Simulation of increased vehicle fleet to adapt transport optimization in a Model of competitiveness associated with a Smart City

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ABSTRACT

The proposal of a model of intelligent logistics that allows help influence the optimization of a Smart City is presented in this investigation, and thereby achieve reduce traffic accidents specifically those related to transport any type of product to generate energy. In addition, the problem of routing of vehicles (VRP) is the approach from which faces the problem of logistics, management, management and distribution of goods from one point to a destination. When is required to distribute loads to the classic problem, then it is considered the VRP with the capacity extension or (CVRP). The present work focuses on using an instance with the purpose of implementing an improvement to transport of hydrocarbonsation in the Metropolitan Area of Cuernavaca (MAoC). It uses the language for technical calculation called (MATLAB). The algorithm used in this work is described below: a) Start from the depot, b) Examine the outputs that have not been served, outputs may be feasible and infeasible) For choose the best feasible outputs, for example having the shortest distance, insert it into the route and position before the last exit on that route, d) If there are more feasible outputs, repeat from point b), but to create a new route and start the flow from the point a), e) If all exits were covered, but finish initiate flow from the point a). The results show that the route can be optimized by distributing and reordering of units so that all points are covered.

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1. INTRODUCTION

The cities represent the evolution of our society and according to the latest reports from the UN in 2050 concentrated 70% of the world population. This means that 6.700 million people, or what is the same, the entire world population of just seven years ago, coexist in just over 35 years in urban environments. Given this reality, we must strive to convert these urban spaces, efficient and sustainable environments. These two major challenges require intensive actions to support and accelerate the development and transformation of our current cities, smart to serve the public spaces. Transport of hydrocarbons represents a field of study every day more extensive for the academic and scientific sector since moving from one point of the city to another is a difficult activity [11] and it is necessary to study techniques and alternatives that will contribute to the improvement of the problem. According to the last census event named "Conteo 2015" of the National Institute of Statistics and Geography (INEGI) of 2015, in Morelos exists 977,268 motor vehicles and 547,925 in the ZMC of which 7,884 were trucks of passengers including transport to carry energy supplements [3], the problem lies in the fact that if it is considered that for that year the total population of the State was of 1.892,567 [4] then the percentage of people who had a car was of 52.7% which means that had more than one car per person. In regard to the distribution of transport in the ZMC, stands out in second place on transport of hydrocarbons with the 28.3% only below the trips on foot with a 37.4% [2] as shown in Graph 1. This research proposes the implementation of an instance to resolve the CVRP implementing data from actual data from a path of transport of hydrocarbons in the ZMC. The distribution of the present work is shown in the following order: in section 2, we discuss the complexity to optimize transport of hydrocarbons in the Metropolitan Area of Cuernavaca (MAC), México, in section 3 is analyzed the VRP with its variants, in section 4are explained the instances, in section 5,we discussed the deployment, in section 6 we present our approach to optimize transport of hydrocarbons in MAC as the results of the implementation, finally we present the conclusions and future work.

2. COMPLEXITY TO OPTIMIZE TRANSPORT OF HYDROCARBONS IN THE METROPOLITAN AREA OF CUERNAVACA

The metropolitan problems beyond the institutional capacities of governments given the excessive population growth increases demand for public services, so the more desirable intergovernmental coordination is intrinsic too municipal, state and national agencies in which that area is part. Besides this, there is no adequate legal framework at national level allowing institutions be obliged to organize for the implementation of plans and programs for the benefit of citizens. Thus, the intergovernmental coordination in the Cuernavaca Metropolitan Area is given by agreement of wills, rather than comply with existing regulations. The relevance of the study is based on the fact that the literature on Social Logistics draws intergovernmental coordination as a mechanism for strengthening local levels, especially in the search for efficiency in the delivery of public services. However, in metropolitan areas such coordination is given by agreements goodwill among the various levels of government rather than a present institutionalization. To address the issue is necessary to analyse the evolution in the way of interaction between different levels of government, which has taken place in Mexico, from the decentralization processes in planning and management of resources for transportation. These processes concur in the eighties and involved the participation of sub-national levels for effective development planning; and the development of tools for the rational use of public resources. With this, you begin to glimpse a change in intergovernmental relations, albeit incipient as it is passed from a model of coordinated authority on the Federal and State Government establishes its borders and local level is subject to the State level, a concurrent authority in which a certain type of interdependence between different levels of government or within them, in the administrative law to strengthen the management capacity of governments aspect arises. This research aims to analyse the transport problem from the perspective of intelligent systems, specifically using the technique of Social Data Mining, for it must consider all the factors that influence this problem.

