SEMINAR NASIONAL
SAINS MIPA DAN APLIKASINYA

Bandar Lampung, 8 - 9 Desember 2010

SN-SMAP FMIPA UNIVERSITAS LAMPUNG

Tema :

"Membangun Jejaring Pengembang Dan Pengguna SAINS dan Matematika"

PROSIDING

ISSN:2086-2342

9 772086 234005

Vol.2 Tahun 2010
Buku 2

FAKULTAS MATEMATIKA DAN ILMU PENGETAHUAN ALAM UNIVERSITAS LAMPUNG

Http://www.unila.ac.id/~mipa/, E-mail : seminar-smap@unila.ac.id;

PROSIDING
SEMINAR NASIONAL SAINS MIPA DAN APLIKASINYA 2010
(SN SMAP 10)

FAKULTAS MATEMATIKA DAN ILMU PENGETAHUAN ALAM
UNIVERSITAS LAMPUNG
DESEMBER 2010

Prosiding Seminar Nasional Sains MIPA dan Aplikasinya Tahun 2010 FMIPA Universitas Lampung

TEAM PENYUNTING :
Rochmah Agustrina, Ph.D.
Wasinton, Ph.D.
Simon Sembiring, Ph.D.
Mulyono, Ph.D.
Warsono, Ph.D.
Dian Septiani Pratama, M.Si.
Ni Luh Gede Ratna Juliasih, M.Si.

PENERBIT
Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Lampung

ALAMAT REDAKSI
Gedung Dekanat Lantai 4
Fakultas Matematika dan Ilmu Pengetahuan Alam Universitas Lampung
Jl. S. Brodjonegoro No. 1, Bandar Lampung 35145
Telp./Fax: +62-721-704625;
http://fmipa.unila.ac.id/
E-mail: seminar-smap@unila.ac.id

Prosiding Seminar Nasional
Sains MIPA dan Aplikasinya FMIPA UNILA:
penyunting, Rochmah Agustrina[et al.]
Desember 2010 / — Bandar Lampung
ix + 248 hlm.; 21 x 29,7 cm

ISSN 2086-2342
(Terbit satu kali setahun)

9 772086 234006

KATA PENGANTAR

Assalamu'alaikum wa Rohmatullahi wa Barokatuhu.

Alhamduluillah dengan perkenan-Nya lah, maka Prosiding Seminar Nasional Sains MIPA dan Aplikasinya tahun 2010 (SN SMAP 10) 8 – 9 Desember 2010 dengan tema: " Membangun Jejaring Pengembang dan Pengguna Sains dan Matematika", telah dapat kami selesaikan. Kegiatan seminar ini merupakan salah satu rangkaian kegiatan dalam rangka Dies Natalis FMIPA UNILA, yang diagendakan dilakukan secara rutin tahunan.

Segenap panitia mengucapkan terima kasih kepada Rektor UNILA Bapak Prof. Dr. Ir. Sugeng P Harianto, M.S. dan Dekan Fakultas MIPA Bapak Dr. Sutyarso, M.Biomed. yang telah memfasilitasi berlangsungnya kegiatan ini. Demikian pula kepada para Keynote Speakers: Ir. Edi Yanto, M.Si., Kepala Bappeda Provinsi Lampung; Prof. Dr. Ir. Suprapto DEA., Ketua Tim Ahli Pengembangan HKI, DP2M- Ditjen Dikti, Kemendiknas dan Dosen Jurusan Teknik Kimia FTI - ITS; dan Bapak Dr. Sutyarso, M.Biomed., Dekan FMIPA Universitas Lampung, yang telah berkenan memberikan materi pada kegiatan ini.

Kami juga menyampaikan penghargaan dan terima kasih atas apresiasi rekan-rekan akademisi dan peneliti untuk berkenan mempresentasikan hasil penelitiannya dalam kegiatan Seminar Nasional ini. Seminar ini diikuti oleh berbagai kelompok Sains MIPA dan aplikasinya dalam kategori kelompok ilmu Matematika, Fisika, Biologi, dan Kimia. Jumlah makalah yang dipresentasikan dalam kegiatan ini sebanyak 84 makalah dan yang masuk dalam prosiding ini adalah sebanyak 83 makalah. Akhir kata, kami sampaikan terima kasih kepada semua fihak yang telah mendukung penyusunan prosiding kegiatan seminar ini. Dalam kesempatan ini, kami juga memohon maaf apabila ada hal hal yang kurang berkenan selama pelaksanaan kegiatan seminar ataupun dalam penyusunan prosiding seminar ini. Akhir kata mari kita bersama mendukung upaya peningkatan daya saing bangsa melalui karya nyata dalam bidang Sains MIPA dan Aplikasinya.

Wassalamu'alaikum wa Rohmatullahi wa Barokatuhu.

