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Using optimization methods to reduce traffic in urban areas with Bing Map service

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ABSTRACT

In this paper, car sharing is introduced as a new method for traffic optimization. Car sharing system is a new subject, which is studied in several recent researches. This method finds the best pathway between drivers and passengers by employing controled optimization techniques. The optimized path results in less traffic jam, more people using a vehicle, and finally cheaper and cleaner transportaion for everyone. Car sharing's main target is to reduce single-seating vehicles as much as possible. That being said, this method tries to oprimize the pathways to find the closest and the most number of passengers for each driver. Eventhough this method is proven very useful worldwide, there has been limited numbers of researchers in Iran studying its reuirement and employment methods inside the country. So, here, car sharing method is discussed by utilizing optimization algorithm within cloud services such as Bing Map. This paper demonstrates how to use such a cloud service to solve car sharing problems. By using this optimizd system, drivers will provide transportation for more numbers of passengers with much shorter trips.

Keyword:
Optimization; Traffic; Make smart; Car sharing, Autonomous

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INTRODUCTION

Private vehicle occupation rates (the number of trips per journey trip) are relatively down; average car holders in Europe vary from 1.8 for relief journeys to 1.1 for commuters [1]. Equivalent occupancy measures are also detected in the US [2]. The big request for vehicle transit at rush hours together with down occupations causes traffic congestion in many urban regions. The yearly cost of congestion in the US with regard to lost hours and wasted fuel was computed to be $78 billion in 2007 [3].

Active usage of empty vehicle seats by carpooling may show an important chance to raise occupancy rates, and could substantially raise the utility of urban transportation systems, potentially cutting roadway congestion, fuel consumption, and air pollution [4] with the grow in traffic congestion, the ability to monitor the state of the urban route network, by a variety of means, has become serious. Over the recent decade, there has been a huge amount of study produced in intelligent transportation systems (ITSs) for advanced traffic monitoring and handling [5]. ITS make use of guidance edge information and telecommunication technologies to prepare traffic and trip information. It raises the performance of traffic handling, develops the overall volume of the transportation system, enhances road security and decreases vehicle wear, trip times, and fuel consumption. ITS enjoys traffic control and surveillance, public trip data, electronic equipment collection, fleet handling, vehicle navigation systems, etc. [6].

Mapping technologies are an important element providing ITS applications to rapidly and efficiently spread data to travelers so that they can make intelligent intentions based on the situation of roads. With improvement of low power and efficient memory systems [7,8] and processing units [9] which could be accessed ubiquitously to store terabytes of data and process it in less than a second [10,11], there is less need for large memories and big processing units in portable devices. For example, with the advances of Google Map and subsequently Microsoft Bing Map release, a huge number of ITS applications, such as Advanced Traveler Information Systems(ATIS), have moved towards taking advantage of such highly collective, internet-based mapping systems. Although there are multiple distinctions between the two systems, both propose an great user interface that allows users to rapidly navigate geographic data, and both use standard web development practices manufacturing them simple to integrate into websites [12].

Driving takes a big bite out of your money and your time. Carpooling is the sharing of vehicle travel so that more than one person travels in a car. These articles [13, 14] provide information of the history of carpooling activity in the United States. Since the world oil shortages in the mid-1970s, Federal and local governments have implemented a range of policies and plan to support carpooling activity. After that interval, carpooling accepted in United States, approximately 20% of commute travel using a carpool in the 1970s. However, this decreased abruptly after 1980, and has reduced to 10% in 2010. Slumping oil prices, growing transportation options and growing incomes are acceptable reasons for opposed using carpool for trips [13, 14].

There are many great benefits to carpooling, these benefits could include reduced gas prices, reduced toll prices, reduced commuting time (if high-occupancy vehicle (HOV) lanes are handy to use), and implicitly reduced driving problem for the passengers in the car [15]. Carpooling is an effective means of reducing traffic congestion and also air and sound pollution. A carpool group shares a car for their trip, which decrease the number of vehicles on the road during heavy traffic [15].