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3 EVOLUTION AND PROSPECTS OF TRANSPORTATION IN METROPOLITAN AREAS

Necessary coordination of "complex Metropolitan Areas", one is immediately considered Cuernavaca Metropolitan Area because the number of elements that account is insufficient for the population served, which is considered is around 871,452, making seventh in Mexico Metropolitan Area (see figure 1) behind only that Mexico City. The study and analysis called "metropolitan areas" metropolis or megalopolis is a big challenge for scholars of Social modelling because of the complexity that require issues like federalism, decentralization, intergovernmental relations and any name you want to give the interaction between the different political and territorial units. The complexity in the treatment of metropolitan areas lies in the overlapping functions of various levels of government that leads to alliances and conflicts between groups of power in the provision of public services; coupled with the lack of representation of municipalities in senior management levels, difficult financing mechanisms and distribution of public resources. As already mentioned, the metropolitan problem goes beyond the institutional capacities of government's dad growing demand for public services. Besides this, there is no legal framework in Mexico requiring institutions to organize for the implementation of plans and programs for the benefit of citizens. Thus, intergovernmental coordination that is given by agreement of wills, rather than comply with existing regulations. According to the literature related with metropolitan areas are defined as "the territorial area of dominant influence of a population centre; focused on the powers of municipalities and states as to the intergovernmental coordination interstate for administration. Its main features are:

• Is an extended land area in one or more municipalities or counties;

* Municipalities can belong to one or more states;

* Directly affects the other urban, semi-urban, and rural localities established in that space:

*Influences and state, regional economic attraction, political and demographic. National or binational;

* Maintains territorial and / or functional unit through various chains of direct, daily and reciprocal codependence among its components;

* Not necessarily complex metropolitan conurbation;

* Concentrate secondary and tertiary activities;

* High social and urban stratification.

In Mexico, the exponential growth of cities can be explained by population growth and rural-urban migration and city-city. In addition to this, the locator's processes of the economy have led industrialization of cities and as a result, large urban concentrations in small territorial areas. The main challenge is to get better income opportunities to improve the already meager living standards of migrants.

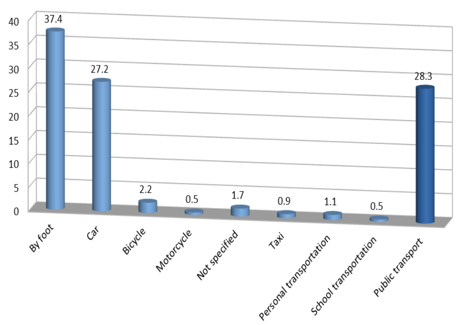
This involves a change in the vision of local governments, now called metropolitans, to meet and try to meet the demands of citizens (including Transport) that will increase disproportionately. Thus, coordination is not only desirable for greater efficiency in the presentation of municipal public services; but it is intrinsic in the daily life of the metropolitan municipalities.

From 2015, in Mexico it is considered nine cities with over one million inhabitants corresponding to the metropolitan areas of Mexico City, and Guadalajara, Monterrey, Puebla, Cuernavaca Metropolitan Area, Leon de los Aldama, Tijuana, Torreon and Toluca. By 2020, there will be 12 cities, including Acapulco, Merida-Progreso and San Luis Potosi Soledad de Gracia Sanchez; in 2020, 18 cities, adding Cuautla, Queretaro, Coatzacoalcos, Mexicali, Cancun and Aguascalientes; and by 2030 the areas of Tampico and Chihuahua, respectively, an important consideration in order of the problems of Transportation, Cuernavaca Metropolitan Area is positioned in third place just behind Acapulco and Tampico will be added.

