

# A study on the solution approach for the stochastic vehicle routing problem

黃金智、吳泰熙

E-mail: 9900284@mail.dyu.edu.tw

## ABSTRACT

Vehicle routing problem (VRP) and its variants have been widely studied for several decades. Since they are of the class of NP-Hard problems, it is very difficult to obtain optimal solutions within acceptable amount of time. Heuristic algorithms are thus applied for solving VRP with large scale. Several assumptions are usually made in the modeling of VRP and its variants including: 1. demand of each customer is constant, 2. fleet type is homogeneous, 3. unlimited number of vehicles can be used. The above assumptions obviously conflict with the reality. We hence study four types of VRP variants: general VRP with single type of fleet, general VRP with mix fleet type, VRP considering stochastic demands with single fleet type, and VRP considering stochastic demands with multiple type of fleet to reflect the real situations. As far as the solution method is concerned, tabu search is used for solving the SVRP. The results indicate that the size of tabu list does not play an important role in the solving process for all types of problems. When solving the SVRP, the objective function gets better as the route failure probability increases, and besides, the objective function gets better as the capacity filling coefficient  $f$  decreases.

Keywords : Vehicle Routing Problem ; Stochastic VRP ; Mix Fleet ; Tabu Search

## Table of Contents

第一章 緒論	1
1.1 研究背景與動機	1
1.2 研究目的	2
1.3 研究範圍與假設	2
1.4 研究架構	3
第二章 文獻回顧	4
2.1 車輛途程問題	4
2.1.1 車輛途程問題(VRP)之定義	4
2.1.2 車輛途程問題數學模式	4
2.1.3 車輛途程問題之研究	6
2.1.4 車輛途程問題之延伸	9
2.2 多種車輛途程問題	11
2.2.1 多車種車輛途程問題之定義	11
2.2.2 多車種車輛途程問題之數學模式	11
2.2.3 多車種車輛途程問題問題之研究	13
2.3 隨機車輛途程問題	16
2.3.1 隨機車輛途程問題之數學模式	16
2.3.2 隨機車輛途程問題之研究	18
2.4 禁忌搜尋法	21
2.4.1 禁忌搜尋法之基本模組	22
2.4.2 禁忌搜尋法之應用	25
第三章 車輛途程問題之禁忌搜尋法	28
3.1 路線建構階段	28
3.2 路線改善階段	30
3.2.1 途程間及途程內移步之設計	31
3.2.2 禁忌名單之設計	34
3.2.3 搜尋停止準則	36
3.3.4 禁忌搜尋法之作業流程	36
3.2.4.1 途程間改善模組	37
3.2.4.2 途程內改善模組	40
第四章 巨網切割之多車種車輛途程問題	41
4.1 起始解---Tabu TSP	41
4.2 巨網切割	41
4.2.1 單巨網切	41
4.2.2 多巨網切割	44
4.3 移步改善階段	47
第五章 隨機車輛途程問題之演算法設計	49
第六章 結果分析	52
6.1 確定型單一車種車輛途程問題	52
6.2 確定型多車種VRP問題	56
6.3 隨機車輛途程問題	59
6.4 研究心得	70
6.4.1 途程內移步之效果討論	70
6.4.2 途程間三種移步方式必要性討論	71
第七章 結論與建議	73
7.1 結論	73
7.2 建議	74
參考文獻	75
附錄一	82
附錄二	94
附錄三	99
附錄四	104
附錄五	125

## REFERENCES

- [1]李宗儒、翁基華, “具工作負荷平衡支配送車輛途程問題”, 運輸學刊, 11, 59-72 (1999)。
- [2]林明俊, “隨機環境下多車種派車問題之研究”, 私立中原大學, 工業工程研究所碩士論文, 民國八十七年六月。
- [3]陳正元, “節省法與路線間交換改善法在車輛路線問題上之應用”, 國立交通大學, 土木工程研究所碩士論文, 民國八十一年六月。
- [4]張祖明, “多車種車輛路線問題啟發式解法之研究”, 國立交通大學, 土木工程研究所碩士論文, 民國八十二年六月。
- [5]陳勝男, “禁忌搜尋法應用於車輛路線問題之研究”, 私立大葉工學院, 工業工程研究所碩士論文, 民國八十五年六月。
- [6]韓復華、楊智凱、卓裕仁, “應用門檻接受法求解車輛路線問題之研究”, 運輸計劃季刊, 26, 253-280 (1997)。
- [7] Ball, M. O., B. L. Golden, A. A. Assad, and L. D. Bodin, “Planning for truck fleet size in the presence of a common-carrier option,” Decision Sciences, 14, 103-120 (1983)。
- [8] Barbarosoglu, G. and D. Ozgur, “A tabu search algorithm for the vehicle routing problem,” Computer & operations Research, 26, 255-270 (1999)。
- [9] Bartholdi, J. J., and L. K. Platzman, “Heuristics based on spacefilling curves for combinatorial problems in Euclidean space,” Management Science, 34, 291-305 (1988)。
- [10] Bastian, C. and A. H. G. R. Kan, “The stochastic vehicle routing problem revisited,” European Journal of Operational Research, 56, 407-412 (1992)。
- [11] Benton, W. C. and M. D. Rossetti, “The vehicle scheduling problem with intermittent customer demands,” Computer Operations Research, 19, 521-531 (1992)。

