

# **Optimization of the Transportation Problem in the Covid Pandemic with Time-Window Vehicle Routing Problem**

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### **Abstract**

*Logistics is one of the most important factors in any country and it has become a crucial topic due to the significant effect of Covid 19 on the world economics. Since the beginning of time, logistics is a critical link for products circulation throughout the world. When the Covid 19 pandemic came, logistics is becoming an essential role in preventing supply chain disruption. Meanwhile, transportation activity accounts for the highest portion in logistics. Therefore, improving the transportation system and optimizing the delivery method of goods are essential not only in the pandemic but also in any normal business situation. This paper focuses on optimizing the vehicle routing problem with the time window (VRPTW) by Genetic algorithm (GA) since the receiving time of the customer has some boundaries and restrictions. Furthermore, our VRPTW model include vehicle selection algorithm, which will automatically select the most efficient fleet from the set of vehicles with different capacity. This paper analyzes the application of the algorithm to GK logistics – a Vietnamese logistics company, compared to common direct transportation. The result proves that VRPTW is more efficient in term of distance, travel time and vehicle used.*

#### **Research purpose:**

*There are many transportation problems such as time constraints, capacity constraints, pick-up, and delivery constraints, which create many difficulties for transport routers. Finding the vehicle routing is always big issue of any logistics company and manufactures not only in the pandemic but also in any normal business situation. Many enterprises should determine vehicles route allocation to minimize costs by considering capacity and time windows of customers' requirements.*

*Therefore, this paper aims to develop the vehicle routing problem with time windows and selecting the appropriate fleet of trucks to minimize the total distribution cost through finding optimal routes and satisfy the customer demand at specific of receiving time. In this article, the genetic algorithm is applied to solve and optimize vehicle routing problem with hard-time window. The algorithm will be tested and compared with direct transportation method in experiment section.*

*Vehicle routing problem is based on integrating vehicles that deliver goods in the transport network affected by the time. The time window refers to time slot when the fleet reaches the customer's node. Two types of time windows impose each vehicle delivering the goods to the customers within a specific time interval. The vehicle may not arrive at the customer's node closing time and before node open time. The best route must be on time and follow disciplined capacity as well as minimum distance and cost.*

#### **Research motivation:**

*In recent years, E-commerce is developing rapidly in all over the world. Transportation plays an important role in delivering goods to customer and has a close relationship with E-commerce. Vietnam is among Asian countries having fastest growth in E-commerce. E-commerce has been developed sharply in recent years, since more and more people using the internet to purchase goods. Especially, the percentage of people doing online shopping has increased much more in the Covid 19 pandemic. When customers place orders from supermarkets and E-commerce companies, the supermarkets or E-commerce companies make a plan for delivery. They might manage the transportation activities or outsource to a 3PL provider. Furthermore, Logistics plays an important role in preventing broken supply chain. Transportation should manage the operation not only to meet the customer requirements at the right place, right time, and provide the right quality and but also to minimize the operation costs. As a result, providing cost-effective and efficient service is the top target of any logistics enterprise. In addition, the required receiving time should be strict during the pandemic thus the time window of receiving order also should be included in the research. Therefore, the motivation of this paper is developing the transportation model that minimize transportation distance, optimize capacity but still can meet the customers' requirements in term of time windows and transportation quantity.*

**Research design, approach and method:**

*This research develops the optimization model for vehicle routing problem with added constraints of time windows and selection of fleets. The problem of vehicle routing with time window constraint and fleet selection is non-linear programming, hence it is difficult to solve. As a result, we develop genetic algorithm to solve the problem faster and address more complicated distribution network. A downside of the classic vehicle routing model is the initial fixed capacity fleet condition. This problem causes reducing of flexibility when choosing vehicles to deliver to customers. This research has tried with actual data, the fixed capacity fleet has not as high fill rate as expected. Therefore, the research paper improves this problem with a vehicle selection model. Basically, the model helps us to choose the trucks with capacity approximately satisfying to the customer's requirements, thereby helping to reduce cost, increase the occupancy rate, simplify the transport management process. This research uses real data from GK Logistics company to test the model and derive applicable results in term of traveling distance, fleet selection and time control.*

