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Scalable and Synchronized City-Scale Taxi Sharing

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ABSTRACT

A scalable and synchronized city-scale taxi sharing system that accepts passenger real-time requests and assigns proper taxi based on time, capacity, and monetary constraint has been developed. The monetary constraints provide inducement for both passengers and drivers .Scalable and synchronized city-scale taxi sharing system mainly concern the efficiency and scalability of ridesharing i.e. how fast a query can be answered and how many queries the system can handle. Passengers and drivers use the taxi-sharing service provided by the system via a smart phone App. To this end, a mobile- cloud architecture based taxi sharing system is devised to accomplish this end. The Cloud first finds the candidate taxi quickly for a passenger request using a taxi searching algorithm supported by a spatio-temporal index. A scheduling process is then performed in the cloud to select a taxi that satisfies the request with minimum increase in travel distance. The Proposed system demonstrated its efficacy, effectiveness and scalability

Keywords:- Taxi, Carpool

I. INTRODUCTION

Taxi is an important mode of transportation between the public and the private transportations, delivering millions of passengers to different locations in urban areas. However, passenger demand for taxi cab depends not only on the price of a ride, but also on the waiting time. The vacant taxi cruising on roads not only wastes the time of a taxi driver, but also generates additional traffic in a city. The main problems of transportation are traffic jams and parking. Taxi demands are usually much higher than the number of taxis in the peak hours of major cities, resulting in that many people spending a long time on road-sides before getting a taxi. Increasing the number of taxis seems to be an obvious solution. But it brings-in some negative effects, such as causing additional traffic on the road surface, consequently more consumption of energy and decreasing the income of taxi drivers.

II. LITERATURE SURVEY

This section demonstrates the problems in taxi recommendation and dispatching service and carpooling service.

2.1. TAXI RECOMMENDATION AND DISPATCHING:

Taxi Recommendation and dispatching services are designed from the perspective of taxi drivers only. They suggest some parking places for individual taxi drivers towards which they can find passengers quickly and maximize the profit of the next trip.

2.2. CARPOOL SERVICE:

Carpool often refers to ride-sharing which deals with routine commutes. In carpooling driver need to change their routes due to ride- sharing.

The probability of picking up the next passenger is

$$S = \bigcup_{i=1}^{n+1} S_i$$

S – it indicates that driver succeeds in picking up the next passenger.

S_i – it is the event that the driver pick up a passenger at the parking place where i=1,2---n [1].

Lagrangean coloumn generation is used to solve the carpooling problem [2].

Taxi trajectories are aggregated and mined in the cloud to answer queries from ordinary drivers [3].

Estimated time with the real travel time using ErrorRatio(ER) has been compared [4].

$$ER = \frac{estimated\ time - real\ travel\ time}{real\ travel\ time}$$

The pickup and delivery problem with time windows involves minimum cost routes for those vehicles which satisfy all the requests [5].

Matching an original GPS tracking data to a digital road network is often referred to as Map Matching [15].

III. PROBLEM DEFINITION

Since multiple taxis may satisfy a request, we aim to find the taxi status with minimum increase in travel distance.

IV. IMPLEMENTATION

Passenger Request and Taxi Status are considered for implementation.

4.1. Passenger Request

A request (r) is associated with a timestamp (r.t) indicating when r was submitted, a origin point r.o, a destination point r.d, a time interval r.pw defining the time interval when the passenger wants to be picked up at the origin point, and a time window r.dw defining the time interval when the passenger wants to be dropped off at the destination point. The early and late bounds of the pickup window are denoted by r.pw.e and r.pw.l respectively. R.dw.e and r.dw.l indicate delivery window.

4.2. Taxi Status

Taxi status is characterized by the following fields, which are updated by a taxi driver to the server.

$T_s.ID$ - The unique identifier of the taxi.

$T_s.t$ - The timestamp associated with the taxi.

$T_s.l$ – The geographical location of the taxi at $Ts.t$

$T_s.sc$ - The current schedule of the taxi.

$T_s.R$ - The current projected route.

4.3. Constraints

The following constrains are considered in this work.

CAPACITY CONSTRAINTS

The number of riders that sit in the taxi should not exceed the number of seats of a taxi.

TIME CONSTRAINTS

All passengers that are assigned to T_s should be able to depart from the origin point and arrive at the destination point during corresponding pickup and delivery time.

MONETARY CONSTRAINTS

These constraints provide inducement for both drivers and passengers.