These urban concentrations cause inequities both within their societies -this would be one of the main reasons for the problem of Transportation- as with the rest of the cities. These inequities are mainly a result the failure in presenting public services (the reason of this project), social benefits, and public safety, among others. An important figure indicates that 49.8% of the employed population in metropolitan areas of the country works without receiving legal benefits such as social security, bonuses, holiday pay, housing fund and payment of utilities. It is in this tenor coordination effort at both national and international level are essential, given the rapid growth of cities; as well as the need for infrastructure, equipment and urban services. Although urban municipalities have comparative advantages in relation to rural municipalities; the problem is accentuated when the financial capacity of municipalities is overwhelmed by the demands of public services, which is why we must analyse carefully the optimization of public security elements and generate the best logistics to make their patrols.

Another limitation is that the metropolitan problems include two or more jurisdictions, whether state or municipal, as well as various political parties will have to decide whether to perform activities designed to benefit a single group, or become suppliers of satisfactions for a large number of people who suffer daily deprivation and social insecurity generated by population growth.

The outlook for the promotion of metropolitan development of Cuernavaca metropolitan area is very complicated in terms of intergovernmental relations, that is why we must think in a different dynamic in terms of transportation, since a limited number of units possessed transport to cover a large area covering the metropolitan area. The dynamics in the Metropolitan Area Cuernavaca Metropolitan Area exceeds the institutional capacities of the municipality and counties that make up given the growing demand for transport of hydrocarbons services and roads increasingly scarce drinking water, public safety with outdated regulations, environment, human settlements and civil protection. So, a national legal framework that allows institutions at all three levels, are obliged to organize for the implementation of plans and programs for the benefit of citizenship is required. Thus, we can say that there is no adequate institutional framework for strengthening government coordination.



Graph 1. Distribution by type of transport of the travel/person/day made in a working day in the ZMC, 2012 [2].

4. THE VRP MODEL PROPOSED

One of the strategies used to address the problem of transport has been the VRP [1] This is a proposal made by G. B. Dantzig and J. H. Ramser that originally is a generalization of the problem of Travel Agent (TSP) which estrablece a strategy where cars to decrease the consumption of petrol [13] as well as the distncia between points that visit the agent during its travel along the path of distribution.

- VRP Description

The relevance of this problem is because is an important part of transportation and logistic which are crucial in a traditional business model. The elements of this model are: production, distribution and sales. The cost of the transportation is added to the final price of any product but in some cases this cost is high. For these reason, many research have been done to improve this situation. Disciplines like Supply Chain Management try to integrate the data and management procedures, but this was not easy because there was no integration between Enterprise Resource Planning (ERP) and the Enterprise Data Processing (EDP) system In the 90's began to integrate ERP and DRP implementing logistic system which saw the supply chain like a unique process from the start to the end, where the improvement of the transportation cost was the key of this chain.

The use of these systems allows significant savings from 5% to 20%. This is possible, even though the minimization cost is tiny, because the distribution process is carried out daily.

- VRP Formulation

The VRP was defined 40 years ago and some example is the paper published en 1959 by Dantzig [13]. The VRP is related with two problems: Traveling Salesman Problem (TSP) and the Bin Packing Problem (BPP). The Traveling Salesman Problem is a NP-Hard routing problem in the optimization version. This problem is about a salesman that has to visit n cities, each of them exactly once, and he/she should start and finish the tour in the same city. In this problem is considered that the transport have unlimited capacity. Other variant of this problem is the m-TSP, where the m-salesman has to cover the n cities and each city has to be visited by only one salesman. Every salesman goes out from the same city (depot), and must return to this city again (Vehicle Routing and Traveling Salesman Problems). Until this point the VRP is like the m-TSP but, in addition, the number of vehicles is considered like minimization criterion. The Bin Packing Problem is other NP-Hard problem (Garey, 1979) which is about to pack object of different volume in a finite number of bins with a capacity C so that the number of bin used is minimum. In general terms, VRP try to find the optimum route to attend all customers using a fleet of vehicles. The constraints that should be considered are: the vehicle capacity and the driver's maximum working time, to finally minimize the total transportation cost (including the use of minimum number of vehicles)., The VRP is a problem of Nonlinear Programming but its combinatorial nature and characteristics can be represented by a graph and on that basis describe the objective function and restrictions.

Given a graph G(V, E) where V is the vertexes set and E is the edges set, the VRP is formulated as follows:

$V = \{v0, v1, \dots, vn\}$ is a vertexes set, where:

$v0$ is considered as a depot.

And V'=V \{v0} be used as the set of n costumers.