**Main findings:**

*From the result of research, it reveals that the complex transportation issue during the pandemic can be solved with vehicle routing problem with time window control. Since the labor resources for transportation is limited and each route requires extra cost for testing virus, then the minimum vehicles used with minimum waiting time and late time can be solve and optimized. The model has been tested with data from GK Logistics company, the result shows that total travel distance has been reduced by 34.77% while the demand of customer still meet. Although direct transportation eliminates the waiting time and late time, the total time in VRPTW is still smaller than direct transportation, which decreases 10.09%. Quantity of vehicles mobilized also significantly reduced. From the implementation of research, it is evident that direct transportation will cost GK logistics more time to transport, especially for time-sensitive goods, leading to a drop in supply chain performance and customer service. On the other hand, VRPTW with GA, which surpass direct transportation in all important metrics, could be a good solution not only for GK Logistics Company but also for other Logistics companies and other manufacturers that have transportation activity.*

**Practical/managerial implications:**

*The pandemic has been affected much to whole Vietnam especially in Ho Chi Minh, Binh Duong, Dong Nai, Ha Noi, Bac Ninh and Bac Giang since the beginning of the pandemic. The supply chain has been broken and delayed especially in terms of transportation. As a result, logistics becomes a critical link for products circulation in the whole country and becoming an essential role in preventing supply chain disruption. In this paper, we optimize the vehicle routing problem with the time window (VRPTW) by Genetic algorithm (GA) to solve the transportation issue with some boundaries and restrictions on receiving time. Furthermore, our VRPTW model include vehicle selection algorithm, which will automatically select the most efficient fleet from the set of vehicles having different capacity. This paper analyzes application of the algorithm to GK logistics company. The result proved that VRPTW is more efficient in term of distance, travel time and vehicle used that could be applied both during and beyond the pandemic. The study shows the effectiveness of the genetic algorithm in optimization problems, especially solving the complex transportation issue. During the pandemic, the labor resources for transportation is limited and each route requires extra cost for testing Covid-19, then the minimum vehicles used with minimum waiting time and late time need to be solve and optimized. The research team has established optimization model of VRPTW using GA and demonstrated the effectiveness of the program, which could be applied widely to other field of transportation management. Some of the most useful applications of the VRPTW include postal deliveries, national franchise restaurant services, school bus routing, security patrol services, and JIT (just in time) manufacturing.*

**Keywords:** *Vehicle Routing Problem - VRP, Vehicle Routing Problem with Time Window - VRPTW, Genetic Algorithm, Optimization.*

**1.INTRODUCTION**

In recent years, E-commerce is having rapid development in all over the world. Transportation plays important role in delivering goods to customer and has a close relationship with E-commerce. Vietnam is among Asian countries has fastest growth in E-commerce. E-commerce has been developed sharply in recent years, since more and more people using the internet to purchase goods, and order online. Especially, the percentage of people have online shopping has increased much more in the Covid 19 pandemic. When customers place orders from supermarkets and E-commerce companies, the

supermarkets or E-commerce companies make a plan for delivery. They might manage the transportation activities or outsource to a 3PL provider. Furthermore, Logistics plays an important role in preventing broken supply chain. Transportation should manage the operation not only to meet the customer requirements at the right place, right time, and the right quality and but also to optimize the operation costs. As a result, providing cost-effective and efficient service is the top target of any logistics enterprise. In addition, the required receiving time should be strict during the pandemic then the time window of receiving order also should be included in the research.

There are many transportation problems such as time constraints, capacity constraints, pick-up, and delivery constraints, backhaul... which make many difficulties for transport routers. The vehicle routing problem (VRP) is a well-known solution in logistics system which has been researched widely in recent years to solve the above problem. Many complex VRP problems have been developed from the classic VRP combination problems. One of some problem is vehicle routing problem with time windows (VRPTW). VRPTW has the primary goal of determining vehicles and routes' allocation to minimize costs by considering capacity, and time windows. VRPTW is based on integrating vehicles that deliver and goods in the transport network affected by the time. The time window refers to when the fleet reaches the customer's node. Two types of time windows impose each vehicle delivers the goods to the customers within a specific time interval. The vehicle may not arrive at the customer's node closing time and before node open time. The best route must be on time and disciplined capacity as well as minimum distance and cost. Some of the most useful applications of the VRPTW include bank deliveries, postal deliveries, national franchise restaurant services, school bus routing, security patrol services, and JIT (just intime) manufacturing.

