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Solving vehicle routing problem by using improved genetic algorithm for optimal solution

Mazin Abed Mohammed[a,b,*], Mohd Khanapi Abd Ghani[a], Raed Ibraheem Hamed[c], Salama A. Mostafa[d], Mohd Sharifuddin Ahmad[e], Dheyaa Ahmed Ibrahim[b]

[a] Biomedical Computing and Engineering Technologies (BIOCORE) Applied Research Group, Faculty of Information and Communication Technology, Universiti Teknikal Malaysia Melaka, Malaysia
[b] Planning and Follow Up Department, University Headquarter, University of Anbar, Anbar, Iraq
[c] Department of IT, College of Science and Technology, University of Human Development, Sulaymaniyah KRG, Iraq
[d] Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia
[e] College of Computer Science & Information Technology, Universiti Tenaga Nasional, Putrajaya, Malaysia

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ABSTRACT

Context: The Vehicle Routing Problem (VRP) has numerous applications in real life. It clarifies in a wide area of transportation and distribution such as transportation of individuals and items, conveyance service and garbage collection. Thus, an appropriate selecting of vehicle routing has an extensive influence role to improve the economic interests and appropriateness of logistics planning.
Problem: In this study the problem is as follows: Universiti Tenaga Nasional (UNITEN) has eight buses which are used for transporting students within the campus. Each bus starts from a main location at different times every day. The bus picks up students from eight locations inside the campus in two different routes and returns back to the main location at specific times every day, starting from early morning until the end of official working hours, on the following conditions: Every location will be visited once in each route and the capacity of each bus is enough for all students included in each route.
Objectives: Our paper attempt to find an optimal route result for VRP of UNITEN by using genetic algorithm. To achieve an optimal solution for VRP of UNITEN with the accompanying targets: To reduce the time consuming and distance for all paths. which leads to the speedy transportation of students to their locations, to reduce the transportation costs such as fuel utilization and additionally the vehicle upkeep costs, to implement the Capacitated Vehicle Routing Problem (CVRP) model for optimizing UNITEN's shuttle bus services. To implement the algorithm which can be used and applied for any problems in the like of UNITEN VRP.
Approach: The Approach has been presented based on two phases: firstly, find the shortest route for VRP to help UNITEN University reduce student's transportation costs by genetic algorithm is used to solve this problem as it is capable of solving many complex problems; secondly, identify The CVRP model is implemented for optimizing UNITEN shuttle bus services.
Finding: The findings outcome from this study have shown that: (1) A comprehensive listed of active GACVRP; (2) Identified and established an evaluation criterion for GACVRP of UNITEN; (3) Highlight the methods, based on hybrid crossover operation, for selecting the best way (4) genetic algorithm finds a shorter distance for route A and route B. The proportion of reduction the distance for each route is relatively short, but the savings in the distance becomes greater when calculating the total distances traveled by all buses daily or monthly. This applies also to the time factor that has been reduced slightly based on the rate of reduction in the distances of the routes.

* Corresponding author at: Biomedical Computing and Engineering Technologies (BIOCORE) Applied Research Group, Faculty of Information and Communication Technology, Universiti Teknikal Malaysia Melaka, Malaysia.
E-mail addresses: mazin_top_86@yahoo.com (M.A. Mohammed), khanapi@utem.edu.my (M.K. Abd Gani), raed.alfalahy@uhd.edu.iq (R.I. Hamed), semnah@yahoo.com (S.A. Mostafa), sharif@uniten.edu.my (M.S. Ahmad), dheyaa.ibrahim88@gmail.com (D.A. Ibrahim).

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1. Introduction

The VRP models are applied in a wide area of transportation and distribution such as transportation of individuals and items, conveyance service and garbage collection. The models have economic importance, particularly in developed countries. The economic factor in savings expenditures is a big motive for companies and researchers in an attempt to find the best way to resolve and improve transport efficiency [1]. The concept of VRP can be described as the issues of designing shortest paths routes from one location to a group of geographically distributed locations (customers, cities, universities, warehouses, schools, stores, etc.) [1–4]. For example, a fleet of vehicles (for distribution of goods) starts from one location and visits a group of scattered cities or customers and return to the same location with less distance and costs on the conditions of [5]:

- Every city is visited by one vehicle only once within a single route.
- The capacity of each vehicle is enough for all cities included in the route.
- Routes begin and end at the same location.

The number of vehicles is supposed to be less than what can be proposed for routes as well as the number of routes is to be less than what can be provided to cover all cities. Many researchers have tried to solve the problem but failed to find the optimal solution. However, they have managed to come up with approximate solutions that differ in efficiency depending on the search space. In this paper, the genetic algorithm will be used to find a best result for the research problem, as it is capable to of solving many complex problems. The economic factor in saving expenditures is a strong motive for organizations and researchers in an attempt to find the best way to resolve and improve transport efficiency.

The motivation of this study vehicle routing problem is one of the many problems that have no perfect solutions yet. Many researchers over the last few decades till now have established a lot of researches and used many methods with different techniques to handle it. But, for all researches, finding the lowest cost is very complex and needing innovative methods to find an approximate optimal solution. Since the presentation of this issue by Dantzig and Fulkerson in 1954 and Dantzig and Ramser in 1959 [5–7], a many expansions and differences have been added to the fundamental VRP pattern, in order to meet of the need of sensible applications that are intricate and realistic in nature. Confining the ability of the vehicle and determining certain work times for travelling to customers are among the well-known requirements that have been considered while tending to the VRP. One vital variation of the VRP is the Capacitated Vehicle Routing Problem (CVRP), The methods for the CVRP help in enhance the VRP issue in situation of transportation utilization. The main goal of the CVRP is to serve every one of the clients while reducing the aggregate travel distance under the limitation that the aggregate requests of the served clients can't surpass the capacity of the vehicle, where every vehicle starts from a similar station, serves the clients doled out to the depot, and comes back to the depot with the station of the terminal and the clients are given [8–11].