- [12] Bertsimas, D. J., " A vehicle routing problem with stochastic demand, " *Operations Research* , 40,574-585 ( 1992 ) .
- [13] Bodin, L.,and B. Golden, " Classification in vehicle routing and scheduling, " *Networks* ,11,97-108 (1981).
- [14] Bodin , L. D., B. L. Golden ,A.A.Assad and M.O. Ball, " Routing and scheduling of vehicles and crews. The state of the art, " *Computers and Operations Research* ,10,69-211 (1983).
- [15] Bramel, J. and D. Simchi-Levi, " On the effectiveness of set covering formulations for the vehicle routing problem with time windows, " *Operations Research* ,45 ,295-301 (1997).
- [16] Brandao, J. ,A. Mercer, " A tabu search algorithm for the multi-trip vehicle routing and scheduling problem, " *European Journal of Operational Research* ,100,180-191 (1997).
- [17] Breedam ,A.V., " Improvement heuristics for the vehicle routing problem based on simulated annealing, " *European Journal of Operational Research* ,86 ,480-490 (1995).
- [18] Chao, I. M. , B. L. Golden, and E. Wasil, " A new heuristic for the multi-depot vehicle routing problem that improves upon best-know solutions, " *Am. J. Math. Mgmt Dci.* ,13, 371-406 (1993).
- [19] Christofides, N. and S.Eilon, " An algorithm for the vehicle dispatching problem, " *Operational Research Quarterly* ,20 ,309-318 (1969).
- [20] Clarke,G. and J. W.Wright, " Scheduling of vehicles from a central depot to a number of delivery points, " *Ops Res*,12,568-581 (1964).
- [21] Dantzig, G. and J. H. Ramser, " The truck dispatching problem, " *Management science*, 6, 80-91 (1959).
- [22] Dammeyer, F. and V. Stefan, " Dynamic tabu list management using the reverse elimination method, " *Annals of Operation Research* ,41 ,31-46 (1993).
- [23] Desrochers, M.,J.Desrosiers and M.Solomon, " A new optimization algorithm for the vehicle routing problem with time windows, " *Operations Research*, 40,342-354 (1992).
- [24] Desrochers, M., and T.W.Verhoog, " A new heuristic for the fleet size and mix vehicle routing problem, " *Computer Ops Res*,18,263-274 (1991).
- [25] Dror, M.,G. Laporte and P. Trudeau, " Vehicle routing with stochastic demands:properties and solution frameworks, " *Transportation Science* ,23,166-176 (1989).
- [26] Dror, M. and P. Trudeau, " Stochastic vehicle routing with modified savings algorithm, " *European Journal of Operational Research* ,23,228-235 (1986).
- [27] Duhamel, C.,J.-Y. Potvin and J.-M. Rousseau, " A tabu search heuristic for the vehicle routing problem with backhauls and time windows, " *Transportation Science* ,31,49-59 (1997).
- [28] Etezadi, T. and J.E. Beasley, " Vehicle Fleet Composition, " *J. Opl Res. Soc.*,34,87-91 (1983).
- [29] Fisher, M. L.,K.O.Jornsten,and O. B. G.Madsen, " Vehicle routing with time windows:two optimization algorithms, " *Operations Research* , 45,488-492 (1997).
- [30] Fisher, M. L. and R. Jaikumar, " A generalized assignment heuristic for vehicle routing problems, " *Networks*, 11,109-124 (1981).
- [31] Gendreau, M., G. Laporte and R. Seguin, " An exact algorithm for the vehicle routing problem with stochastic demands and customers, " *Transportation Science* ,29,143-155 (1995).
- [32] Gendreau ,M., G. Laporte and R. Seguin, " Stochastic vehicle routing, " *European Journal of Operational Research* ,88,3-12 (1996).
- [33] Gendreau, M., G. Laporte and R. Seguin, " A tabu search heuristic for the vehicle routing problem with stochastic demands and customers, " *Operations Research* , 44,469-477 (1996).
- [34] Gerdessen, J.C., " Vehicle routing problem with trailers, " *European Journal of Operational Research*,93,135-147 (1996).
- [35] Gillett ,B.E. and L.R.Miller, " A heuristic algorithm for the vehicle-dispatch problem, " *Operations Research* ,22,340-349 (1974).
- [36] Golden, B., A. Assad, L. Levy and F. Gheysens, " The Fleet Size and Mix Vehicle Routing Problem, " *Comput & Ops Res.* ,11,49-66 (1984) .
- [37] Kohl, N. and O.B. G.Madsen, " An optimization algorithm for the vehicle routing problem with time windows based on lagrangian relaxation, " *Operational Research*,45,395-406 (1997).
- [38] Lambert, V., G. Laporte and F. Louveaux, " Designing collection routes through bank branches, " *Computers Ops Res.*,20,783-791 (1993).
- [39] Laporte, G., F. Louveaux and H. Mercure, " Models and exact solutions for a class of stochastic location-routing problems, " *European Journal of Operational Research* ,39,71-78 (1989).
- [40] Laporte, G. , F. Louveaux and H. Mercure, " The vehicle routing problem with stochastic travel times, " *Transportation Science*, 26,161-170 (1992).
- [41] Little , J. D. C, K.G. Murty, D.W. Sweeney and C. Karel, " Algorithm for the traveling salesman problem, " *Ops. Res.* ,11, 979 (1963).
- [42] Mole, R. and S.Jameson, " A sequential route-building algorithm employing a generalized savings criterion, " *Operations Research Quarterly*,27,503-511 (1976).
- [43] Ong,H. L., B.W. Ang, T.N. Goh and C.C. Deng, " A vehicle routing and scheduling problem with time windows and stochastic demand constraints, " *Asia-Pacific Journal Operation Research* ,14, 1-17 (1997).
- [44] Osman, I. H., " Metastrategy simulated annealing and tabu search algorithms for the vehicle routing problem, " *Annals of Operations*