Therefore, this paper aims to develop the vehicle routing problem with time windows and selecting the appropriate fleet of trucks to minimize the total distribution cost with finding optimal routes and satisfy the customer demand at specific of receiving time. In this article, the genetic algorithm is applied to solve and optimize vehicle routing problem with hard-time window. The algorithm will be tested and compared with direct transportation method in experiment section

## 2. LITERATURE REVIEW

Vehicle routing problem (VRP) originates from a well-known algorithm, traveling salesman problem (TSP). The first application of VRP is for petrol deliveries (George et al, 1959). VRP's research rapidly accelerated, primarily due to improvement in computational technology, the researcher could implement more complex method such as meta-heuristics (Burak et al, 2009). VRP has been extended in many ways by introducing real life aspects or characteristics, creating many extensions from classical VRP (Kiris et al, 2016). According to the research conducted by Flavien Lucas et al., 2019, classical VRP's characteristics include the information and constraints of the problem such as delivering customers' demand with a fleet of vehicles, all routes start and end at the depot, all vehicles are identical and limited by their capacity, each customer must be visited and served at once.

VRP with time window (VRPTW) is one of the most popular variants, assumes that deliveries to a

given customer must occur in a certain time interval, which varies from customer to customer (Kiris et al, 2016). In some circumstances, vehicles don't need to arrive at the exact time interval, customers may be served before or after the time window bounds, the term "soft time window" is widely used in this case. Duygu Tas introduced, A Vehicle Routing Problem with Flexible Time Windows, in which feasible vehicle routes are constructed via a tabu search algorithm (Duygu et al, 2016). This paper only focuses on hard-time window and constructing vehicle routes by Genetic algorithm

The above-mentioned variables can also be combined with many extensions of classical VRP, such as VRP pick and delivery (VRPPD), in which the vehicles must pick up goods at various locations and deliver to other delivery locations. Jing Fan presented VRPPD based on customer satisfaction, where the consumer satisfaction is inversely proportional to the waiting time for the vehicle from the lower bound of the time window (Jin Fang, 2011).

Genetic Algorithm (GA) is the most used algorithm. Genetic is a type of Metaheuristic Algorithm based on 3 well known laws in biology: crossover, mutation, selection. Genetic algorithms first appeared in theory in the early 1970's, but John Holland is said to have founded the field of genetic algorithms in 1975 (Vickie,1993). Until now, many researchers use GA for solving complicated VRP. The genetic algorithm is an excellent technique to solve huge VRP problem with a high computational complexity and when the linear programming method is unable to find a theoretical solution in proper time.

There are also some researchs regarding to efficiency of VRPTW appliaction to real life case. Nguyen Huy Nghia implement VRPTW in ICD Tien son (ICD stands for In land container depot) through popular heuristic algorithm of Clarke and Wright. With the support of C++ software, seven routes serving 25 positions were constructed. In comparison with the ICD Tien Son's network, the number of routes and trucks decrease by one and one respectively, the total travelled distance presents an about 8% reduction however the total time of completing transport duties is the same because of a rise in the waiting time (approximately 2.5%) at customers' points. In our paper, we focus on implementing genetic algorithm (GA) on VRPTW and include vehicle selection algorithm as an improvement.