A= {(vi, vj) | vi, vj V; i j} is an arc set

C is a matrix of costs (positives) or distances cij between customers vi and vj.

d is a vector of the customer demands.

Ri is the route for vehicle i

m is the number or vehicles with the same characteristics. One route is assigned to each vehicle.

When the problem is symmetric, it means, cij=cji for all (vi, vj) A, then E= {(vi, vj)| vi, vj V; i< j}

With each vertex vi in V' is associated a quantity qi of some goods to be delivered by a vehicle. The VRP thus consists of determining a set of m vehicle routes of minimal total cost, starting and ending at a depot, such that every vertex in V' is visited exactly once by one vehicle. For easy computation, it can be defined b(V)=[(Σvi v di)/C], an obvious lower bound on the number of trucks needed to service the customers in set V. If is considered a service time ∂i (time needed to unload all goods), required by a vehicle to unload the quantity qi at vi. It is required that the total duration of any vehicle route (travel plus service times) may not surpass a given bound D, so, in this context the cost cij is taken to be the travel time between the cities. The VRP defined above is NP-hard. The feasible solution of it can be represented as follows:

a partition R1,...,Rm of V; and

a permutation σi of Ri U 0 specifying the order of the customers on route i.

The cost of a given route (Ri={ v0, v1, … , vm+1 }), where viV and v0=vm+1=0 (0 denotes the depot), is given by:

$$C(R_i)=\sum_{i=0}^{m} c_{i,i+1}+\sum_{i=1}^{m}\partial_i \qquad (1)$$

A route Ri is feasible if the vehicle stop exactly once in each customer and the total duration of the route does not exceed a pre-specified bound D: C(Ri)≤D.

Finally, the cost of the problem solution S is:

$$FVRP(S)=\sum_{i=0}^{m} C(R_i) \qquad (2)$$

Figure 1 shows the diagram of the VRP; in the left image appreciate points by way of destinations and the center a origin; in a real picture these points can be in different geographical locations. The problem of the VRP consists in finding a set of optimal routes through which it is possible to serve (visit) to each of the clients [7].

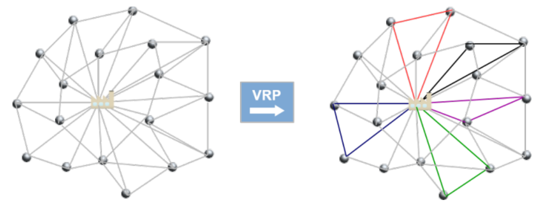


Figure 1. The VRP

Originally in the VRP does not envisage a metric for loads that should lead each vehicle, that is why the VRP considers extensions or variants that are adjusted to reality, as shown in figure 2.

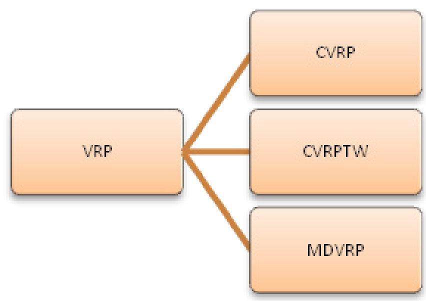


Figure 2. Variants of the VRP

The CVRP also covers, in addition to the distance and the path, the load to be delivered to each client [6]. The CVRP with time windows (CVRPTW) defines the same problems of CVRP and adds a variant: times in which each vehicle must deliver the goods to each client [8]. The VRP with multiple deposits (MDVRP) defines the possibility to add more than one tank or origin, possibility that does not contemplate the VRP original where there is only one deposit [9]. For the present work, we choose the variant CVRP since, as is well known, each unit of transport of hydrocarbons carries people and usually each unit varies in its capacity. The following chapter describes the instance.

