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Analysis and Practice of the Vehicle Schedule and Route Choice Algorithm for the Distribution Centre

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Abstract: The social economy in high gear and the rapid development of information technology, logistics and distribution requirements of the region continues to increase. Logistics management and optimization highlights its importance, the high share of logistics costs calls for the research of the optimization of the transport. Based on the latter study for the vehicle scheduling and route choice of the distribution centre, with customer demand, vehicle condition, road traffic and other factors, the paper does its research works and its actual distribution for the vehicle routing maybe used in very important significance. In the vehicle routing problem, we take the phase change occurred in the time windows into account, appropriate TABU search algorithm is designed to solve this problems.

Key words: Logistics and distribution, vehicle routing problem, transport costs, TABU search algorithm

INTRODUCTION

It is proved to be a NP hard (Non-deterministic Polynomial) that regional logistics route optimization choosing, there is no effective solution for such NP hard problems till now, in most cases we can only get some approximate optimal solutions. Then it will be very interesting work that regional logistics route optimization choosing problem and attract many researchers to do these kinds of works include the author (Ataka and Gen, 2009; Guo, 2009; Guan and Bai, 2007).

In spite of unpredictable results always accrues in many logistics and distribution cases, some random event maybe approximately predicated by previous appearance regulation in some real applications. When the logistics and distribution center design and program its vehicle routine, some relative information will be not defined (such as road condition), these items could be obtained only by statistic law and experience or field investigation, random traffic flow and time window with restriction will lead to driving time changed, then the shortest route will be random unpredictably in traffic web, there are still many other factors keep random in the Vehicle Route Problem (VRP) (Liao, 2009; Liu and Chen, 2005). The route strategy of logistic and distribution center will turn to be more difficult and hard to find its optimal way. Those problems have their wide application in economics field and transportation areas, it is great valuable to discuss such subject (Cao and Wu, 2009; Schwind *et al.*, 2009).

REGIONAL PHYSICAL DISTRIBUTION ROUTE MODEL WITH TIME WINDOWS

The vehicle routing problem with time window is the combination program problem of distribution center, vehicle and cargo. As the new demands continues coming, dispatching system has to adjust old routine or set up new route for dynamic task nodes. We investigated the real application in the logistics and distribution center in Changxing Zhejiang Province, neglect some factors that infective the model, such as vehicles and drivers who served, routine network performance, multi time widow and distribution.

Then our problem turn to be an optimal routine of logistics and distribution with time window, we want to find an optimal driving route for the vehicle to meet condition of the constraint to keep costumer's logistics cost in or near lowest degree.

There is a logistics and distribution center (parking lot), each freight car with certain loading capacity, we can know the position and loading demand of costumer and far most distance of distribution driving beforehand, also the driving expenses from center to costumers can be defined before distribution, our problem is how to arrange the proper driving route to make the distribution more efficient (Lee *et al.*, 2010; Yao *et al.*, 2010).

Before building the algorithm model, we have known something about time window, there is a hard and a soft time window in our discussion, the difference between them is the loose and comfortable of the time widow restriction, the restriction of soft time widow is loosen than the hard relatively, the load cart can be allowed earlier or later than the costumer required in a limitation, it would be a non-restriction time tolerance. The hard time window is exactly the reverse, it should be strictly on time, no later allowed, if earlier it should be waiting for the certain time to serve.

Model assumption:

- Each customer visits the cart exactly once and its demand will meet fully
- The sum of all costumers' demands in one route is no more than total vehicle carrying capacity
- The length of each distribution route is no more than the maximum driving range of each distribution
- The vehicle flowrate of each section of way in each distribution route is no more than the maximum vehicle flowrate restriction
- Each vehicle starts off from the distribution center and then back to the center after delivery
- The arriving time of each vehicle is restricted in a certain time bond for certain costumer

These are the common restriction of the problems that generally meet in most situations, in real application we may add or delete some restrictions depends on concrete conditions.

Model building: For the route choice of the regional logistics and distribution center, traffic network is much complicated, we here take air-line distance of each points as driving route. In real application of our certain distribution center in Changxing Zhejiang Province, our regional vehicle route choice problem can be described as: In certain distribution center, there are some same like freight cars with certain cargo capacity, each freight car serves some costumers, our purpose of design is to realize lowest distribution cost as satisfied all the distribution demand.