Research ,41,421-451 (1993).

[45] Reingold, E. M. and J. Neivergelt, and N. Deo, Combinatorial Algorithms: Theory and Practice (Prentice-Hall, Englewood Cliffs, N. J.), (1977).

[46] Renaud, J., G. Laporte and F. F. Boctor, " A tabu search heuristic for the multi-depot vehicle routing problem, " Computers Ops Res., 23, 229-235 (1996).

[47] Salhi, S. and G. K. Rand, " Incorporating vehicle routing into the vehicle fleet composition problem, " European Journal of Operational Research , 66, 313-330 (1993).

[48] Salhi S, and M. Sari, " A multi-level composite heuristic for the multi-depot vehicle fleet mix problem, " European Journal of Operational Research , 103, 95-112 (1997).

[49] Salhi, S., M. Sari, D. Saidi and N. Touati, " Adaptation of Some Vehicle Fleet Mix Heuristics, " OMEGA Int . J. of Mgmt Sci., 20, 653-660 (1992).

[50] Solomon, M. M., " Algorithms for the vehicle routing and scheduling problems with time window constraints, " Operations Research, 35, 254-265 (1987).

[51] Stewart, W. R. Jr. and B. L. Golden, " Stochastic vehicle routing: a comprehensive approach, " European Journal of Operational Research , 14 , 371-385 (1983).

[52] Taillard, E., P. Badeau, M. Gendreau, F. Guertin and J.-Y. Potvin, " A tabu search heuristic for the vehicle routing problem with soft time windows, " Transportation Science, 31, 170-186 (1997).

[53] Thangiah, S. R., J.-Y. Potvin and T. Sun, " Heuristic approaches to vehicle routing with backhauls and time windows, " Computers Ops Res , 23, 1043-1057 (1996).

[54] Tillman, F. A., " The multiple Terminal Delivery problem with probabilistic demands, " Transportation Science , 3, 192-204 (1969).

[55] Toth, P. and D. Vigo, " An exact algorithm for the vehicle routing problem with backhauls, " Transportation Science, 31, 372-385 (1997).

[56] Waters, C. D. J., " Vehicle-scheduling problem with uncertainty and omitted customer, " J. Opl Rse. Soc., 40, 1099-1108 (1989).

[57] Wiliard, J. A. G., Vehicle routing using r-optimal tabu search, M. Sc. Dissertation. The management school, Imperial College, London (1989)

o

[58] Xu, J. and J. P. Kelly, " A network flow-based tabu search heuristic for the vehicle routing problem, " Transportation science , 30, 379-393 (1996).