## 3. METHODOLOGY

### 3.1 Mathematical model

The notations, assumptions and descriptions of the capacitated vehicle routing problem with time windows (VRPTW)

The notions used in this problem are presented as follows:

$K$  : Set the number of vehicles  
 $k$  : vehicle index,  $k \in K, k=1, \dots, N$   
 $Q_k$  : the capacity of vehicle  $k$   
 $N$  : Set the number of customers  
 $i, j$  : customer index;  $i, j \in N ; i, j=1, \dots, N$  ( $0$  indicates the depot)  
 $d_i$  : total demand on customers  $i$   
 $t_{ij}$  : travel time between customer  $i$  and  $j$  (proportional to distance)  
 $t_i$  : time of arrival at the customer  $i$   
 $f_i$  : customer service time  $i$   
 $e_i$  : earliest time to serve customers  $i$   
 $l_i$  : latest time to serve customer service  $i$   
 $W_i$  : waiting time before customer service  $i$   
 $L_i$  : lateness of service in customers  $i$   
 $PW_i$  : opening penalty on customer  $i$   
 $PL_i$  : closing penalty at customer  $i$   
 $x_{ijk}$  : has a value of 1, meaning that vehicle  $k$  from customer  $i$  go straight to customer  $j$ , and if it is worth 0, then vice versa.

$$e_i \leq t_i \leq l_i ; i=1, \dots, N \tag{7}$$

$$t_i \geq 0 ; i=1, \dots, N \tag{8}$$

$$W_i = \max\{0, (e_i - t_i)\} ; i=1, \dots, N \tag{9}$$

$$PW_i = \begin{cases} 1, & W_i > 0 \\ 0, & \text{otherwise} \end{cases} \tag{10}$$

$$L_i = \max\{0, (t_i - l_i)\} ; i=1, \dots, N \tag{11}$$

$$PL_i = \begin{cases} 1, & L_i > 0 \\ 0, & \text{otherwise} \end{cases} \tag{12}$$

$$x_{ijk} = \begin{cases} 1, & \text{If vehicle travels directly from } i \text{ to } j \\ 0, & \text{otherwise} \end{cases} \tag{13}$$

The assumptions used in this problem are

- (i) Time window (open and close) customer is fixed.
- (ii) Vehicle speed is considered constant, equally 50 km/hour.
- (iii) Each route visits the depot node.
- (iv) Each customer node is visited precisely on one route.
- (v) Demand of customer is deterministic.
- (vi) The total load of vehicle is not exceed the maximum capacity of this vehicle.

The mathematical model of the VRPTW problem is as follows:

**Objective function**

$$\text{Min} = \sum_{i=1}^N (PW_i + PL_i) + \sum_{k=1}^K \sum_{i=0}^N \sum_{j=0}^N x_{ijk} t_{ij} \tag{1}$$

**Constraint:**

$$\sum_{k \in K} \sum_{i \in N} x_{ijk} = 1, \forall j \in N \tag{2}$$

$$\sum_{i \in N} x_{ijk} - \sum_{i \in N} x_{jik} = 0, \forall j \in N, \forall k \in K \tag{3}$$

$$\sum_{i \in V} x_{ik} \leq 1, \forall k \in K \tag{4}$$

$$\sum_{i \in V} d_i \sum_{i \in V} x_{ijk} \leq Q_k, \forall k \in K \tag{5}$$

$$t_j \geq t_i + w_i + f_i + t_{ij} - M(1 - x_{ij}); i, j=1, \dots, N ; k=1, \dots, K \tag{6}$$

The optimization model in equation (1) indicates the minimization of the opening penalty, closing penalty and transportation cost (distance). Equation (2) to ensure that each customer must be visited by 1 vehicle. Equation (3) to ensure that after a vehicle arrives at a customer it has to leave for another destination. Equation (4) is used to define that each vehicle only serves once. Equation (5) the total vehicle loading is less than or equal the maximum capacity. Constraint (6) is used to ensure that the two consumers' arrival times are compatible, where  $M$  is a huge real number. Constraint (7) ensures that the vehicle arrives at each consumer during the consumer's time window. Constraint (8) ensures that the arrival time of the vehicle to each customer is always positive. Equation (9) shows the waiting time for the vehicle to the customer  $i$ . Equation (10) has a value of 1 when the vehicle experiences waiting time for the  $i$ -th customer. Constraint (11) shows the time of delay in service in the  $i$ -th customer. Equation (12) has a value of 1 when the vehicle is delayed, and vice versa is 0. Equation (13) represents the characteristics and decision variables.  $PW_i, PL_i, x_{ijk}$  are binary variables.