This model is the regional physical distribution route model with time windows (Liu and Chen, 2005), it touches the amount of costumers, the demand of costumers, sum of the cargo vehicles and time window, we define those variables as below:

N = Stands for costumers number that distribution center serves
K = Stands for the number of vehicles that distribution center has
d_{ij} = Stands for the distance between costumer i to costumer j
k = Stands for the sum of cargo vehicle;
qk = Stands for the maximum cargo capability of vehicle k, k = 1, 2, …, k
g_I = Stands for the cargo demands of the costumer node i, i=1, 2, …, n
w_d = Stand for the punish weight per distance costs
wq = Stands for the punish weight per cargo weigh costs that exceed maximum cargo load
We = Stands for the punish weight per waiting time of costumer node
Wl = Stands for the punish weight per delay time of costumer node
t_I = Stands for the time that arrive costumer i
$[Et_i, LT_i]$ = Stand for the time window that costumer i need, Et_i, is the beginning time that the costumer need be served
LT_i = Is the end time that the costumer need be served

Model: According all those assumption and definition, we can get our mathematic model as follow:

The objective function:

$$\min Z = (\sum_i \sum_j \sum_k c_{ij} x_{ijk}) \exp(u) \tag{1}$$

$$\text{St.} \sum_i g_i y_{ki} \le q_k \tag{2}$$

$$\sum_i y_{ki} = 1,\ i = 1, \cdots, n \tag{3}$$

$$\sum_i x_{kij} = y_{kj} \tag{4}$$

$$\sum_i x_{kij} = y_{ki} \tag{5}$$

$$c_{ij} = d_{ij}\ w_d + v_{ij} \tag{6}$$

$$u = \sum_k \mathrm{Max}(\sum_i y_{ki} g_i - q_k) w_q \tag{7}$$

$$\begin{aligned} v_{ij} &= [\max(ET_i - t_i, 0) w_e \\ &+ \max(t_i - LT_i, 0) w_l] / 2 \\ &+ [\max(ET_j - t_j, 0) w_e \\ &+ \max(t_j - LT_j, 0) w_l] / 2 \end{aligned} \tag{8}$$

$$y_{ki} = \begin{cases} 1 & \text{the vehicle k serves the costumer in node i} \\ 0 & \text{otherwise} \end{cases} \tag{9}$$

$$x_{ijk} = \begin{cases} 1 & \text{the vehicle k drive from costumer i to costumer j} \\ 0 & \text{otherwise} \end{cases} \tag{10}$$

$$\forall K \in [I, K] \qquad (11)$$

Here, expression (1) Is the cost of distribution, expression (2) Means the sum of costumer's demands of each vehicle is no more than the cargo load of this vehicle, expression (3) Means each costumer can be served only by one vehicle and each costumer can be served, expression (4), (5) Expresses the vehicle unique for each costumer, expression (6) Means the sum of distance cost and time cost of each costumer, expression (7) Means the sum of overload cost of the vehicle, expression (8) is the sum of waiting and arrive late time cost of the costumer, expression (9), (10) Is the Boolean restriction, expression (11) Means k is the integer range from 1 to K.

Solution of the model: In this case we combine Tabu Search algorithm with the vehicle route problem to improving the regional physical distribution route model with time window. We find that there are many decision variables in the model, such as number of costumer's nodes, position, Tabu length, Tabu list, iterations, terminations, time windows and etc. when we get certain cargo freight, vehicle and costumer amount, our problem is to find an optimal distribution vehicle route in time window. The algorithm can be realized in 6 steps:

- Set all the variable parameters involved, initial solution can be random defined
- Determine whether the solution meet stopping criteria, if meet then end the algorithm and output the result, if not, go on next step
- Call the time window function (include traffic delay time, time window and etc.) to find field solutions to form candidates solution set that satisfied Tabu demand
- If candidates satisfy pardon criterion then take them as current solution, otherwise take non Tabu optimal solution as current
- According to Tabu extend create Tabu list, change the Tabu parameters as well
- Turn to step b, go on iteration

We add Tabu Search algorithm to the program, the method can be mainly divided into two parts here: the route optimization and time window. As for implemented function, there is the process of decomposition of time series, the process of time window, the process of distance optimizer from nodal point to costumer, the process of route drawing and result output.

MODEL SIMULATION

In the case, there is one distribution center with some certain carrying capacity freight cars, time window setting by requirement, here we computed and simulated the distribution model when the number of costumers was se 75, include position, traffic and other vehicle information, the cities and carry freight.

Programming by Matlab, we can get the route planning and scheduling diagrammatic sketch as Fig. 1.

From Fig. 1. We can see the shortest driving route by dynamic route choice.by using Tabu Search algorithm and time window.