Use of genetic algorithm in carpooling has been the issue of researchers in different year's [16-19] but widespread use of these algorithm in various carpool systems such as, van, taxi hasn't taken into consideration, as being able to measure the performance of this algorithm with changes in main variables of problem like, the numbers of drivers. On the other hand compare of present algorithm with other algorithms like, SMA* hasn't been taken into account about carpool so far. Following of this article in solution way part will be considered to problem solution with use of genetic and SMA* algorithm and in results part comparison of two algorithms will be done in problem solution. Finally, conclusion and recommendations will be discussed for future tasks.

2- Problem solutions

In order to grant system users the chance to catch carpool matches anywhere and at any time, drivers and passengers alike can handle the mobile client module to fulfill carpool operations through their mobile devices [20].

The central unit of car sharing services is integrated into the intelligent transportation system with geographic units and public information as well as for the demand management. Then, the optimization algorithms that perform routing and assignment will be used to coordinating drivers with the vehicle sharing service unit.

2-1- Receiving information

Receiving information can be done by geographic cloud services such as the Bing Map and Google Map. Figure 1 shows the location, starting point and destination of the system users (passenger and driver) and the road between these points. Here, the geographic characteristics of users and the road distance between them are calculated with the Bing Map cloud service. Also, the starting point can be displayed automatically through the cell phone positioning system. Eventually, this information is received through the Internet, and according to road distances between users, the travel optimization algorithm is performed and the best group of people is assigned to each other. In Figure 1, the purple and light blue colors indicate the starting point of driver and passenger as well as the gray and pink colors show the distention of the passenger and driver respectively.

Fig 1. Geographic characteristics of users and the road distance between them

The theoretical analysis addressing this type of matching optimization problem with regard to driver–passenger mapping arrangements has been given in this way: 1) single driver to single passenger (S-to-S); 2) multiple drivers to single passenger (M-to-S); and 3) single driver to multiple

wants to provide a ride to a single passenger. As such, each passenger will be allocated to a single vehicle. In other words, passengers are delivered to their target without any transfers. The M-to-S arrangement shows that each driver wishes to take on a single passenger, but the passenger may transfer to another car en route. The S-to-M arrangement

more passengers during their trip [20].

Because drivers put on only single passengers in S-to-S and M-to-S, the seat consumption rate improvement is not as substantial as in S-to-M arrangements. As such, our paper

arrangement.

2-3- Modeling with genetic algorithm

Genetic algorithm offered by John H. Holland 1975 [22] is a stochastic optimization algorithm that is essentially relies on ideology of natural selection and recombination. Genetic algorithm load the initial population randomly and compute the fitness for each individual then choose parent, do crossover mutation operation, compute fitness for each new individual, eventually choose the next generation and iterate this process till a termination criteria or until predefined number of generations [16].