**3.2 Methodology**

A downside of the classic CVRP model is the initial fixed capacity fleet condition. This problem causes reducing of flexibility when choosing vehicles to deliver to customers. This research has tried with actual data, the fixed capacity fleet has not high fill rate as expected. Therefore, the research paper improves this problem with a vehicle selection model. Basically, the model helps us to choose the trucks with capacity approximately satisfying to the customer's

requirements, thereby helping to reduce cost, increase the occupancy rate, simplify the transport management process. The model of vehicle selection algorithm is described below:

Objective:

$$\text{Min } \sum Q_k$$

Constraints:

$$\sum q_{ik} \leq \text{Max}Q_k \leq \text{Max}C$$

Where:

$Q_k$ : The capacity of vehicle k

$q_{ik}$ : The demand of customer i served by vehicle i

$\text{Max}C$ : The maximum capacity of vehicle sets

Algorithm of the model: Rearrange the list of customer's demand to descending order



Fig. 1: Customer's demands in descending order

Sort each request into the list of existing vehicles, if there is no vehicle that meets the customer's demand, add a new vehicle with the largest capacity to the existing vehicle list.

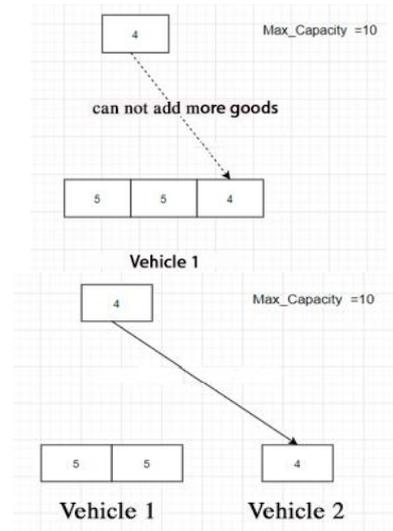


Fig. 2: Add one more vehicle having largest capacity

Implement the GA algorithm with that list of vehicles.

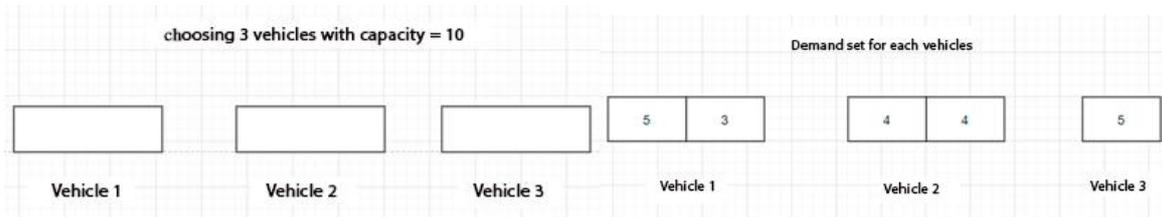


Fig. 3: Generate demand set of each vehicle by GA

After finding the most optimal set of demand for each vehicle, re-select the vehicle so that the capacity of each vehicle is the smallest.

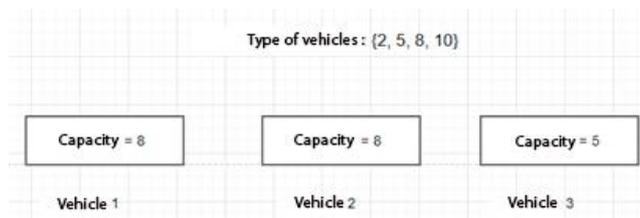


Fig. 4: Result of vehicle selection

As mentioned, the mathematical model is a mix integer programming problem, it is difficult to solve problems in a short time. Then, heuristic approach is proposed which can yield a quick and acceptable solution for the problem.