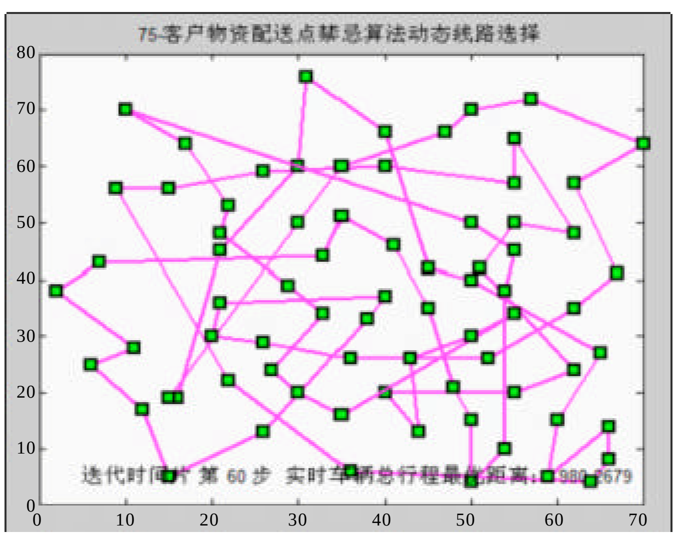

Fig. 1: Regional dynamic route choice simulation

DISCUSSION AND CONCLUSION

We mixed Tabu Search to the distribution vehicle scheduling problem with time window in this paper. With actual example computation, our algorithm can solve the distribution vehicle route problem with time window efficiently, this algorithm can be very useful to those optimal distribution and logistics system.

As for shortcoming of the algorithm, in spite of its powerful fine adjustment ability, the Tabu search algorithm is too depend on initial solution and tends to be trapped in local optima. There are still many things can be improved, first in a dynamic issue, just focus on changes in customer demand and other dynamic factors are ignored. Second in the simulation process, emphasize on theory mainly, it needs specific logistics center of instance data to validate this model and make the appropriate adjustment. Third, the model is just the route choice model considering the logistics vehicles, it is needed to be integrated and the prior distribution, vehicle scheduling, planning as a whole view.

Social progress and economic growth will promote logistics development of efficient, flexible and high quality of service (Xie *et al*., 2002; Pecha, 2002; Schwind *et al*., 2009; Lee and Zhu, 2006). The soul of logistics is the system, the key is management, is the sciences and technology. Future of logistics development is committed to strengthening the integrated logistics service, construction of market system and public information service platform and the establishment of evaluation system of industry logistics operation.