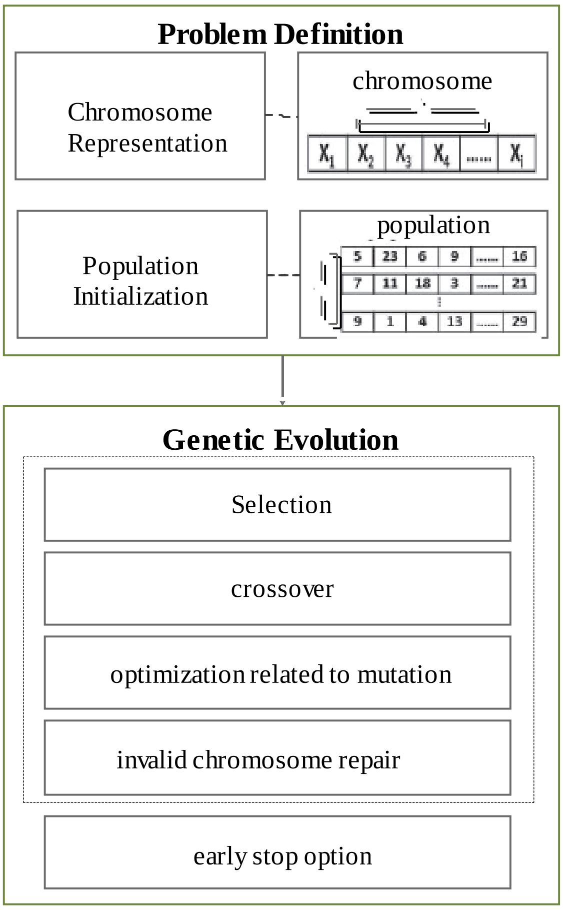

Fig 2. Using genetic algorithm for solving carpool problem

As shown in Figure. 2, the solution which is based on genetic algorithm contains of two great modules: 1) an problem definition module and 2) a genetic evolution module.

In the first model, the initialization chromosomes are done by using samples. The features required for car sharing are presented with using the first section during the operations of definitions' chromosomes, so that the coding solution of the car sharing service problem for the chromosomes is based on the driver's decision and the passenger's needs. Upon generation of efficient initial solutions in the problem definition module, the genetic evolution module exactly specifies optimum solutions to the problem by heuristically simulating natural evolution [20, 21].

2-3-1- Chromosome representation

In this section of the research, we mention to the general process of the problem initialization, one of the characteristics of the genetic algorithm is the chromosome, and its main goal is to achieve the best chromosome. Each chromosome is measured by a criterion, which is known as the fitness function. Here, the fitness function is the minimum of distention traveled for system users. The general process of coding the code in the car sharing problem is that, each passenger is determined by a unique number in the form of a gene and number of passengers (genes) is assigned to each driver. Figure 3 shows the chromosome and how the passenger and driver allocate to each other.

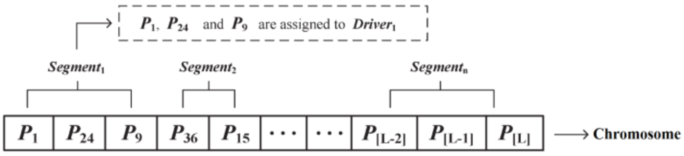

Fig 3. Assignment method for the chromosome representation [20]

2-3-2- Selection

After the initial population, the chromosomes with the highest quality traits in the population are chosen by the select strategy to proceed to the next generation. We sort the population into ascending order. The top-tier chromosomes are kept for the next generation, and the lower-tier chromosomes will be compounded into top tier chromosomes during the crossover procedure.

2-3-3- Crossover

The initial parent chromosome (C_{p1}) is randomly selected from the top-tier chromosomes, consequently the second parent (C_{p2}) is selected from the lower-tier chromosomes to introduce mating diversity.

2-3-4- Optimization related to mutation

Since chromosomes do not involve duplicate passengers, the use of a procedure called swap mutation is offered. Mutation carries with the aim of changing the arrangement of passengers. First, a passenger for the first mutation (pm1) is randomly selected from first section. Then, a passenger for the second mutation (pm2) is randomly selected from second section. Finally, the positions of passenger's pm1 and pm2 are exchanged in the chromosome, as shown in figure 4.

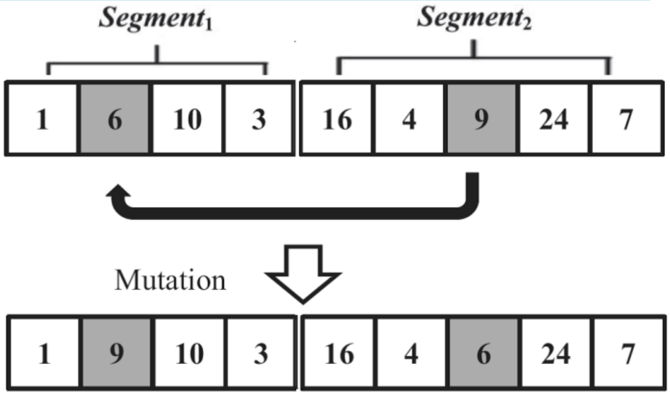

Fig 4. Second mutation for carpool problem

After the procedures of chromosome crossover and chromosome mutation, the chromosome may be invalid when the passenger is assigned to more than one driver. Accordingly, it is necessary to repair the chromosome by replacing the invalid gene.