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. It is efficient to:

- Find a solution when solution space is large, and when linear programming cannot find a 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 following algorithm represents the implementation of the genetic algorithm in the VRPTW:

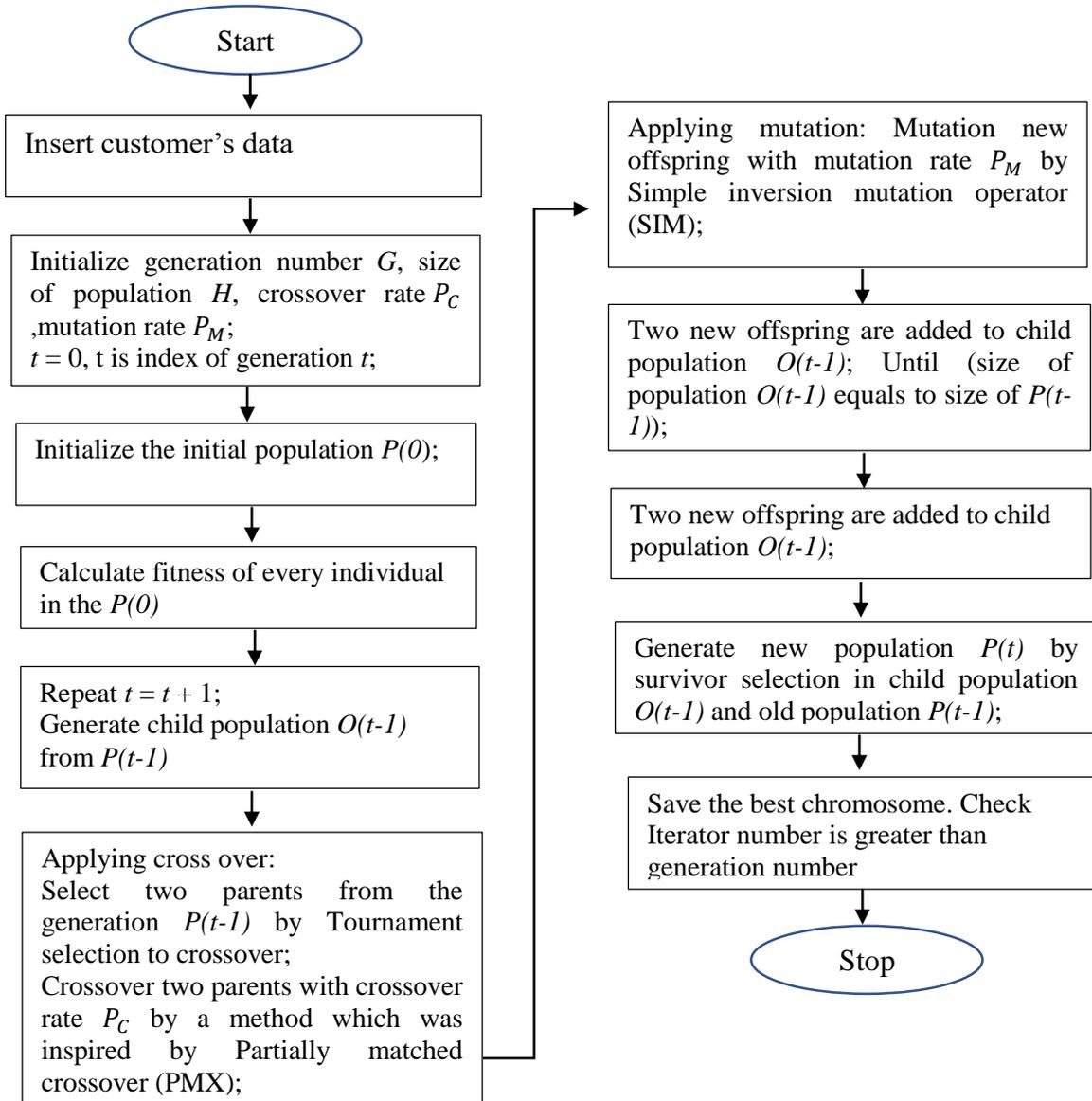
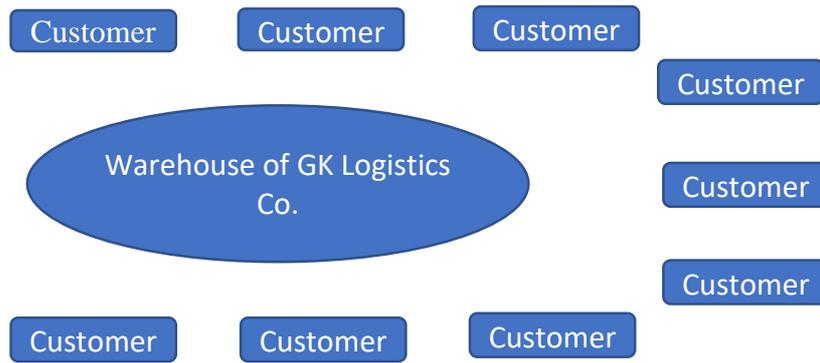