Bin Packing Problem

Bin Packing problem is a complex problem NP (non-deterministic Polynomial) The problem is trying to fit in a container in our case the issue of vehicle fleet with the maximum number of objects of different value and volume, occupying much space as possible. In this problem, what is sought is to try to take the maximum amount of space that is available in the container or container and arrange everything in a better way so you can fit more and can optimize space as shown in the following figure 4:

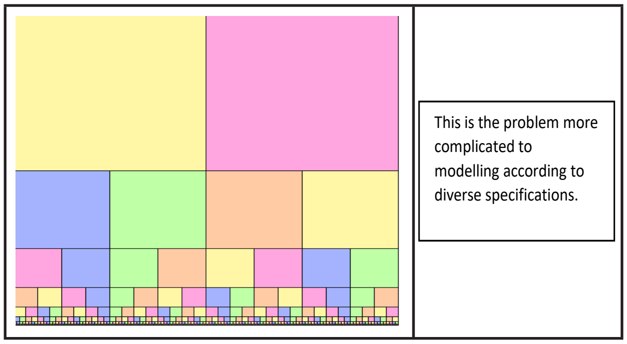


Figure.- 3 Representation of Bin Packing Problem to our research.

The idea is to solve the problem the minimum required number of repetitions corresponds container the ceiling of the greater proportion of the demand required ith object d1 and the number of copies the vessel it h object to I 1, namely, max {[dj / aj 1] / i = 1,2, ..., n}.

Therefore, the first step is to place a copy of all objects in the container (this is possible thanks to that c ≥

n, then the object is selected that defines the minimum number of repetitions of the container to meet all claims and a copy is added of that object in our container, repeating the procedure until it is full.

The algorithm that we evaluated only those associated with a container for objects and make better accommodations to each object related with this problem optimally for the case one type of container. Taken as entry number n of different types of objects, container capacity c and demands objects

d = (d1 D2 ... Dc) T, such that c ≥ n. The output of the algorithm is tuple (x +, TO -), where

x + is the optimum solution to the problem and

A- determines the number copies of each object in the container.

5. GROUP OF INSTANCES

There are currently repositories to which it is possible to find and use a free data sets from the VRP of authors, for the different variants as CVRP, CVRPTW AND MDVRP [10]. The structure of the CVRP shown in Figure 4, it notes that the breakdown of the data described in 4 columns; the first describes the node number of the node, in the second column is the point in the X coordinate, in the third column the point on the Y coordinate and in the fourth column is the demand.

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```
NAME : A-n37-k5
COMMENT : (Augerat et al, Min no of trucks: 5, Optimal value: 669)
TYPE : CVRP
DIMENSION : 37
EDGE_WEIGHT_TYPE : EUC_2D
CAPACITY : 100
nod X    Y    Demand
  1 38   46   0
  2 59   46   16
  3 96   42   18
  4 47   61   1
  5 26   15   13
  6 66   6    8
  7 96   7    23
  8 37   25   7
  9 68   92   27
 10 78   84   1
 11 82   28   3
 12 93   90   6
```

The proposed solution to this structure is shown in Figure 4.