In this paper, we propose a genetic algorithm of CVRP model for UNITEN shuttle bus services. We aim to achieve an optimal solution for CVRP of UNITEN with the accompanying targets: (1) To reduce the time consuming and distance for all paths. which leads to the speedy transportation of students to their locations, (2) To reduce the transportation costs such as fuel utilization and additionally the vehicle upkeep costs, (3) To implement the CVRP model for optimizing UNITEN's shuttle bus services, and (4) To implement the algorithm which can be used and applied for any problems in the like of UNITEN CVRP.

2. Related work

The VRP has been considered as a critical part in the logistic dealing. Thus, an appropriate selecting of vehicle routing has an extensive influence role to improve the economic interests and appropriateness of logistics planning. It presents many examples of the use of genetic algorithm in finding the optimal solutions to the problems of VRP. Since the presentation of VRP in 1959 by Dantzig and Ramser, it has excited the interest of numerous scientists and researchers to study research issue. Numerous techniques and search methods have been improved for the VRP, from exact methods to heuristic techniques until to meta-heuristic. In basic heuristic methods, the objective was fundamentally to get an agreeable result rapidly, and consequently enhance the result. The Literature Review aims at providing a comprehensive literature on the theoretical and practical background for the study of VRP and demonstrating the significance of this study two main objectives for VRP with genetic algorithm. The first objective is to provide a clear and detailed discussion on the topic of genetic algorithm, its methods, and various works. The second objective is to apply genetic algorithm to the VRP to be optimally solved. The problem can be portrayed as a set of vehicles that starts from a depot or more than one depot and has to serve a group of clients, where every vehicle has a limited ability and every client has to be visited once during each route. Wang et al. [7] utilized the genetic algorithm to solve the VRP and enhanced the mutation step and the coding plan of the technique when utilizing normal number. They utilized the normal numbers to represent the chromosome which represent the paths. In this manner, they produced the populations by using the crossover step, and two mutation step. The primary mutation is enhanced inversion mutation step and the other is the gene replace mutation step. They utilized optimal preservation method to avoid the loss of the improved person, where the best individual utilized in state of the bad one. In this manner, they demonstrated that their results enhanced genetic algorithm abbreviated the coding length and improved the solving activity.

Laporte et al. [8] utilized the genetic algorithm to solve the VRP with various limitations. They displayed a new technique to produce singular population and propose another route. Every time a limited automaton begins; it creates another population in each generation's growth and after that brings the great population to the following individuals until the individual population is built. Also, they showed the chromosome as a series of clients representing to a vehicle path, and its fitness is detected by the individual's distance, the quantity of clients, and the aggregate amount dispatched by the vehicle. They considered the main station as a client, since all paths begin and end on it. In the choice level, they proposed another procedure that chooses sets of chromosomes from a similar individual to crossover, from which the poorest quality in the chromosome is selected and removed indiscriminately from the chromosome and after that terminated. They discovered that the experimental results were good and encouraged them to solve the VRP with multi stations. Braysy et al. [9,10] used genetic algorithm to solve the VRP with time windows, in which there is a specific time for any customer to be served. Then he made a comparison between his results and the results of other algorithms like Ant Colony Optimization algorithm and Tabu Search algorithm. He discovered that the genetic algorithm performance is inferior to the other techniques.

Zirour et al. [11] presented a genetic algorithm to solve the VRP with Time Windows and Fuzzy Demand to minimize the aggregate distance for vehicles paths and the delay times at the customers due to any time violations. The GA is utilized to solve this problem which is formulated in two steps, in order to minimize the expenses in both steps due to initial solutions in the first step and the expenses of path failure in the second step. Their research showed that their solutions are close to best solutions. Nazif et al. [12] presented a genetic algorithm with an optimized crossover operator to solve the dynamic VRP with time window. Improved operator was applied by Aggarwal et al. [13] genetic algorithm. The crossover operator is the main factor to choose the individuals from the population for generating the offspring. Instead of the traditional way to produce the offspring, they used the swap node operator, where two hubs from a parent are randomly chosen and distributed and this process is refined for the second parent to produce a second posterity. They tested their results with other algorithms with good solutions and showed that their results are competitive. Zhong [13] presented the VRP with time windows (VRPTW) and proposed a mathematical model for it. He presented an enhanced GA to solve the model. First the initial population was computed then a pair of individuals was selected after calculate the fitness values to make the crossover to generate two new individuals. He used a new crossover operator (NOX) which is better than other operators in generating a child that is different from its parent even if the parents are similar. For permutation, he used a modified mutation operator which includes swapping mutation and inversion operator. In swapping, the genes were swapped on two selected positions. In inversion operator, two separation location within a chromosome were found randomly, and then overthrow the substring among them to produce a child. The research results showed that the improved genetic algorithm is effective in achieving good solutions.