Fig. 5: The genetic algorithm in the VRPTW:

4. EXPERIMENT

We extract 9 customer locations from the transportation record of GK Logistics Company. The travel time matrix was obtained via dividing the

distance matrix by the average speed (50km/h) and the time service at any points is supposed equal by 15 minutes (0.25 hour). The network of distribution is described as follows:



**Fig. 6:** The distribution network of GK Logistics

The travelling time between the warehouse to customers and customer to customer is represented in the table 1 below:

**Table 1:** Travel time matrix (hour)

	WH	C1	C2	C3	C4	C5	C6	C7	C8	C9
WH (Warehouse)	0	1.221	0.7436	0.8218	0.7516	0.9164	0.8262	0.6468	0.6048	0.1072
C1	1.2496	0	1.0744	1.1526	1.0824	1.2472	1.157	1.4412	1.3992	1.1688
C2	0.7616	1.03	0	0.1338	0.012	0.1986	0.16	0.6898	0.6478	0.6808
C3	0.877	1.1456	0.1316	0	0.1346	0.0962	0.0292	0.8052	0.7632	0.7962
C4	0.7734	1.042	0.012	0.1356	0	0.2004	0.1618	0.7018	0.6598	0.6928
C5	0.9724	1.2408	0.1986	0.0982	0.2016	0	0.1246	0.9006	0.8586	0.8916
C6	0.8594	1.128	0.16	0.03	0.163	0.1246	0	0.7878	0.7458	0.7788
C7	0.6716	1.4122	0.6892	0.7674	0.6972	0.8622	0.772	0	0.0522	0.5908
C8	0.6194	1.36	0.637	0.7152	0.645	0.8098	0.7196	0.0534	0	0.5386
C9	0.1446	1.1796	0.7024	0.7806	0.7104	0.8752	0.785	0.6054	0.5636	0

**Table 2:** Types of vehicle by capacity

Types of vehicle (kg)	1000	1500	3000	5000	8000	10000	15000

**Table 3:** Customer’s demand and time window

Customer name	Customer’s demand (kg)	Time window (hour) [Lower bound, Upper bound]
Warehouse		[8, 17]
C1	2000	[8,10]
C2	4000	[9, 10]
C3	6000	[8,10]
C4	8000	[9, 11]
C5	10000	[10,11]
C6	12000	[8,11]
C7	14000	[9,10]
C8	16000	[10,11]
C9	18000	[8,10]

Most of the companies in Viet Nam still apply direct transportation method, especially for time-dependent

transporting like VRPTW. The table below represents a common way that GK logistics transporting goods. To

meet the customer’s demands, 11 vehicles are needed, and the total travel distance is 799,82 km.