```
Route #1: 22 13 10 6 5 33 4 7
Route #2: 1 12 2 19 20 23 14 17
Route #3: 36 29 32 28 31 30 15
Route #4: 3 24 9 11 27 8 25 35 18 26 34
Route #5: 21 16
cost 669
```

Figure 4. Proposed Solution [10]

The graph derived from the solution is shown in figure 5.

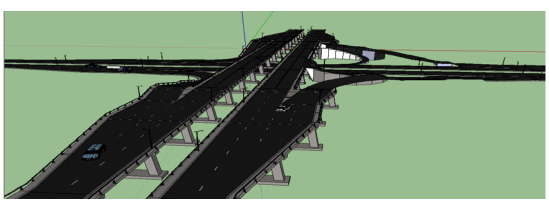


Figure 5. Graph CVRP and their representation in Unity [10]

Analysing the present example is that the instance contains 37 nodes, and a capacity of 100. When the problem is resolved, the result is that you need 6 routes to cover the full path with the combination of numbers that make up each one of them. The combination of numbers means that the sum nodes complete the capacity, in this case of 100.

6. DESIGN OF EXPERIMENTS AND IMPLEMENTATION

For this research, three factors (turns, units and days) to determine the load are analysed. Turns for three moments (M, T and N) where M = 8 a.m., T = 12 p.m. and N = 6 p.m. this because is desired identify which route is more demand. Three units (r5, r12 and r23) are analysed. Finally discusses days a week from Monday to Friday (d1, d2, d3, d4, d5) where d1 = Monday, d2 = Tuesday, d3 = Wednesday, d4 = Thursdays and d5 = Fridays. The image is displayed with the analysis.

turn
M=8 am
T= 12 pm
N=6 pm

unit
r5
r12
r23

day
d1=Monday
d2=Tuesday
d3=Wednesday
d4=Thursday
d5=Friday

The next step is to prepare the matrix in Excel with data prior to analysis in Statgraphics Centurion XVI. The result is the preparation shown below.

	u5				
	d1	d2	d3	d4	d5
M	335	288	286	307	285
T	205	294	291	284	149
N	202	128	101	156	178

	c12				
	d1	d2	d3	d4	d5
M	207	32	246	299	292
T	84	168	135	113	113
N	252	341	246	0	130

	u23				
	d1	d2	d3	d4	d5
M	292	332	286	228	164
T	255	295	258	261	205
N	207	189	183	164	0

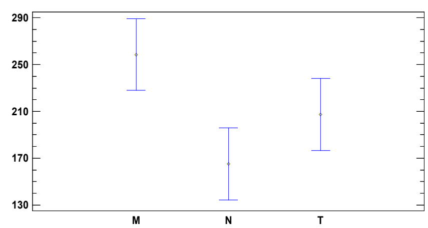
The data within each table represent the sum of the charges that are defined by the times defined in M, T and N.

time	*unit*	*day*	*capacity*
T	*r23*	*3*	*258*
M	*r12*	*5*	*292*
T	*r12*	*1*	*84*
T	*r23*	*2*	*295*
T	*r23*	*1*	*255*
M	*r5*	*2*	*288*
M	*r23*	*3*	*286*

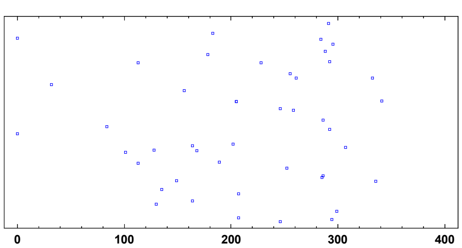
when data are prepared, they sent to Statgraphics; for the present research, it has the version Centurion. the image of how the matrix is created in such software is displayed.

There is a total of 45 records identifying time, unit, day and capacity. The aim of the experiment is to analyse the capacity variable and identify where there is more demand turn. The results are shown in the following images.

Summary Statistics for capacity	
Count	*45*
Average	*210.356*
Median	*207.0*
Variance	*7722.69*
Standard deviation	*87.8788*
Coeff. of variation	*41.7763%*
Minimum	*0*
Maximum	*341.0*
Range	*341.0*

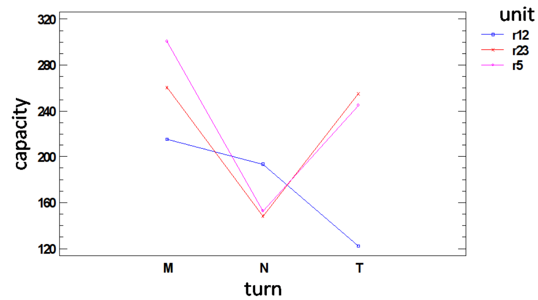


In the picture above statistical capacity variable is displayed. Capacity distribution shown in graph where it is possible to appreciate indicating statistics.



The following image shows in what turn exist more loads.

The graph shows that the turn where more loads is in the M, approximately 290, followed by T, is the turn of 12 pm to 200 and less charge is N, that is, that at 8 pm people do not demand equally a unit. The following graph shows a greater capacity per turn, identifying that M turn more capacity for r5 unit while for the same turn the unit r12 is the lower demand has.