2-4- Using SMA* (Simplified Memory Bounded A*) algorithm for solving carpool problem

A* is a graph which search method that based on informed (heuristic) search strategy. This term means this strategy has extra information about the states beyond that provided in the problem meaning. This characteristic of A * (heuristic) makes it a good way to get the minimum cost in shortest path problem (optimum path). A* evaluates nodes by combining function g(n) and the heuristic function h(n) as shown in formula 1.

$$f(n) = g(n) + h(n) \quad (1)$$

Where g(n) is a path cost from the start node to node n and h(n) is an estimated cost of the cheapest path from node n to the goal [23].

SMA* algorithm is an algorithm based on A*, and considers the best leaf of tree, an in case of filling the memory, nodes with high cost will omit and new node will be added. In order to solve the carpool problem formula 2 is used, which w, n are equal to respectively current state and parent state. GF and F are equal respectively to cost and objective value of current state. In the following, (n,w) real cost between n, w state , (w,g) cost is from current state to aim [24, 25]. Figure 5 shows the algorithm function SMA* as solving carpool problem. So, first randomly allocated passengers to drivers and carpool teams will be formed. Then with changes in selected passengers, new states will be formed. In vase of filling the memory, the worst made state will be removed. At last, with help of pointed function f(n), the best team in searching space will be appeared .

$$w.gF = n.gF + cost(n,w)$$
$$w.F = w.gF + cost'(w, g) \quad (2)$$

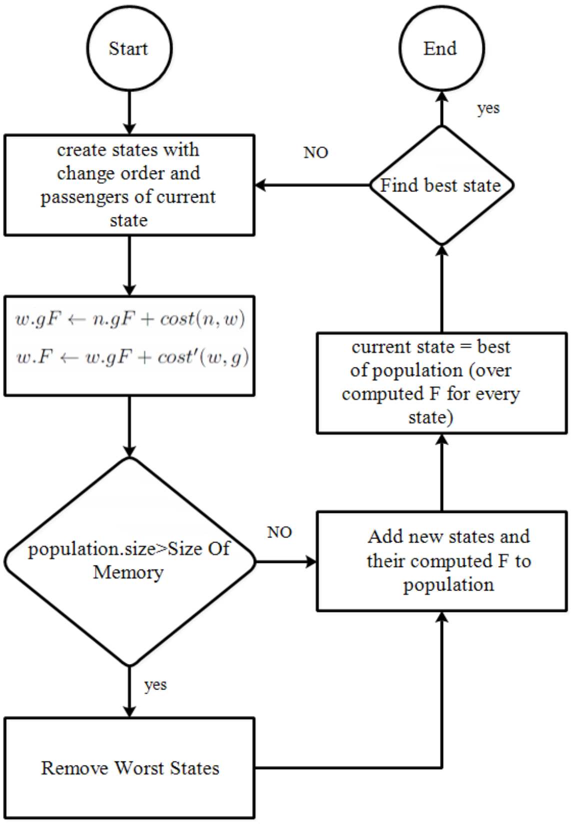

Fig 5. Using SMA* algorithm for solving carpool problem

3- RESULTS

It is possible to find the most optimal route for each driver and also the largest by number of passengers with the minimum of distance using the methods outlined in sections 2-3 and 2-4. Each driver collects the maximum number of passengers on the route according to the starting point and destination; as a result, the total traveled distance decreases as well as it leads to reduce the amount of carbon dioxide released into the air and also gas consumption.