Zhang et al. [14] presented a new method to optimize VRP with multiple depots, multiple customers used the vehicle, and multiple products by using a new search method called the fuzzy logic-guided genetic algorithms (FLGA). The fuzzy logic is used to set the crossover and mutation average after ten successive generations. In crossover, a new crossover operator is used to solve this problem called the partial uniform and partial order (PUPO) crossover. The PUPO crossover includes two kinds of crossover: a uniform crossover, and an order crossover. In mutation, a new mutation operator is suggested to resolve this problem called the partial uniform and a partial swap (PUPS) mutation. The PUPS mutation contains two kinds of mutation: a uniform mutation and a swap mutation. The results showed that their search technique in a set of data generated randomly surpassed other searches used to solve the problem such as tabu search branch and bound, simulated annealing, and standard genetic algorithm.

Lau et al. [15] presented a hybrid genetic algorithm to solve the multi-depot and periodic VRP. They proposed many contributions in crossover operation, management of unfeasible solutions, evaluation procedure and diversity. These contributions enhance the hybrid algorithm to achieve good solutions. Cao et al. [16] presented a developed genetic algorithm to tackle the weaknesses of early and delayed convergence of classical genetic algorithm. Their research showed that the performance of the technique used is best than the traditional genetic algorithm. Chunhua et al. [17] presented a developed genetic algorithm to resolve the VRP with disruption events that may happen during the routes such as traffic accidents or vehicle breakdowns. The VRP pattern is depend on a set of solving traditional strategies depend on the notion of disruption management. These procedures are used to simplify the solving of complicated optimization problem and simplify the solution space. When a vehicle on a tabled task in the distribution program breaks down, the other transport vehicles or additional ones could compensate for that and complete the mission to deliver the goods of the disabled vehicle at the time, where serving the customer at the time is the most important goal for each solution. They improved the population and crossover operations in the genetic algorithm to improve the solution. They also improved the validity of procedures and methods by representing the failure times and disruption vehicles.

The genetic algorithm is effective in solving difficult and complex issues for large space, and although it is used for solving the different types of the VRP, it is scarcely used to solve the CVRP, which is the problem of this research [18–20].

3. Materials and methods

Genetic algorithms are typically used to search very large and possibly very high dimensional search space. They are adaptive heuristic search systems premised on the evolutionary ideas of natural selection and genetics. Hence, the basic concepts of genetic algorithm are designed to simulate processes in a natural system necessary for evolution. As such they represent an intelligent exploitation of a random search within a defined search space to solve a problem [18].

In this paper, genetic algorithm is applied to solve and optimize the bus routing problem of UNITEN. The VRP and the model of UNITEN CVRP are described. The common genetic algorithm and its techniques, initial population, crossover, fitness value and mutation are explained. The procedure and the techniques of the resolution to the problem are described. The main focus of this research is to model and evaluate solutions for the bus routing problem in transporting UNITEN students using genetic algorithm. The application of genetic algorithm is confined to complex problems which have a huge solution space. The goal is to explore the solution space and try to reduce its size. The problem data is taken from UNITEN's Property Management Unit, which manages the shuttle bus service.

4. Capacitated Vehicle Routing Problem (CVRP) Model

The CVRP has many applications in real life. It clarifies in a wide area of transportation and distribution such as transportation of individuals and items, conveyance service and garbage collection. All these problems have economic importance, particularly in developed countries. We attempt to find an optimal route result for CVRP of UNITEN using genetic algorithm.

Let a graph $Gr = (S, D)$; $S = \{s_0, s_1, \ldots, s_n\}$ in which Gr has $n+1$ station and $D = \left\{ \left(s_x, s_y\right) : s_x, s_y \in S, x < y \right\}$ is the set of distances between the stations. Buses starting point is station 0 and the $S = S \backslash \left\{0\right\}$related to n stations of bus stops. Let a cost variable be associated with each S of D, $c_{x,y}$; A set of buses, B with capacities of St students are located at the starting station 0; each of the B implements a rout of Gr in a straightforward cycle with the consideration of the St aggregate does not exceed the vehicle capacity; a *decisionfactorfunction*, for z number of vehicles, $Df_{x,y,z}(x, y = 0, 1, 2, 3, \ldots.n; z = 1, 2, 3, \ldots, n; x \neq y)$ determines the rout options:

$$Df(x, y, z) \begin{cases} 1, & \text{true} \longleftarrow \text{arc}(x, y) \\ 0, & \textit{otherwise} \end{cases} \tag{1}$$

The z is assumed 1 as the aim to reduce the route distance but not the number of vehicles. Since the cost of the route is a function of a route distance then; CVRP can be formulated as:

$$Minimize = \left(\sum_{x=0, x \neq y}^{n} D_{x,y} Df_{x,y} \right) \tag{2}$$

Therefore,$x = 0$, $y = 1$ are subject to:

$$Df_{x,y} = 1, \forall x \in S$$

$$Df_{x,y} = 1, \forall y \in S$$

Since the slightest cost of every path in this issue relies on the distance, the distance should be reduced to raise chromosome fitness value. The fitness can be formulated as [1]:

$$f(x) = 100/ \sum_{x=0,y=1}^{n} D_{x,y} \tag{3}$$

4.1. Genetic algorithm

The trend begins using metaheuristic, especially genetic algorithm to find a good solution for the complex problems, particularly, when the other searches have failed to find an optimal solution. genetic algorithm is a key technology in random search to solve unclear and complex problems, which require large time space for optimal solution. It is an important technique in the search for the perfect choice of the solution set that is available for a particular design. Genetic algorithm is efficient to solve high computational complexity problems such as VRP. These problems are mainly optimization problems. It is efficient to [20–22]:

- Find a solution when solution space is large, and when linear programming cannot find theoretical solution in proper time.
- Deal with multi-constraints problems.
- Solve a problem when there is limited time or resources of the problem.
- Find approximate solution.