TAXI CHARGE OF PASSENGER

$$Ci = TA(D_i)$$

Ci – It indicate taxi charge of passenger

TA - It indicate transportation authority

D_i – It indicates distance between r.0 and r.d on the road network.

DRIVER MONETARY CONSTRAINT

$$RDM \geq TA(D)$$

TA – It indicate transportation authority

RDM – It indicates revenue of the driver.

V. SYSTEM ARCHITECTURE

The architecture of our system is shown in below figure 1.

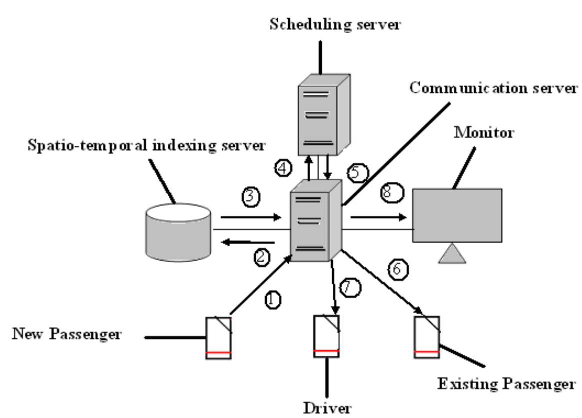

Figure 1: Architecture of the taxi sharing system

In the above Figure 1, cloud maintains multiple servers for different purposes. Driver and passenger use the smart phone app to interact with the system.

1-passenger submits a new request(r) to the communication server.

2-Now, the communication server sends the request to spatio-temporal indexing server to search for candidate taxi.

3-Spatio-temporal indexing server return candidate taxi set(Se_v) to the communication server.

4-communication server send passenger request(r) and received candidate taxi set to (Se_v) to the scheduling server.

5-Now,the scheduling server checks whether each taxi in candidate taxi set(Se_v) satisfy the passenger request(r) or not and also return the qualified taxi(T_s) with a detailed schedule to communication server.

6-Each passenger (p) who has been already assigned the taxi ((T_s) will be enquired to know whether they would like to accept the join of the new passenger or not.

7-Taxi status information is sent to both new passenger and driver.

VI. TAXI SEARCHING MODULE

Taxi searching module quickly selects a small set of taxi with the help of the spatio-temporal index. Spatio-temporal index is mainly used to speed up the taxi searching process.

The following figure 2 shows the division of road using grids. Within each grid cell, we choose a node which is closest to the grid cell (G_i).

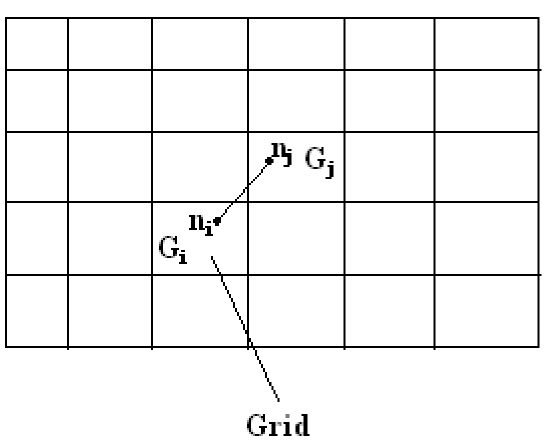

Figure 2: Division of road using grids

Distance Matrix

This matrix provides distance between two nodes on the road.

$$\begin{array}{c c}
 & \begin{array}{ccccc} G_0 & G_1 & G_2 & \cdots & G_n \end{array} \\
\begin{array}{c} G_0 \\ G_1 \\ G_2 \\ \vdots \\ G_n \end{array} & \begin{pmatrix} 0 & DG_{01} & DG_{02} & \cdots & DG_{0n} \\ DG_{10} & DG_{11} & DG_{12} & \cdots & DG_{1n} \\ DG_{20} & DG_{21} & DG_{22} & \cdots & DG_{2n} \\ \vdots & \vdots & \vdots & & \vdots \\ DG_{n0} & DG_{n1} & DG_{n2} & \cdots & DG_{nn} \end{pmatrix}
\end{array}$$