3-1- Comparison of the efficiency of two algorithms

Figure 6, was examined genetic and SMA* algorithms as obtained answers and time of performance in medium seats 3, 6 modes. For SMA* algorithm, numbers of memory spaces are considered equal to 100.

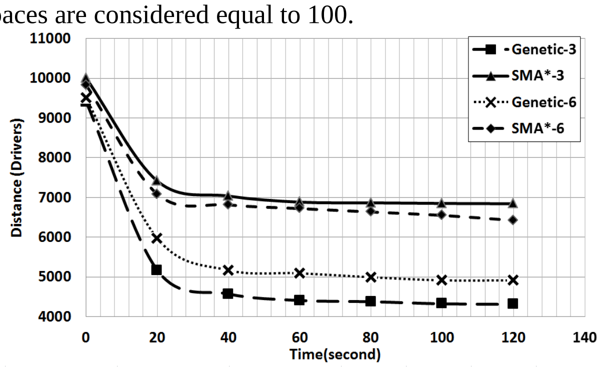

Fig 6. Use genetic and SMA* algorithms to obtain drivers distance in medium seats (3 - 6 modes)

Times of two algorithms are compared in the following. as its shown in figure 6 with increasing the numbers of seats from 3 to 6, in both modes, genetic algorithm could obtain better answers rather than SMA* algorithm. And distance parameter decreased as well as passing the time. In genetic algorithm with increasing the numbers of seats and in conclusion increasing the size of every part, distance measure in average mode 6 seats rather than the 3 seats are increased. In the following, other parameters related to traffic like, gasoline, and CO_2 is examined. For computing the results for each 100 kilometers, 7 liters of gasoline is considered, which for each kilometer 1 g CO_2 enters into the air and also the average speed of 50 kilometers are considered for drivers.

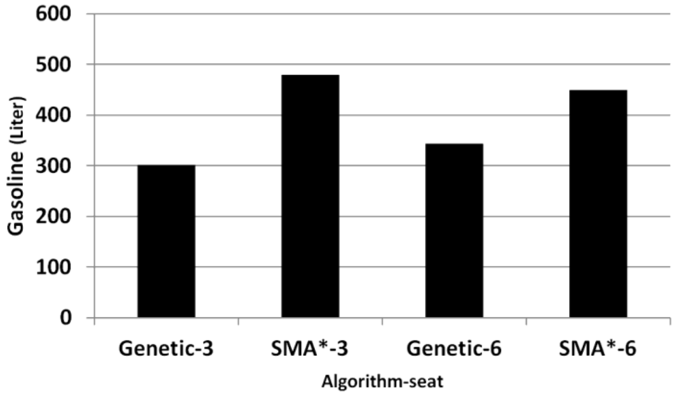

Fig 7. Use genetic and SMA* algorithms to obtain gasoline in medium seats (3 - 6 modes)

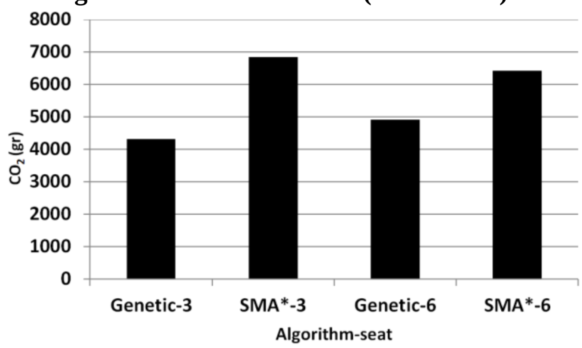

Fig 8. Use two genetic and SMA* algorithms to obtain CO2 in medium seats (3 - 6 modes)