The genetic algorithm is applied to solve the UNITEN student's transportation problem. The problem is a real example and application of CVRP. All the operators of the genetic algorithm are described and as shown in Fig. 1.

The following algorithm represents the implementation of the genetic algorithm in the CVRP:

Algorithm 1: The CVRP model

```
1. begin;
2. initialize the population (route) to the default (i.e. 1 → 2 → 3 → 4 → 5);
3. calculate length and fitness of initial route, fitness = 1/ (length of route);
4. set best chromosome = initial route;
5. loop for 2000 iterations, in each iteration:
   5.1  copy best chromosome to new chromosome;
   5.2  do a crossover between new chromosome and best chromosome:
   5.3  choose a random number [a] in the range "2" to "No of stops";
   5.4  set b to the place holding the value [a] in new chromosome;
   5.5  swap the values of best gene[a] and best gene[b];
   5.2  do three mutations in each step:
        5.2.1  choose two random numbers [a], [b] in the range "2" to "No of stops";
        //Note: The first stop is fixed, always no. 1
        5.2.2  swap the values of new gene[a] and new gene[b];
        5.2.3  repeat (for 3 times only);
   //Validate new chromosome:
   5.3  if there is no immediate route among any two consequent stops,
        5.3.1  then new chromosome is worthless,
   5.4  otherwise it is useful;
   5.5  if new chromosome is valid,
        5.5.1  then evaluate new chromosome and best chromosome,
        5.5.2  if the fitness value of new chromosome is better,
               //The fitness value greater than that of best chromosome
               5.5.2.1  if the fitness value of new chromosome is better,
               5.5.2.2  then write out "better route found" and the path of new chromosome;
               5.5.2.3  set best chromosome = new chromosome;
6. end of loop;
7. write out the (best) path stored in best route;
7. draw the path of best route;
8. end.
```

4.2. Genetic algorithm operators

4.2.1. Population

The population is created randomly. Numbers are determined for each point. Each chromosome represents a single valid route that can be represented by set of numbers, where each location represents a gene. Numbers are sufficient to encode the chromosomes, because there is only a single variable in the issue, which is the distances among stations. The population is initialized to default, where the initial route represents the first chromosome:

1 2 3 4 5 6 7 8 9

Then the fitness is computed, and the chromosome is represented as the best one. Loop is refined for 3000 cycles in order to compute the population, where each iteration contains crossover and tree mutations.

4.2.2. Fitness values

Minimal cost of every path in this issue relies on upon the distance, which is the main variable. Since it is desirable to abbreviate the path distance, then the fitness of chromosome can be essentially computed by getting the total of distances for every path, where $D1$ = distance from satation1 to stop 2, $D2$ = Distance from station 2 to stop 5, until the aggregate total are acquired. The distance should be reduced to expand chromosome fitness (the less distance the more fitness). The fitness is computed as follows:

$$\text{fitness} = 100/\text{totalsumofdistance}$$

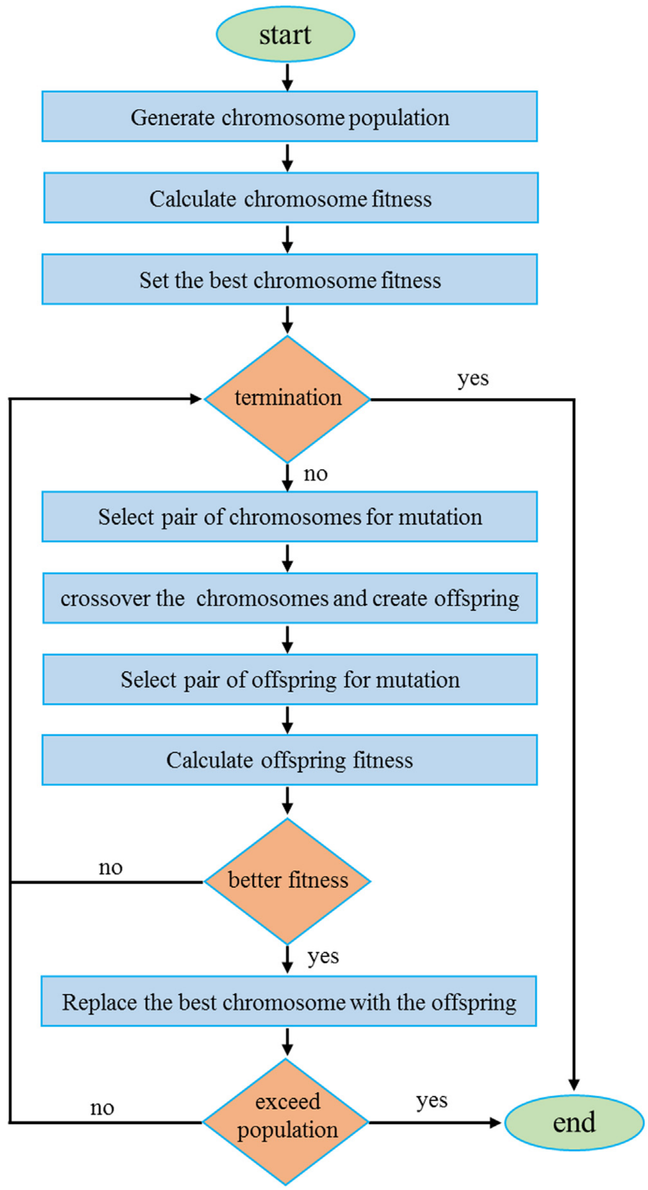

Fig. 1. The genetic algorithm procedure.