Figure 3: Distance Matrix

Each grid cell(G_i) maintains a three lists

1. Spatial list($G_i.l^s_n$)
2. Temporal list($G_i.l^t_n$)
3. Taxi list ($G_i.l_t$)

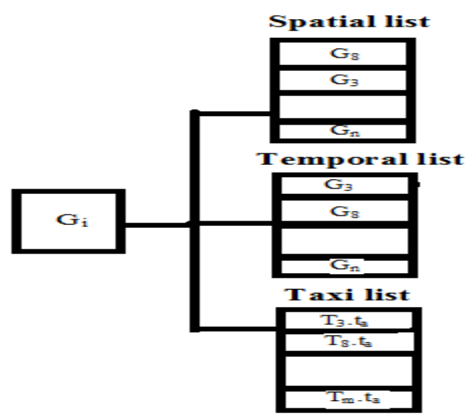

Figure 4: Spatial list,Temporal list and Taxi list

Now, we are ready to describe our searching algorithm. Consider the example shown in figure below. Suppose there is a request 'r' and the current time is T_c.G_8 is the grid cell in which r.o is located.

$$T_{i7} + T_c \leq r.pw.l$$

T_{i7} – it represents the travel time from grid cell(G_i) to grid cell (G_8)

The above equation indicates that any taxi with in grid cell G_i can enter in G_8 before the late bound of the pick up time.

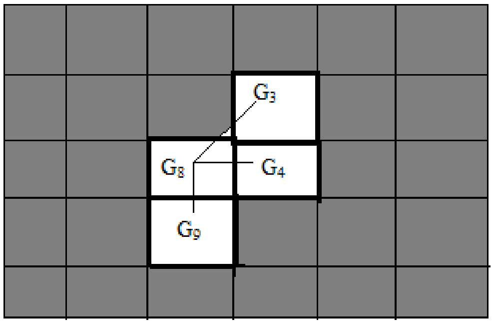

Figure 5: Taxi Searching

VII. TAXI SCHEDULING MODULE

The purpore of the scheduling module is to find the taxi status in taxi list(T_l) which satisfies request 'r' with minimum increase in travel distance.

Algorithm: Scheduling

Input: Request R, Taxi status T_s, Current time T_c.

Output: Return new schedule.

1. Begin procedure
2. if $T_c + (T_s.l \rightarrow R.0) \prec R.pw.l$ then
3. return true
4. Otherwise return false
5. new schedule $\leftarrow$ insert $R.0$ into $T_s.S$
6. $T_j \leftarrow$the arrival time of the jth point of $T_s.S$
7. T_j -the geographical location of the jth point of $T_s.S$
8. if $T_j + (l_j \rightarrow R.d) < R.dw.l$ then
9. return true
10. Otherwise return false
11. new schedule $\leftarrow R.d$ insert into new schedule at position j
12. return schedule.
13. End procedure.

VIII. RESULT ANALYSIS

The number of passengers requests inflated and extracted in a day is represented in the form of graph.

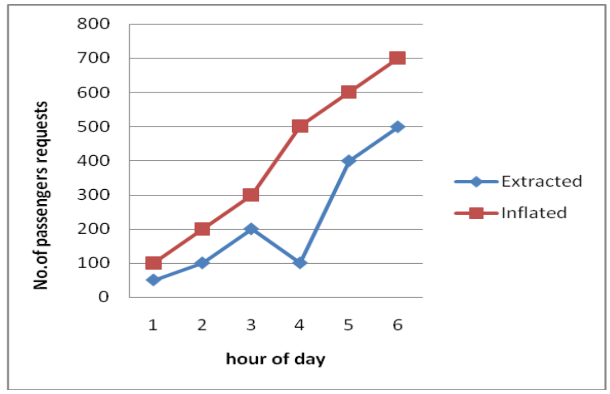

Figure 6: Particular road segment

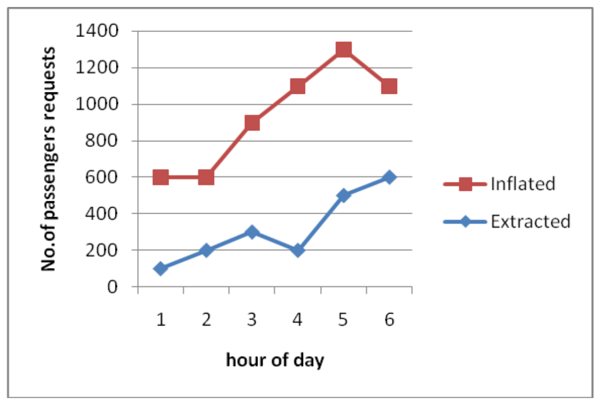

Figure 7: All road segments

The figure 8 shows Seat Occupancy Rate (SOR), which measures the seat occupancy rate in all taxi during a given time period, denoted by C the number of passenger seats in a taxi, by N the number of taxi, by T a period of time, and by Ts the sum of the travel time of all requests that are satisfied during period T. SOR is calculated by below equation.