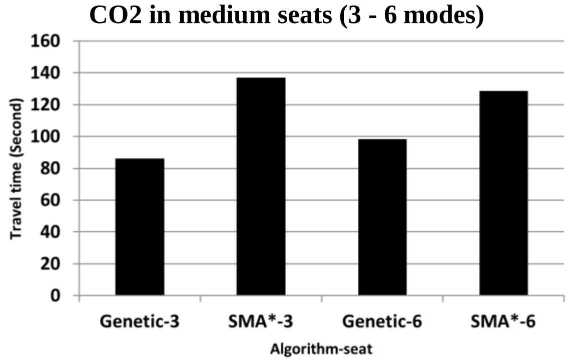

Fig 9. Use genetic and SMA* algorithms to obtain travel time in medium seats (3 - 6 modes)

As it's seen in 7, 8, 9 figures, by performing genetic algorithm, other related parameters with traffic like gasoline, CO_2 and travel time is decreased. Of course with increasing the size of each part, optimization process for genetic algorithm in 6 seats mode, contain more time than performing this algorithm in 3 seats mode.

3-2- Run sample with Bing Map cloud service

In this section, the simulation is carried out in a real situation for ensuring the issue implementation, and with the help of the Bing Map cloud service, twelve passengers with numbers from zero to eleven and three drivers with numbers from zero to two have been selected and according to all roads between the selected passengers and drivers (system users) in California, the best passengers have been assigned to the best drivers. It has been attempted to distribute the passengers and drivers randomly, so that the taking advantage of using optimization algorithms becomes visible by forming the best carpool teams as well as the passengers and drivers travel the least possible route.

Selectable routes include the roads and paths that are suitable for the driver, and these roads have been more indicated by the light purple. The appropriate roads are shown in figure 10.

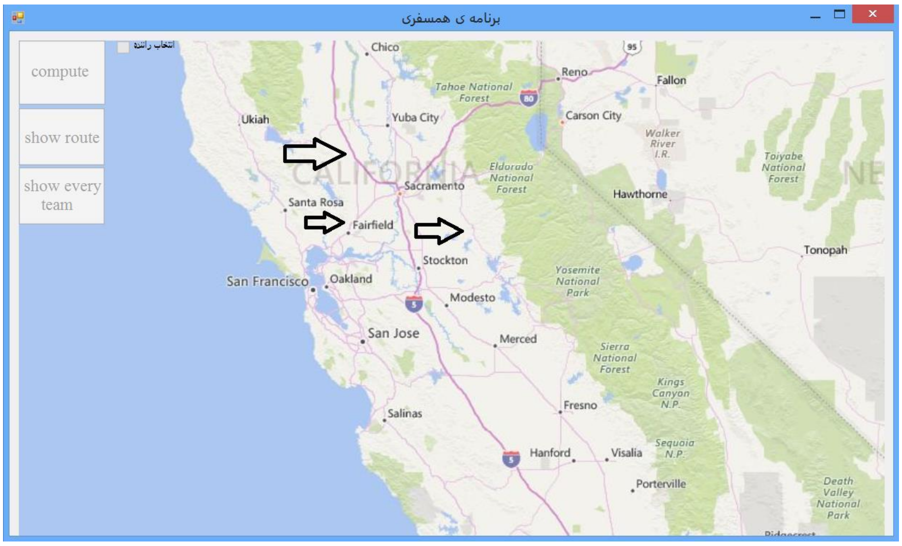

Fig 10. Appropriate roads for moving

The starting point and destination of the system users in Figures 11 to 14 are expressed in Figure 1.