While in the previous chapter showed an example of the public authority, solution and graph of NEO, in this chapter shows the implementation with the instance proposal. Working with data obtained from the route 214 of the alliance of lorry drivers in Jalisco, belonging to module 6. During his trip, this route covers three municipalities (Temixco, Cuernavaca and Jiutepec) of the 8 that make up the ZMC (Cuernavaca, Tepoztlán, Jiutepec, Temixco, Yautepec de Zaragoza, Emiliano Zapata, Xochitepec y Huitzilac) [5]. In Figure 6 can be seen the route and the municipalities already mentioned of the route. The starting point of the route is in the municipality of Jiutepec crosses Cuernavaca and ends the half turn in Temixco; to close the path is necessary to return to the point source, i.e. the base which is in Jiutepec.

Figure 6. Route 11 [12].

For the implementation used the Nearest Neighbor algorithm (NNA), in which is shown in figure 7.

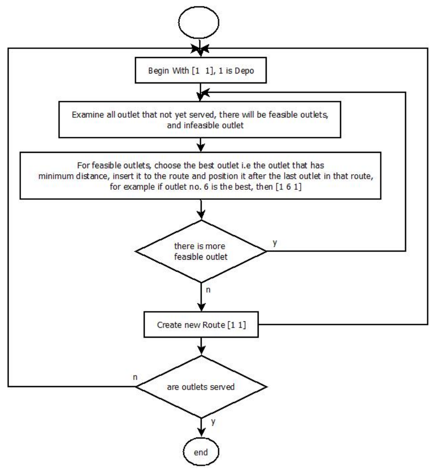


Figure 7. Nearest Neighbor algorithm

For the present study were caught 20 points of IDA and 17 back as part of the complete path of the path. So, the first step was to locate the geographical points. The second step was to create a Google merger in order to be able to export table the .csv file with geographic data. Once in Google Merger tables, was exported the map view in the image. The third step was to transform these geographical points in XY coordinates within a plane from 0 to 100. To achieve this was imported the fusion image tables to a .ppt in where you created the document 100 cm. X 100 cm. for the identification point by point. The fourth step was to create a table that contains the geographic nodes and their equivalent in XY. Figure 8 shows the result of this process.

vuelta	num	punto	lat	long
vuelta	1	contestación	20.62345	103.399858
	2	Zansibar-Imss	20.626311	-103.391305
	3	Reyes Heroles	20.62875	-103.39091
	4	Isla Gomer	20.636798	-103.391563
	5	Retorno 61	20.657921	-103.377251
	6	Enrique D/Washing	20.66463	-103.363758
	7	Paztolsa	20.666511	-103.359493
	8	Pque. Sn. Fco.	20.672856	-103.346813
	9	Med 56	20.670988	-103.340621
	10	Cv Ruiz Sanchez	20.662675	-103.319915
	11	Vinos la playa	20.658138	-103.307686
	12	Mercado Osos	20.652805	-103.293658
	13	Templo Malecón	20.64762	-103.273948
	14	Subida malecón	20.641685	-103.276623

Nodo	X	Y	D
1	5.84	84.48	
2	11.34	81.83	
3	11.91	76.92	
4	11.34	65.96	
5	20.06	36.10	
6	31.57	33.16	
7	33.83	25.51	
8	43.92	21.70	
9	48.15	24.70	
10	62.97	36.51	
11	72.14	42.33	
12	81.84	49.39	
13	94.31	50.08	
14	94.2	65.1	

vuelta	num	punto	lat	long
ida	1	Base 214	20.631275	-103.27242
	2	Farm GDL	20.635641	-103.27629
	3	Rio Nilo	20.63904	-103.276768
	4	Curva Malecon	20.643665	-103.277506
	5	Templo Malecón	20.64762	-103.273948
	6	Pizzeria 61	20.653115	-103.280195
	7	Boleria	20.655203	-103.293706
	8	Ramón Val-Pensador	20.65748	-103.308781
	9	Arena Jalisco	20.664685	-103.31713
	10	Cuartel colorado	20.670491	-103.334153
	11	Zapateria prado	20.672975	-103.342323
	12	Pque. Sn. Fco.	20.67357	-103.348021
	13	8 de julio- la paz	20.672156	-103.353053
	14	Paztolsa	20.66566	-103.359538
	15	Lab. Piza	20.663861	-103.36495
	16	Retorno 61	20.657995	-103.378498
	17	Isla Gomer	20.636815	-103.391545
	18	Reyes Heroles	20.62875	-103.39091
	19	Zansibar-Imss	20.626311	-103.391305
	20	Contestación	20.62345	-103.399858

Nodo	X	Y	Demanda
1	95.06	73.33	0.00
2	92.42	67.66	2.00
3	91.85	62.56	8.00
4	91.66	55.56	0.00
5	94.31	50.08	1.00
6	89.58	42.90	2.00
7	80.32	39.50	9.00
8	69.93	36.66	9.00
9	63.69	26.27	6.00
10	52.16	17.77	10.00
11	45.92	14.55	1.00
12	41.96	13.80	3.00
13	38.36	15.69	10.00
14	33.83	25.51	0.00
15	30.05	27.59	0.00
16	20.06	36.10	6.00
17	11.34	65.96	0.00
18	11.91	76.92	0.00
19	11.34	81.83	7.00
20	5.84	84.48	3.00

Figure 8. Transformation of points

Once identified the points in XY format data is sent to MATLAB to perform the calculation.