ATTACHMENT

Some main functions programmed in MATLAB

```
%TABU function£¬include 10¡¢30¡¢50¡¢75 costumers' information
function [DLn,cityn]=TSInf(n)
if n==10
  city10=[0.4 0.4439;0.2439 0.1463;0.1707 0.2293;0.2293 0.761;0.5171
0.9414;
  0.8732 0.6536;0.6878 0.5219;0.8488 0.3609;0.6683 0.2536;
  0.6195 0.2634];%10 cities
  for i=1:10
  for j=1:10
  DL10(i,j)=((city10(i,1)-city10(j,1))^2+(city10(i,2)-city10(j,2))^2)^0.5;
  end
  end
  DLn=DL10;
  cityn=city10;
 end.
 if n==30
  city30=[41 94;37 84;54 67;25 62;7 64;2 99;68 58;71 44;54 62;83 69;64
60;
  18 54;22 60;83 46;91 38;25 38;24 42;58 69;71 71;74 78;87 76;
  18 40;13 40;82 7;62 32;58 35;45 21;41 26;44 35;4 50];
  for i=1:30
  for j=1:30
  DL30(i,j)=((city30(i,1)-city30(j,1))^2+(city30(i,2)-city30(j,2))^2)^0.5;
  end
  end
  DLn=DL30;
  cityn=city30;
 end
 if n==50
   city50=[31 32;32 39;40 30;37 69;27 68;37 52;38 46;31 62;30 48;21
47;25 55;
  16 57;17 63;42 41;17 33;25 32;5 64;8 52;12 42;7 38;5 25; 10 77;
  45 35;42 57;32 22;27 23;56 37;52 41;49 49;58 48;57 58;39 10;
  46 10;59 15;51 21;48 28;52 33;58 27;61 33;62 63;20 26;5 6;
  13 13;21 10;30 15;36 16;62 42;63 69;52 64;43 67];
  for i=1:50
  for j=1:50
  DL50(i,j)=((city50(i,1)-city50(j,1))^2+(city50(i,2)-city50(j,2))^2)^0.5;
  end
  end
  DLn=DL50;
  cityn=city50;
 end
 if n==75
   city75=[48 21;52 26;55 50;50 50;41 46;51 42;55 45;38 33;33 34;45
35;40 37;
  50 30;55 34;54 38;26 13;15 5;21 48;29 39;33 44;15 19;16 19;12 17;
  50 40;22 53;21 36;20 30;26 29;40 20;36 26;62 48;67 41;62 35;
  65 27;62 24;55 20;35 51;30 50;45 42;21 45;36 6;6 25;11 28;26 59;
  30 60;22 22;27 24;30 20;35 16;54 10;50 15;44 13;35 60;40 60;
  40 66;31 76;47 66;50 70;57 72;55 65;2 38;7 43;9 56;15 56;10 70;
  17 64;55 57;62 57;70 64;64 4;59 5;50 4;60 15;66 14;66 8;43 26];
  for i=1:75
  for j=1:75
  DL75(i,j)=((city75(i,1)-city75(j,1))^2+(city75(i,2)-city75(j,2))^2)^0.5;
  end
  end
  DLn=DL75;
  cityn=city75;
 end
   %%%%%traffic delay, time widow function %%%%%
 function
[Smean,Sdeltmean,Scor,tau,tw]=ShiJin(X,max_d)
 % X: input time series
 % max_d :max traffic delay
 % Smean£¬Sdeltmean,Scor: function returns
 % tau :traffic delay time
 % tw: time window
 N=length(X);
 Smean=zeros(1,max_d);
 Scmean=zeros(1,max_d);
 Scor=zeros(1,max_d);
 delt=std(X);
 % Smean,Sdeltmean,Scor
 for t=1:max_d
  S=zeros(4,4);
  Sdelt=zeros(1,4);
  for m=2:5
  for j=1:4
  r=delt*j/2;
Xdt=DisTimes(X,N,t); % split time series X into t disjoint time series
  Xdt=Xdt';
  s=0;
  for tau=1:t
  N_t=floor(N/t); % split series length
  Y=Xdt(:,tau); % each sub-series
  Cs1(tau)=CalIntegral(Y,N_t,r); C(1,N/t,r,t)
  Z=ReXiang(Y,N_t,m,1); % restructure phase space
  Z=Z';
  M=N_t-(m-1);
  Cs(tau)=CalIntegral(Z,M,r); C(m,N/t,r,t)
  s=s+(Cs(tau)-Cs1(tau)^m);
  end
  S(m-1,j)=s/tau;
  end
```

```
  Sdelt(m-1)=max(S(m-1,:))-min(S(m-1,:)); endSmean(t)=mean(mean(S));
Sdeltmean(t)=mean(Sdelt);
Scor(t)=abs(Smean(t))+Sdeltmean(t);
 end
 function F=DistCalculation(dislist,s)
 DistanV=0;
 n=size(s,2);
 for i=1:(n-1)
  DistanV=DistanV+dislist(s(i),s(i+1));
 end
 DistanV=DistanV+dislist(s(n),s(1));
 F=DistanV;
  %%%%%%%%%time series%%%%%%%%%
  for t=1:max_d
 S=zeros(4,4); Sdelt=zeros(1,4);
 for m=2:5
 for j=1:4
 r=sigma*j/2;
 Xdt=disjoint(data,t);
 S=0;
 for tau=1:t
 N_t=floor(N/t) ;
         Y=Xdt(:,tau);
        Cs1(tau)=0;
         for ii=1:N_t-1
         for jj=ii+1:N_t
         d1=abs(Y(ii)-Y(jj));
         if r>d1
         Cs1(tau)=Cs1(tau))+1;
             end
           end
         end
          Cs1(tau)=2*Cs1(tau)/(N_t*(N_t-1));
          Z=reconstiution3(Y, m,1);
       M=N_t-(m-1);
       Cs(tau)=correlation_integral(Z,M,r);
       s=s+(Cs(tau)-Cs1(tau)^m);
    end
    S(m-1,j)=s/tau;
   end
  Sdelt(m-1)=max(S(m-1,:))-min(S(m-1,:));
 end
 Smean(t)=mean(mean(S));
 Sdeltmean(t)=mean(Sdelt);
 Scor(t)=abs(Smean(t)+Sdeltmean(t));
End
%%%%%%time series end%%%%%%%%
```

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