**Table 4:** Direct transportation method

Customer name	Types of vehicle by capacity (kg)	Total service time	Total travel time	Waiting time	Late time	Total time
WH (depot)						
C1	3000	0.25	2.4706	0	0	2.7206
C2	5000	0.25	1.5046	0	0	1.7546
C3	8000	0.25	1.698	0	0	1.948
C4	10000	0.25	1.5244	0	0	1.7744
C5	15000	0.25	1.8884	0	0	2.1384
C6	15000	0.25	1.6874	0	0	1.9374
C7	15000	0.25	1.3176	0	0	1.5676
C8	15000+1000	0.25	1.2234	0	0	1.4734
C9	15000 + 3000	0.25	0.2516	0	0	0.5016
<b>TOTAL</b>	11 trucks	2.75	13.566	0	0	15.816

To demonstrate the optimization of distances and costs by applying the GA algorithm and vehicle selection model, the GA algorithm has been implemented with the inputs in table 1,2,3. The optimal results is generated after 3 iterations. The start time is 8 for all vehicles

**Table 5:** Using GA to solve VRPTW

No.	Vehicle type	Route	Total service time	Total travel time	Total Waiting time	Total Late time	Total time
0	15000 kg	WH-C7- WH	0.25	1.317	0.354	0	1.921
1	15000 kg	WH-C2-C5-C8-WH	0.75	2.418	0.809	0.108	4.085
2	15000 kg	WH-C1-C6-WH	0.5	2.378	0	0	2.878
3	3000 kg	WH-C9-WH	0.25	0.251	0	0	0.501
4	15000 kg	WH-C3-C4-WH	0.5	1.728	0	0	2.228
5	15000 kg	WH-C8-WH	0.25	0.604	1.396	0	2.25
6	15000 kg	WH-C9-WH	0.25	0.107	0	0	0.357
	<b>TOTAL</b>		2.75	8.803	2.559	0.108	14.22

With the above collected data, the research team compares the efficiency of the traditional shipping method that GK logistics companies applying with the

research team's algorithm, specifically shown in the table below:

**Table 6:** Comparing results

	Direct transportation	Using GA to solve VRPTW and select the vehicle
Total distance (km)	799.82	492.82
Total time (hour)	15.816	14.22
Total late time (hour)	0	0,108
Total waiting time (hour)	0	2.559
Total vehicles ( units)	11	7

From the result of research, it reveals that the complex transportation issue can be solved during the pandemic. Since the labor resources for transportation is limited and each route requires extra cost for testing virus, then the minimum vehicles used with minimum waiting

time and late time can be solve and optimized. Total travel distance has been reduced by 34.77% while the demand of customer still meet. Although direct transportation eliminates the waiting time and late time, the total time in VRPTW is still smaller than

direct transportation, which is 14.22 compared with 15.816 (decreased by 10.09%). Quantity of vehicles mobilized also significantly reduced. From the implementation and comparison of 2 methods, it is evident that direct transportation will cost GK logistics more time to transport, especially for time-sensitive goods, leading to a drop in supply chain performance and customer service. While VRPTW with GA, which surpass direct transportation in all important metrics, could be a solution.

## 5. CONCLUSION

The pandemic has been affected much to whole Vietnam especially in Ho Chi Minh, Binh Duong, Dong Nai, Ha Noi, Bac Ninh and Bac Giang. The supply chain has been broken and delayed in transportation. Then, logistics is a critical link for products circulation in the whole country, and becoming an essential role in preventing supply chain disruption. In this paper, we optimize the vehicle routing problem with the time window (VRPTW) by Genetic algorithm (GA) to solve the transportation issue with some boundaries and restrictions on receiving time. Furthermore, our VRPTW model include vehicle selection algorithm, which will automatically select the most efficient fleet from the set of vehicles having different capacity. This paper analyzes application of the algorithm to GK logistics – a Vietnamese logistics company, compared to common direct transportation. The result proved that VRPTW is more efficient in term of distance, travel time and vehicle used that could be applied during and pandemic and after pandemic. The study shows the effectiveness of the genetic algorithm in optimization problems. It reveals that the complex transportation issue can be solved during the pandemic. Since the labor resources for transportation is limited and each route requires extra cost for testing virus, then the minimum vehicles used with minimum waiting time and late time can be solve and optimized. The research team has established optimization model of VRPTW using GA and demonstrated the effectiveness of the program and could be apply widely to other field of transportation management.

This research could be extended to add the other constraint to the research, such as a penalty on late shipment, and backhaul delivery to optimize returns a vehicle to the warehouse. This research could expand the research for city transportation management with adding more constraints of city transportation mode.

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