7. RESULTS

Shows the results of MATLAB for two calculations; for going and return.

The calculation for the going is given with a load of 40 people that is allowed in the trucks of public transport.

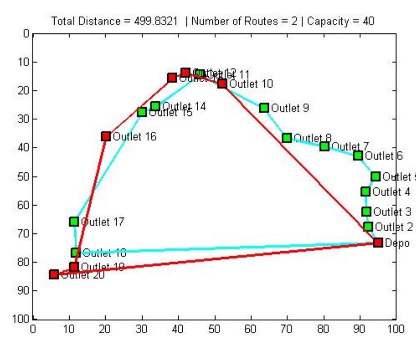
The result for the going is shown below:

Route_VRP_1 = 1 2 3 4 5 6 7 8 9 11 14 15 17 18 1

Route_VRP_2 = 1 10 12 13 16 19 20 1

NumberOfRoutes = 2

It can be seen that after calculation, the algorithm shows the cycle with two routes. The graph that represents the path shown below:



For the lap is also provides a load of 40 people.

The calculation in MATLAB shows that the cycle is complete with 3 routes.

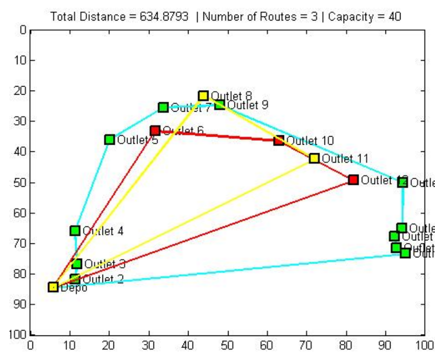
Route_VRP_1 = 1 2 3 4 5 7 9 13 14 16 15 17 1

Route_VRP_2 = 1 6 10 12 1

Route_VRP_3 = 1 8 11 1

NumberOfRoutes = 3

The graph that accompanies the result is the following:



If you take any path and joined the loads of each node that points, the result must not exceed the present charge, i.e. the 40 passengers. The results shown here are due to a unit of a route which is composed in total by a park of 35 units that circulate in 3 municipalities the ZMC. Which means that it is possible to deepen in the study of this work with the aim of glimpse areas of opportunity greater than those shown here.

8. CONCLUSIONS AND FUTURE RESEARCH

In the present research, we analysed a path of public transport in the ZMC with its instance. It was noted in the previous section that the calculations are promising if you have as a point of comparison as shown in Figure 9.

Distancia Total
24.43 km.

Figure 9. Detail of path [12].

In this work was observed distances and the number of routes in which case the improvement was obtained from which the distance of the complete cycle (roundtrip) is less than the displayed in [12]. The improvement shown in the wear of the units to not have to only one to all points. In the comfort of the passengers since in reality the units exceed the maximum capacity of 40. Determine the best transportation route in a metropolis it will be a challenge in the future, which is why this research aims to determine through intelligent application, the best routes generated from specific instances characterized for the city of Cuernavaca and its metropolitan area. This research pretends to solve the CVRP with the optimization algorithm by ant colony (ACO) since it is expected that with the parallelism is achieved further improvement as the proposed in [15]. Determine the supply chain related with an emergence or Humanitarian Logistics will be a priority in our novel research as in [14]. Once formalized variants BPP, and established a mathematical model, the main future work is the incorporation of hybrid genetic algorithm to the problem of transportation of products organized in the distribution of hydrocarbons in a density traffic area. When it has a competitive algorithm with excellent results for the Standard resolution of problem cases in its simplest form, it equally solves a more complex problem addressed towards the same ultimate goal. Therefore, incorporating variants thereof represents only the effort to validate the conditions established by the new mathematical model, whether through conditions or criminalization of the objective function. In addition is important define all spaces which be improved using a novel model of Smart Cities based on Smart mobility, as is shown in the figure 10.

Figure 10. Features of Smart Cities in the perspective of improved competitiveness in a Latin-American society.

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