Tim Penyunting

DAFTAR ISI

Kelompok Fisika halaman

Kelompok Matematika

COMPUTATIONAL ASPECT OF WADR1 AND WADR2 ALGORITHMS FOR THE MULTI PERIOD DEGREE CONSTRAINED MINIMUM SPANNING TREE PROBLEM

Wamiliana, Dwi Sakethi, and Restu Yuniarti
Department of Mathematics, faculty of Mathematics and Natural Sciences, The University of Lampung

ABSTRACT

The Multi Period Degree Constrained Minimum Spanning Tree Problem (MPDCMST) is a problem of determining the total minimum installation cost in a certain network, where the installation process is divided into some periods due to the fund limitation. In addition, the network itself must maintain it reliability by restricting the number of links at every node (can be computer, city, road, and so on). In this paper we will discuss the computational aspects of two algorithms, WADR1 and WADR2 for the MPDCMST and compare the solutions of those two algorithms.

Keywords: *multi period, degree constrained, computational aspects*

INTRODUCTION

Multi Period Degree Constrained Minimum Spanning Tree (MPDCMST) Problem is one of network problems that frequently occur in real life situation, especially in networks installation. For example, the installation of power supply network system, the installation of telecommunication network, computer network, water supply network, and so on. However, in reality, the installation process needs to be done in some periods , mostly because of the fund limitation. When the installation process only needs one period, the problem is called as Degree Constrained Minimum Spanning Tree (DCMST) Problem.

DCMST can be applied in some cases where n vertices (represents terminals, servers, depot, etc) must be connected in such a way so that the minimum distance/cost/time (represented by edges/arcs) is minimum whilst also restrict the interconnection in every vertex. The restriction needed to ensure reliability of the network (Wamiliana, 2002). If we disregard the restriction in every vertex, the problem reduced to a well known problem in network design, which is The Minimum Spanning Tree (MST) problem.

Minimum spanning trees or spanning trees in general, are used in many network optimization problems as the key structure. Since G.R. Kirchoff designed electrical circuits in the 19^{th} century, spanning trees have been considered as one of the most used subgraphs in many network design applications. Deo and Kumar (1997) reported that spanning trees can be computed in linear time for a given connected weighted graph. When the spanning tree is required to have minimum weight (minimum spanning tree), the computational time only slightly increases. Rouvray (1995), reported that Flavitsky, in 1871 was the one who was the first to use combinatorial techniques to determine isomer counts. Flavitsky studied the homologues series of the alcohols and enumerated the first ten members. His investigations arrived at a conclusion that this problem is the equivalent to enumerating rooted tree graphs all of whose vertices are of degree one or four. Based on this investigation, then Cayley in 1874 introduced generating functions into isomer enumeration.

In this paper we will discuss two algorithms for solving the MPDCMST problem, and we will organize our paper as follow: In Section 1 we give a brief information about MPDCMST, its derivates and applications, in Section 2 we give information about some of the methods already investigated, in Section 3 we will discuss our proposed algorithm, In Section 4 we give the implementation and results, followed by conclusion.

METHODS AVAILABLE IN LITERATURE

The Minimum Spanning Tree (MST) problem is one of the classical problems arising in many network design applications. To find a minimum-spanning tree, there are two well-known algorithms: Kruskal's (1956) and Prim's (1957). However, the earliest algorithm for finding a minimum spanning tree according to Graham and Hell (1982) was suggested by Boruvka (1926a,b) who developed an algorithm for finding the most economical layout for a power-line network. Minimum spanning tree algorithms have been studied extensively and a variety of fast algorithms have been developed. Gabow et al. (1986) developed an efficient and fast minimum spanning tree algorithm that requires computational time nearly linear in the number of edges.

The DCMST problem is MST with additional constrained. The objective is to construct a minimum cost network that satisfies the prescribed graph parameters, which is the degree. The DCMST can be formulated as a Mixed Integer Linear Programming as follow (Wamiliana, 2002):

$$Minimise \ \sum_{i}^{n}\sum_{j}^{n} c_{ij}x_{ij} \quad (1)$$

Subject to:

$$\sum_{i,j} x_{ij} = n-1 \quad (2)$$

$$\sum_{i,j\in V'} x_{ij} \leq |V'|-1, \qquad \forall \emptyset \neq V' \subseteq V \quad (3)$$

$$1 \leq \sum_{j=1, i\neq j} x_{ij} \leq b_i \qquad i = 1,2,\dots, n \quad (4)$$

$$x_{ij} = 0 \text{ or } 1, \qquad 1 \leq i \neq j \leq n. \quad (5)$$

c_{ij} is the weight (or distance or cost) of the edge (i,j), b_i is the degree bound on vertex i and n is the number of vertices. Constraint (2.2) ensures that $(n-1)$ edges are selected. Constraint (2.3) is the usual subtour elimination constraints. Constraint (2.4) specifies the degree restriction on the vertices. The last constraint (2.5), is just the variable constraint, which restricts the variables to the value of 0 or 1. x_{ij} is 1 if the edge x_{ij} is selected or included in the tree T and 0, otherwise.