4.2.3. Selection

Strong selective factor can prompt to nearby ideal state solution from selecting only the optimal fit chromosomes for hybrid crossover. This factor compels the GA to early search end. Weak selective factor has a negative effect. The selection stretches out even to low fitness people for hybrid crossover, which causes the GA to investigate the solution space [23,24]. In this manner, the traditional roulette wheel is proposed for chromosomes choice in which the most elevated chromosomes fitness value is chosen to be changed and traversed to shape new chromosomes and contributes in copy and reproduction resulting new generation formation operation.

4.2.4. Crossover

Hybrid crossover is used in this algorithm, where which produces a random vector and chooses the genes where the vector is a 1 from the primary parent, and chooses the genes where the vector is a 0 from the second parent and joins with the gene to create the child [25,26]. For instance, if C1 and C2 are the parents

C1 = [abcdefgh]

C2 = [12345678]

The binary vector is [10101001], the capacity gives back the accompanying:
child1 = [a 2 c 4 e 6 7 h]

Table 1
The distances for the existing routes of UNITEN.

Routes	Distance per week m	Distance per month m	Distance per year meter
A	1,309,790	5,239,160	62,869,920
B	865,080	3,460,320	41,523,840
Total	2,174,87	8,699,48	10,4393,760

4.2.5. Mutation

The process of mutation happens after the crossover process and before the offspring is released into the space. The procedure of mutation occurs after the hybrid crossover and before the posterity is discharged into the space. The likelihood of mutation is named as mutation rate. mutation is well thoroughly considered as a random stroll through the search space to discover the chromosome that best fit to be changed [27]. Adaptive mutation that randomly generates guidelines that are common with regard to the last effective or ineffective generation created. The appropriate area is confined by the equality limitations and inequality limitations. A stage length is selected along every path so that straight limitations and bounds are all of it convinced [1]. The Mutation scheme is repeated three circumstances in every loop, keeping in mind the end goal to ensure that an alternate chromosome from the first is produced and consequently gives a higher likelihood of discovering ideal outcome. The last chromosome is then approved by testing the route between two stations. In the event that there is no immediate route between any two resulting genes (points) then the new chromosome produced above is invalid. If the new chromosome is good, then the fitness function value is computed [28,29]. If the fitness function value is superior to the good chromosome, then the new chromosome turns into the best, and the loop is finished.

5. Results and discussion

The target of both VRP and CVRP is to reduce the aggregate transportation cost. The CVRP is proportional to the VRP only if the aggregate of all client requests for every path does not surpass the vehicle's ability. The VRP is effective if the ability of every vehicle is not restricted to take in new requests. The VRP is a standout amongst the most difficult issues that attracted in much concern and ordered a great deal of studies. It has numerous using in real life applications and finding an ideal result for it is an on-going attempt. The improved genetic algorithm has been proven to find the best route for the quantity of stations amid testing and validation stage. One of the test outcomes is gotten by utilizing the predefined genetic algorithm steps and parameters appeared in Table 1. The research aims to reduce the aggregate cost of students' transportation in UNITEN. The cost is mainly a function of route distance, which can lead to minimize the other functions such as number of vehicles and drivers, fuel consumption, and vehicles operation and maintenance. Minimizing the total costs is the goal of the research to help UNITEN reduce the expenditures of student's transportation. The buses follow two routes, A and B, every day for

Table 2
The new distances for both routes.

Routes	Distance per week m	Distance per month m	Distance per year m
A	1,271,200	5,084,800	6,1017,600
B	837,540	3,350,160	40,201,920
Total	2,108,740	8,434,960	101,219,520

Table 3
The distances reduction rate for both routes.

Routes	Reduction rate m per week	Reduction rate m per month	Reduction rate m per year
A	38,590	154,360	1,852,320
B	27,540	110,160	1,321,920
Total	66,130	264,520	3,174,240

transporting the students. Since the working days per week equal four normal days (Monday to Thursday and Friday):

5.1. The results of the existing routes

Route A is traversed 48 times every day except on Friday when it is traversed for 35 times. The distance traveled each time for route A equal to 5770 km. Total distance for route A for a normal day = 48*5770 = 276,960 m

- Total distance for route A for Friday = 35*5770 = 201,950 m
- The total distance per week = 276,960 *4 + 201,950 = 1,309,790 m

Route B is traversed 35 times every day except on Friday when it is traversed for 22 times, and the distance traveled in route B equals to 5340 m.

- The total distance for route B for normal day = 35 * 5340 = 186,900 m
- The total distance for route B for Friday = 22 * 5340 = 117,480 m
- The total distance per week = 186,900 * 4 + 117,480 = 865,080 m

The distances for both routes are determined per month (distance per week*4) and year (distance per month *12) to be compared with the distances achieved by the algorithm to establish the reduction rate. Table 1 shows the distances for both routes.

5.2. The results of the optimized routes

The new distance of route A becomes:

- The total distance for route A for normal day = 48*5600=268,800 m
- The total distance for route A for Friday = 35*5600 = 196,000 m
- The total distance per week = 268,800 *4 + 196,000 = 1,271,200 m

The new distance for route B becomes:

- The total distance for route B for normal day = 35*5170 = 180,950 m
- The total distance for route B for Friday = 22*5170=113,740 m
- The total distance per week = 180,950 *4 + 113,740 = 837,540 m

The distances for both routes are determined per month (distance per week*4) and year (distance per month *12), as shown in Table 2.