$$SOR = TS / (N \times C \times T_p)$$

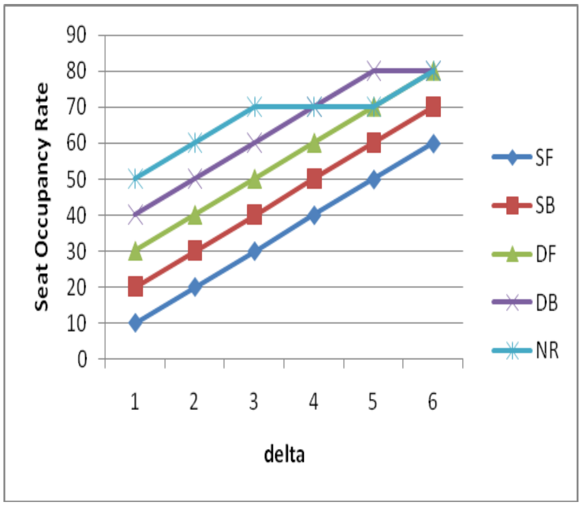

Figure 8: Seat Occupancy Rate

SF- Single-side and First Fit Taxi-sharing
SB- Single-side and Best-fit Taxi-sharing DF- Dual-side and First Fit Taxi-sharing
DB- Dual-side and Best-fit Taxi-sharing
NR- Non-Taxi-sharing method

Relative Distance Rate (RDR) defines the distance of a ride request as the distance between its origin point and its destination point.

$$RDR = DV / DSR$$

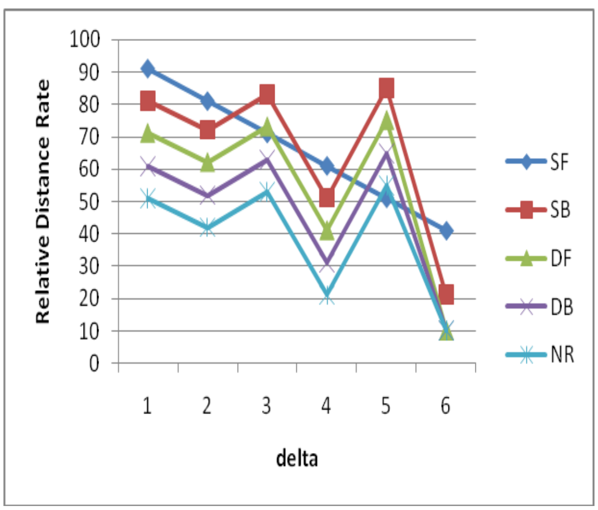

Figure 9: Relative Distance Rate

The figure 10 shows Taxi-sharing Rate(TR) which means the percentage of passenger requests participating in taxi-sharing among all satisfied ride requests, for all taxi-sharing methods.

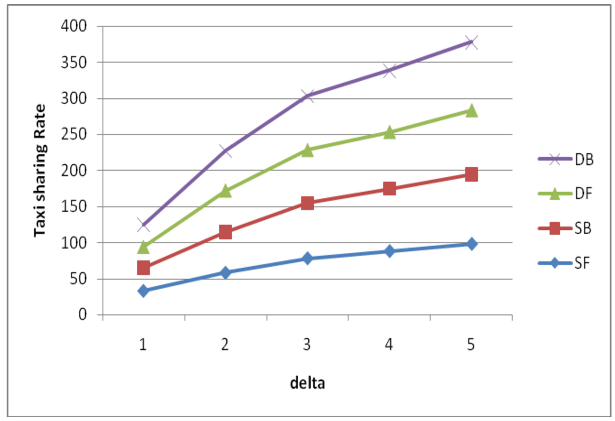

Figure 10: Taxi- Sharing Rate

IX. CONCLUSION

Hence, we conclude that by encouraging passengers to share taxi trips, there is a chance of saving on energy consumption and also satisfying people's needs in peak hours. In this paper, we developed a scalable and synchronized city-scale taxi sharing system, which efficiently serves real-time requests and also reduce the total travel distance significantly. The experimental results demonstrated the efficacy of our system in serving real-time ride requests.

X. FUTURE ENHANCEMENT

Scalable and synchronized city-scale taxi sharing system saves the travel distance of taxi and also reduces passenger's fare because of sharing. In the future, we consider a partition-prediction algorithm to split the whole trip into discrete partitions indexed by trip start time and start and end locations.

Future scope would also include time windows and location zones. Time windows are divided into hourly windows, week windows and peek period windows. Location zones are divided into static zoning and dynamic zoning.

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