Many authors have proposed solution methods for the DCMST problem, which include both exact and heuristic methods. Since this problem is NP complete, heuristic methods have dominated. Some of the heuristics that have been investigated include: a number of basic MST algorithms of Prim and Kruskal (see Narula and Ho ,1980); the genetic Algorithm by Zhou and Gen (1997); Simulated Annealing by Krishnamoorthy et al. (2001); and Iterative Refinement by Boldon et al. (1996) and Deo and Kumar (1997), Modified Penalty by Wamiliana (2002); Wamiliana and Caccetta (2006), and Tabu Search by Caccetta and Wamiliana (2001,2004), and Wamiliana and Caccetta (2004).

Multi Period Degree Constrained Minimum Spanning Tree (MPDCMST) is a problem derived from the Degree Constrained Minimum Spanning Tree Problem (DCMST). The difference of the two problems lies on the period in which restrict the network considered to be installed in some periods or stages. Usually, in real-life implementation, the installation must be done in some periods due to fund limitation. In DCMST, all the vertices (can represent computers, cities, and so on) can be installed in one period and there is no center vertex specified. Either DCMST or MPDCMST problems appear in some real-life problems such as installation of pipe for: water supply, liquid natural gas, electricity, telephone (cable) and so on.

Kawatra (2002) solved MPDCMST using *hybrid* methods between Lagrangean Relaxation and branch exchange. This method implemented using vertices varying from 40 to 100 vertices. They used a 10-year planning horizon and the time period for activating each terminal is uniformly distributed from 1 to 6, and vertex 1 as central vertex. Wamiliana et al (2005) investigated other types of MPDCMST where they used a one year planning horizon and divided the installations into three periods (4 months each), and four periods (three months each), and set vertex 1 as central vertex. They did the modifications in order to mimic the real situations occurs in Indonesia where the funding for each project usually divided into three or four periods. Wamiliana et al (2005) had investigated the greedy method to solve the MPDCMST problem and get feasible solution for all data tested. However, the solutions are still not guarantee to be optimal because they were not using benchmark problems and there is no exact method yet investigated to be compared. Junaidi et al (2008) improved the method proposed by Wamiliana et al (2005) and tested using some problems taken from TSPLIB. Next, we will propose the new algorithm for MPDCMST which are WADR1 and WADR2.

WADR1 and WADR2 Algorithms

Both WADR1 and WADR2 algorithms in general use Modified Kruskal's algorithms to find the MPDCMST, but in the sorting process we adopt the DFS techniques until two vertices and two edges ahead to be connected in the tree (or maybe forest). Below is pseudocode of the algorithms:

Initialization : Set $V = \{1\}$, $T = \varnothing$, $k = 2$, and set vertex 1 as central of the network, set HVT_i , $MAXVT_i$

begin

Determine vertices in HVT_i

Sort edges connected with vertices in HVT_i whose path length k in ascending order

Set $i = 1$

if $|HVT_i| \geq |MAXVT_i|$, Stop

else do

while {the number of edges in T is $< n - 1$}

do

```
                    Choose the smallest edge in the sorting  and connect it with T
                         if the connection of  that edge constitutes cycle
                           Remove and choose the next available
                              else  if the connection  violates the degree restriction
in every vertex in T
                                Remove and choose the next available
                                i = i + 1
                                if  i > 3
                                end
                           end
                         end
                    end
                 end
               end
   end
```

In these algorithms we set MaxVTi = $\lfloor (n-1)/3 \rfloor$. The difference between WADR1 and WADR2 algorithms lies on the rules of connection of HVT_i. In WADR1, if the vertex in HVT_i already installed then we are asked to install the other uninstalled vertex, while in WADR2, if the vertex in HVT_i already installed then we don't need to determine the next vertex to be installed in that period, just let the program choose/determine it.