The distance reduction rate for both routes can be obtained by subtracting Table 2 from Table 1, therefore, the results become as follows in Table 3:

It is shown from the above table, that the total distances of both routes are reduced yearly by a remarkable amount; 3174,240 km. According to the information taken from UNITEN's Property Management unit, which is responsible for student's transportation, all buses use the diesel fuel. The price of one liter of diesel is RM1.80, and each bus consumes one liter of fuel for travelling 2.8 km. Therefore, the fuel and cost saving is calculated as follows:

Table 4
The fuel and cost savings.

The Period	Distances Reduction KM	Fuel Saving liter	Cost Saving RM
Weekly	66,130	23,617	42,512
Monthly	264,520	94,471	170,048
Yearly	3174,240	1,133,657	2,040,528

- Fuel cost = number of liters * price per liter
- Distance = fuel (number of liters) * distance per liter;
- Cost Saving = Fuel Saving (number of liters) * 1.8
- Fuel saving (number of liters) = Distances Reduction/2.8

Table 4 shows the fuel and cost saving for different periods.

The cost saving includes only the fuel saving and does not include the savings in other expenses such as maintenance expenses, which if calculated, also represents a significant amount of money. The problem of the university represents a real challenge to the algorithm's capability in solving such problem and the challenge is open to any other problem for measuring its reliability. The algorithm is applied to solve UNITEN student's transportation problem, and it succeeded in solving the problem in a short time and found a shorter distance for route A and B as shown in (Fig. 2). The total reduction in distance for both routes for different periods is calculated by subtracting the total distances for the new routes calculated by the algorithm from the original distances for the same periods. The distance reduction for each route is small due to the constraints explained earlier, but for both routes and for long periods such as month and year, the reduction is significant to optimize the expenders.

The possibility of choosing any other problem to be solved by the search algorithm is possible and has been included in the implementation of the program. The algorithm is applied to the problem and calculates the distance of the original route, using the data fed to the program from a file. The original route is shown in table, and its distance is equal to 7210 km. The algorithm reduces the route distance to 6590 km. This number represents the distance which can be saved in one traversal and it could be greater if the frequency of the route per day is calculated. The algorithm is applied to solve UNITEN student's transportation problem, and it succeeded in solving the problem in a short time and found a shorter distance for route A and B. The total reduction in distance for both routes for different periods is calculated by subtracting the total distances for the new routes calculated by the algorithm from the original distances for the same periods. The distance reduction for each route is small due to the constraints explained earlier, but for both routes and for long periods such as month and year, the reduction is significant. For the purpose of validating the algorithm's capability and reliability, it was applied to solve the same problem of UKM and it was successful in finding a shorter route. The distance reduction for each route in UKM is quite significant.

6. Conclusion

We implement the capacitated vehicle routing problem (CVRP) model for optimizing UNITEN's shuttle bus services. The meta-

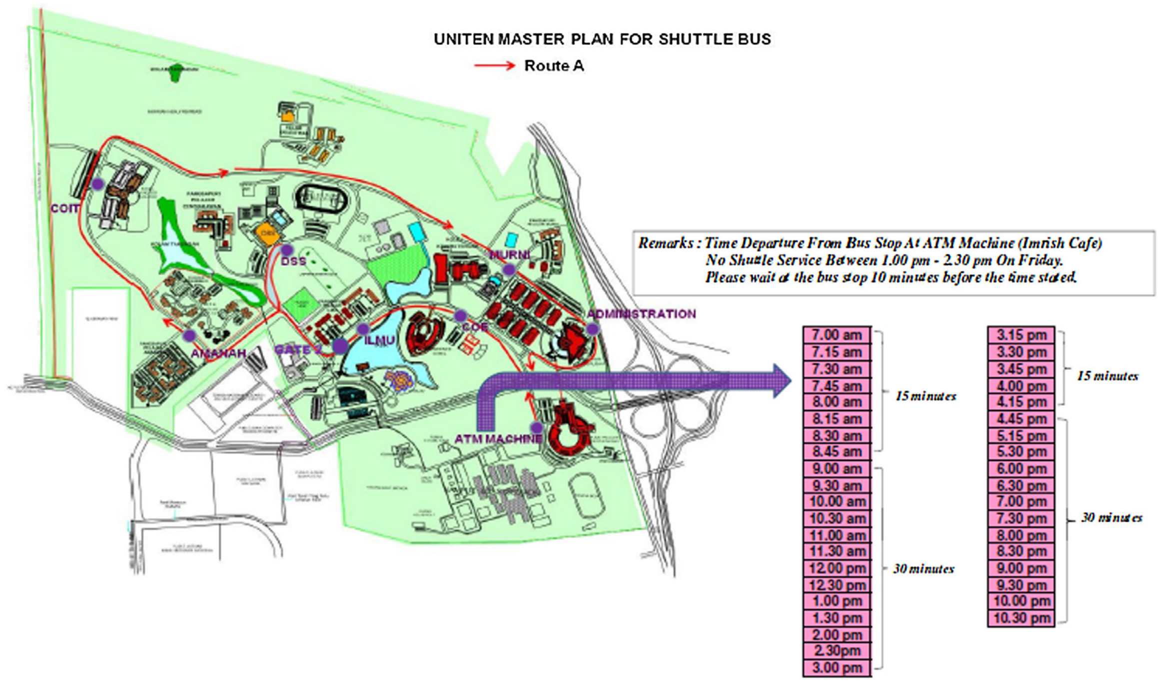

Fig. 2. UNITEN campus map with the routes for bus transportation.