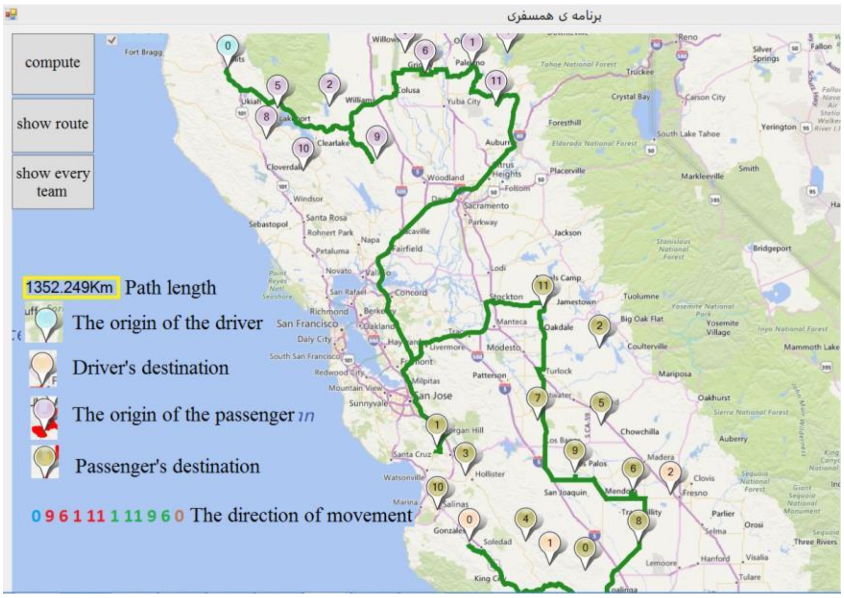

Fig 11. Carpool team for the driver with the number of 0

In figure 11, the driver with the number of 0 has passengers with the numbers of 1, 6, 9 and 11. Arrangements for getting off and picking up passengers are as follows: first, the driver picks up passengers of 9, 6, 1 and 11, then, the passengers of 1, 11, 9, and 6 get off at the destination respectively, and finally, the driver reaches at his own point of destination. This driver travels totally 1352 kilometers.

Among the four passengers assigned, the passengers' destination of the 6 and 9, as well as the starting point is almost in the same area for the three passengers of 1, 6, and 11 that have been assigned to the driver of 0, as well as the passenger's starting point the by the number of five is close to the driver's starting point. Of course, given the requirement to allocate all twelve passengers to three drivers, one of the drivers is forced to travel more distance than the normal route, that this driver is one with the number of 0 due the selectable starting point and destination of the drivers and the routes as well as the starting point and destination of the passengers.

Fig 12. Carpool team for the driver with the number of 1

According to Fig 12, driver 1 have 4 passengers, which number is 2,3,7,10. This driver starts to drive at the original point, then pick up the passenger whit 10,3,7 and 2 and finally rotten to the original point. The whole distance that this driver should be pave is 1410. As can be clearly seen, the aim of this program is to pick the best passenger with the shortest distance for each driver.

Fig 13. Carpool team for the driver with the number of 2

According to Fig 13, the driver with number 2 has passengers with number 0,4,5,8. Firstly, this driver picks up passenger with 5,8,0,4 and then picks off this passenger and finally turns back to the original point. The amount of distance which this driver paves it is 1583. As can clearly be seen, the best rood way chooses for this driver. For example, the original point of passenger with number 5,8,3 and 0 is really close to gather and also the passenger with number 0 is the nearest person to driver 2, also the destination of passenger with 0 and 8 is close together.

As you can see, each team has a special area. The remarkable point is that, although a small collection has been selected, but, using the optimization algorithm leads to reduce 1000 km less than the time that the algorithm is not used. Also, the distances traveled by the three drivers are 1352, 1410, and 1583 respectively, which indicates that the distances traveled are not significantly different with each other.

4- Conclusion

The travel optimization system is a system for optimizing traffic and dealing with traffic nodes, and it is considered as very complex issue, in which the driver and passenger allocate to each other by the best way. In this research, an interchange model has been proposed in which the patterns have been moving throughout the urban area and have presented a genetic algorithm and SMA* to determine the optimal route of travel and users allocation practice. These methods have appropriate solutions to reduce the travel time for optimizing the traffic parameters.

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