cost for every passenger for both the cost sharing scheme for MPMD scenario (for all routes containing 3 passengers)

The above plot does the cost comparision between the two cost schemes for MPMD scenario.

NOTE:

*For every passenger the costs have been normalized with the operational cost for their source and destination i.e., the cost they would have paid if travelled alone.

* The values in the graph are averages of the values from data set.

Color coding :

Orange : Normalised cost from proposed scheme

Voilet : Normalised cost from traditional scheme

The data set used to plot the graph consists of the costs for all paths we got containing **3** passengers after running the program **1000** times.Grid size used was **200 X 200with**

f500 domly generated passengers.

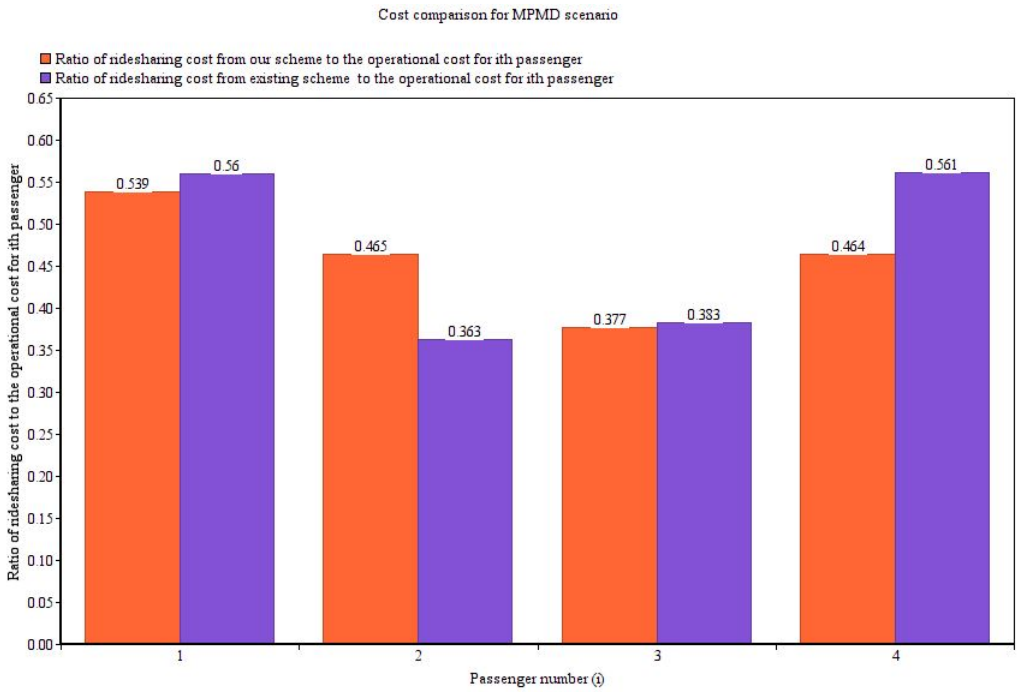

Fig. 4.10: Graph showing the ration of ridesharing costs to the operational cost for every passenger for both the cost sharing scheme for MPMD scenario (for all routes containing 4 passengers)

The above plot does the cost comparision between the two cost schemes for MPMD scenario.

NOTE: *For every passenger the costs have been normalized with the operational cost for their source and destination i.e., the cost they would have paid if travelled alone.

* The values in the graph are averages of the values from data set.

Color coding :

Orange : Normalised cost from proposed scheme

Voilet : Normalised cost from traditional scheme

The data set used to plot the graph consists of the costs for all paths we got containing **4** passengers after running the program **1000** times.Grid size used was **200 X 200** with **500**

randomly generated passengers.

4.3.2 Histogram showing frequency of no of paths for MPMD scenario

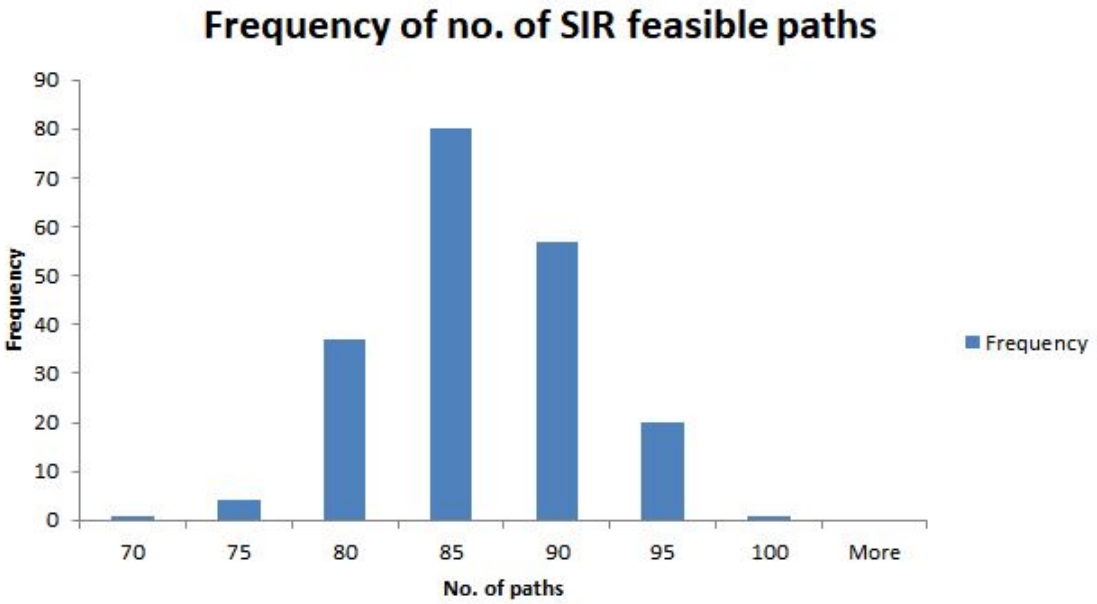

Fig. 4.11: Histogram showing frequency of no of paths for MPMD scenario

The above histogram shows the frequency of the no of routes with (3 or 4 passengers) we get after running the program for 200 times for MPMD.

Chapter 5

Conclusion and Future Work

5.1 Conclusion

The above results show that the passengers are better off with ridesharing than not for both the cost sharing framework. They also capture the difference between the costs calculated with the proposed framework and costs calculated with the traditional framework. This difference comes due to the internal monetary transfers between the passengers in order to compensate for the inconvenience they cause as well as the inconvenience they suffer during a ride. The costs calculated with proposed scheme are budget balanced i.e.; the total costs (operational cost) for a ride calculated with both the frameworks should be same. Due to this property some of the passengers get benefited from the internal monetary transfer where as some passengers pay extra compared to the cost with the traditional scheme.

5.2 Future Work

The concept of Sequential individual rationality enables us to introduce a new concept in ridesharing scenario where the passenger can initially decide the amount he is willing to pay and the ridesharing service provider will provide a route to the passenger accordingly. In this process the participant may need to change vehicles to complete the journey with the money constraint.The amount user can set for his/her ride will have a limit which will be provided by the ridesharing service provider.The limit will depend on the route and the availability of

vehicles.

Also, there exists a possibility to look for more optimal cost coefficients which are being used in the cost functions. The optimization of the cost functions can be done so that the passengers can get maximum benefits after compensating others and getting compensations from other passengers participating in ridesharing.

References

[1] Gopalkrishan, R., "The costs and benefits of ridesharing: Sequential individual rationality and sequential fairness."

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