heuristic genetic algorithm is utilized and applied to resolve CVRP issue since it is effective in solving high computational many-sided quality issues, particularly when the results space is considerable such as VRP. It is clear that the genetic algorithm technique has succeeded with regards to accomplishing the study goals through enhancing and reduce the distance for all paths of student's transportation, and consequently, reducing the transportation costs. It has been demonstrated that the improved genetic algorithm is active in solving the CVRP and finding best result as it is eligible in solving numerous different issues in real life applications. The strength of the improved genetic algorithm comes from its capacity to be adapted and acclimatized to solve of any issue through merging with different techniques, or by adjusting its algorithms according to the issue as has been done in this study. The limitations of the proposed algorithm are the presence of a single variable in the research problem (the distance), and the small and limited number of bus stops, makes it fairly easy to find a solution, and does not reveal the strength of the genetic algorithm, which is known for its efficient in dealing with complex and ambiguous problems. There is no more than one physical road linking the different locations for collecting the students, which impedes the possibility of finding another physical road and comparing between them to find a shortest distance route. The necessity to pave new roads costs the university extra money, at a time in which, UNITEN wants to reduce the expenditures. The bus for student's transportation must pass all the locations identified in advance, which makes it difficult to find a shorter route. Future work aims to extend the domain of the algorithm to find the shortest path between different locations in Selangor and UNITEN to facilitate the student's arrival to the university. Many and wide spread locations could reveal the strength and performance speed of the algorithm.

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References

[1] M.A. Mohammed, M.S. Ahmad, S.A. Mostafa, Using genetic algorithm in implementing capacitated vehicle routing problem, in: Computer & Information Science (ICCIS), 2012 International Conference on (Vol. 1, pp. 257–262). IEEE, June, 2012.
[2] O.I. Obaid, M. Ahmad, S.A. Mostafa, M.A. Mohammed, Comparing performance of genetic algorithm with varying crossover in solving examination timetabling problem, J. Emerg. Trends Comput. Inf. Sci 3 (10) (2012) 1427–1434.
[3] M.A. Mohammed, Design and implementing an efficient expert assistance system for car evaluation via fuzzy logic controller, Int. J. Comput. Scie. Softw. Eng. (IJCSSE) 4 (3) (2015) 60–68.
[4] S.A. Mostafa, M.S. Ahmad, M.A. Mohammed, O.I. Obaid, Implementing an expert diagnostic assistance system for car failure and malfunction, IJCSI Int. J. Comput. Sci. Issues 9 (2) (2012), 1694–0814.
[5] G. Laporte, The vehicle routing problem: an overview of exact and approximate algorithms, Eur. J. Oper. Res. 59 (3) (1992) 345–358.
[6] P. Toth, D. Vigo, Vehicle Routing Problem SIAM Monographs on Discrete Mathematics and Applications, Vol. 9, SIAM, Philadelphia, PA, 2002.
[7] X. Wang, X. Wu, Z. Wang, X. Hu, A model and an improved genetic algorithm for the vehicle routing problem with Break-Down vehicles, in: Innovative Computing, Information and Control (ICICIC), 2009 Fourth International Conference on 696–699. IEEE, December., 2009.
[8] G. Laporte, Fifty years of vehicle routing. transportation science Canada research chair in distribution management, HEC MontreaL 43 (2009) 408–416.
[9] O. Bräysy, M. Gendreau, Genetic algorithms for the vehicle routing problem with time windows, Arpakannus 1 (2001) 33–38.
[10] M.A. Mohammed, M.K.A. Ghani, R.I. Hamed, M.K. Abdullah, D.A. Ibrahim, Automatic segmentation and automatic seed point selection of nasopharyngeal carcinoma from microscopy images using region growing based approach, J. Comput. Sci. (2017), http://dx.doi.org/10.1016/j.jocs.2017.03.009.
[11] M. Zirour, Vehicle routing problem: models and solutions, J. Qual. Meas. Anal. JQMA 4 (1) (2008) 205–218.
[12] H. Nazif, L.S. Lee, Optimized crossover genetic algorithm for vehicle routing problem with time windows, Am. J. Appl. Sci. 7 (1) (2010), p.95.
[13] S. Zhong-yue, G. Zhong-liang, W. Qin, An improved adaptive genetic algorithm for vehicle routing problem, in: Logistics Systems and Intelligent Management, 2010 International Conference on 1, 116–120. IEEE, January, 2010.
[14] Y. Zhang, J. Liu, F. Duan, J. Ren, Genetic algorithm in vehicle routing problem, in: Intelligent Information Hiding and Multimedia Signal Processing, 2007. IIHMSP 2007. Third International Conference on 2, 578–581. IEEE., November, 2007.
[15] H.C. Lau, T.M. Chan, W.T. Tsui, W.K. Pang, Application of genetic algorithms to solve the multidepot vehicle routing problem, IEEE Trans. Autom. Sci. Eng. 7 (2) (2010) 383–392.

[16] E. Cao, M. Lai, An improved genetic algorithm for the vehicle routing problem with simultaneous delivery and pick-up service, Proceedings of the 6th Wuhan International Conference on E-Business 2100–2106 (2007).
[17] M.A. Mohammed, B. Al-Khateeb, D.A. Ibrahim, Case based reasoning shell framework as decision support tool, Indian J. Sci. Technol. 9 (42) (2016).
[18] A. Alvarez, P. Munari, An exact hybrid method for the vehicle routing problem with time windows and multiple deliverymen, Comput. Oper. Res. 83 (2017) 1–12.
[19] T. Chunhua, An improving genetic algorithm for vehicle routing problem with time windows, in: Intelligent Computation Technology and Automation (ICICTA), 2010 International Conference on 1, 603–606. IEEE, May, 2010.
[20] L. Bouhafs, A. Hajjam, A. Koukam, A hybrid heuristic approach to solve the capacitated vehicle routing problem, J. Artif. Intell.: Theor. Appl. 1 (1) (2010) 31–34.
[21] J. Berger, M. Barkaoui, A parallel hybrid genetic algorithm for the vehicle routing problem with time windows, Comput. Oper. Res. 31 (12) (2004) 2037–2053.
[22] A. Haghani, S. Jung, A dynamic vehicle routing problem with time-dependent travel times, Comput. Oper. Res. 32 (11) (2005) 2959–2986.
[23] D.M. Miranda, S.V. Conceição, The vehicle routing problem with hard time windows and stochastic travel and service time, Expert Syst. Appl. 64 (2016) 104–116.
[24] M. Abdulameer, U.T. Malaysia, N. Suryana, H.A. Abdullah, M.M. Jaber, Convert Database Structure into Star Schema Structure for Data Warehouse, 3 (8).
[25] D.M. Pierre, N. Zakaria, Partially optimized cyclic shift crossover for multi-objective genetic algorithms for the multi-objective vehicle routing problem with time-windows, in: Computational Intelligence in Multi-Criteria Decision-Making (MCDM), 2014 IEEE Symposium on 106–115. IEEE, December, 2014.
[26] M.M. Jaber, M.K.A. Ghani, N. Suryana, M.A. Mohammed, T. Abbas, Flexible data warehouse parameters: toward building an integrated architecture, Int. J. Comput. Theor. Eng. 7 (5) (2015), p. 349.
[27] M. Mahmoudi, X. Zhou, Finding optimal solutions for vehicle routing problem with pickup and delivery services with time windows: a dynamic programming approach based on state–space–time network representations, Transp. Res. B: Methodol. 89 (2016) 19–42.
[28] N. Arunkumar, K. Ram Kumar, V. Venkataraman, Automatic detection of epileptic seizures using new entropy measures, J. Med. Imaging Health Inf. 6.3 (2016) 724–730.
[29] N. Arunkumar, K. Ram Kumar, V. Venkataraman, Automatic detection of epileptic seizures using permutation entropy, tsallis entropy and kolmogorov complexity, J. Med. Imaging Health Inf. 6.2 (2016) 526–531.

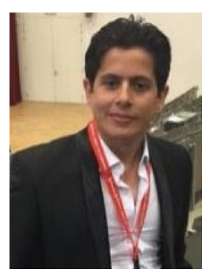
Mr. Mazin Abed Mohammed is a PhD Candidate at Biomedical Computing and Engineering Technologies (BIOCORE) Applied Research Group, Faculty of Information and Communication Technology, Universiti Teknikal Malaysia Melaka, Malaysia. received his B.Sc. in Computer Science from College of Computer, University of Anbar, Iraq in 2008. He obtained his M.Sc. in Information Technology from College of Graduate Studies, Universiti Tenaga Nasional (UNITEN), Malaysia, in 2011. Currently PhD Student of Information & Communications Technology, University Teknikal Malaysia Melaka (UTeM), His current research interests include Artificial Intelligence, Biomedical Computing, Multimedia Applications and Optimization Methods.

Prof. Dr. Mohd Khanapi Abd Ghani has a PhD in Biomedical Computing from Coventry University, U.K. Masters in Software Engineering from Malaysia University of Technology (UTM), BSc (Hons) in Computer Science from Malaysia University of Technology (UTM) and Diploma in Computer Science from Mara Institute of Technology. His research areas of interest include electronic healthcare systems, telemedicine, healthcare knowledge management, system architecture and software reuse.

Dr. Raed Ibraheem Hamed is an associate professor (faculty staff member) Department of IT, College of Science and Technology, University of Human Development, Sulaymaniyah KRG, Iraq. He obtained his M.Sc. in Information Technology from University of Technology, Baghdad Iraq in 2004 and his Ph.D. in Computer Science from the University of Jamia Millia Islamia, New Delhi, India, in 2011. He carried out Doctoral Degree on Computer Science at the University of JMI. His personal research interests include Bioinformatics and computational technology, Petri Nets Modelling and Simulating, » Databases and Data Mining, Fuzzy Logic.

Dr. Salama A. Mostafa obtained his BSc. in Computer Science from University of Mosul, Iraq in 2003. He obtained his MSc. in Information Technology from Universiti Tenaga Nasional (UNITEN), Malaysia in 2011. He obtained his PhD. in Information and Communication Technology from the College of Graduate Studies, UNITEN, Malaysia in 2016. He has produced more than 35 articles in journals, conferences, and tutorials. His research interests are in the area of software engineering, artificial intelligence and their integration including software agents and intelligent autonomous systems.

Prof. Dr. Mohd Sharifuddin Ahmad is currently the Head of Center for Agent Technology (CAT) at the College of Computer Science and Information Technology, Universiti Tenaga Nasional. He obtained his MSc. in Artificial Intelligence from Cranfield University, UK in 1995. He obtained his PhD. in Artificial Intelligence from Imperial College, London, UK in 2005. He has more than 32 years of experience working in various departments in LLN and later TNB. He has produced more than 140 articles in journals, conferences, and tutorials. His research interests include Software Agents and Knowledge Management.



Mr. Dheyaa Ahmed Ibrahim received his B.Sc. in Computer Science from College of Computer, University of Anbar, Iraq in 2009. He obtained his M.Sc. in Computer Science from College of Computer, University of Anbar, in 2012. His current research interests include Artificial Intelligence, Biomedical Computing, medical image processing and Optimization Methods.