IMPLEMENTATION AND RESULTS

In the implementation, we use C++ programming language running on dual core computer with 1.83 GHz, 2 GB RAM. The data used in the implementation are the same as data used in Wamiliana et al (2005), and Junaidi et al (2008). The program is designed in such a way so that the user can give input of HVT_i in every period. The reason to do that is in the real situation where frequently the decision maker wants to know the alternatives of a certain problem. With the tools in hand he can do simulation on HVT_i. The following table show the results:

Table 1. Comparative Analysis of MST, DCMST, WADR1, and WADR2

n	Average (Solution)			
	MST	**DCMST**	**WADR1**	**WADR2**
10	1129.43	1178.80	1672.80	1544.37
20	1196.10	1299.60	1999.30	1966.17
30	1177.43	1304.03	2351.77	2263.13
40	1151.23	1287.97	2515.40	2439.57
50	1223.43	1357.07	2741.03	2609.77
60	1175.57	1282.30	2699.20	2427.80
70	1242.10	1367.53	3527.00	2672.97
80	1236.83	1367.70	2939.53	2794.93
90	1248.00	1367.93	3027.90	2823.50
100	1234.10	1340.23	2962.20	2786.60
Average	**1201.42**	**1315.32**	**2643.61**	**2432.88**

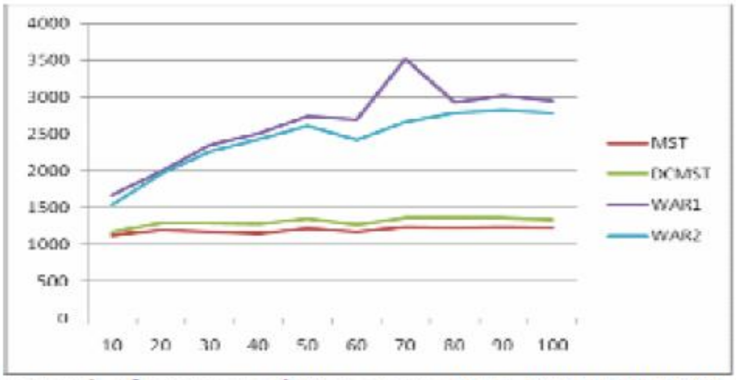

Figure 1. The Graph of average solution among MST, DCMST, WADR1 and WADR2

CONCLUSION

From the graphs we can see that the solution found using WADR2 are better than WADR1. The reason is in WADR1 algorithm we must enter other vertices if the one must be installed in a certain period, already installed before, while in WADR2, if the vertices must be installed in certain period already installed before then the algorithm just continue to find the next available minimum edge. But, these two algorithms give alternative to the decision maker, which problem they are facing for. If they are not really care about what next vertex (city /terminal or other) is supposed to be in the network, then choose WADR2, the cheaper; or use WADR1 if they are concern about what city must be installed soon in a certain period.

ACKNOWLEDGEMENT

This research are part of Competency Grant funded by The Directorate General of Higher Education, The Ministry of National Education, The Republic of Indonesia under contract number 254/SP2H/PP/DP2M/V/2009. We wish to thank for the fund.

REFERENCES

Boldon, B., N. Deo and Nishit Kumar , 1996. ' Minimum Weight Degree-Constrained Spanning Tree Problem: Heuristics and Implementation on an SIMD parallel machine', *Parallel Computing* **vol. 22**, pp.369 –382.

Boruvka, O., 1926 a. ' O Jistém Problému Minimálním '_*Práce Mor.Prírodoved.Spol. v Brne (Acta Soc.Sci_Nat._Moravicea)*, **3** , pp. 37-58.

Boruvka, O.,1926 b. '*Príspevek k. Resení Otázky Ekonomické Stavby Elektrovodních Sítí", Electrotech. Obzor*, **15**, pp. 153-154.

Deo N. and Nishit Kumar,1997. 'Computation of Constrained Spanning Trees: A Unified Approach', *Network Optimization* (Lecture Notes in Economics and Mathematical Systems, Editor : Panos M. Pardalos, et al , Springer-Verlag, Berlin, Germany, pp. 194 – 220.

Caccetta, L., and Wamiliana, 2001. Heuristics Algorithms for the Degree Constrained Minimum Spanning Tree Problems, in Proceeding of the International Congress on Modelling and Simulation (MODSIM 2001), Canberra, Editors: F. Ghassemi et.al, pp. 2161-2166.

Caccetta L. and Wamiliana,2004. "A First Level Tabu Search Method for the Degree Constrained Minimum Spanning Tree", *Journal of Quantitative Methods*, Vol.1 No.1, pp. 20-32.

Gabow, H.N., Galil Z., T.H. Spencer and R.E. Tarjan, 1986. 'Efficient algorithms for finding minimum spanning trees in undiredted and directed graphs, *Combinatorica*, vol 6, pp. 109-122.

Graham, R.L., and Hell, P., 1982. ' On the history of the Minimum Spanning Tree Problem',
Mimeographed , Bell Laboratories, Murray Hill, New Jersey.

Junaidi A, Wamiliana, Dwi Sakethi, and Edy Tri Baskoro, 2008. Computational Aspects for the Multi Period Degree Constrained Minimum Spanning Tree Problems, *Jurnal Sains MIPA*, Special Edition, January 2008, pp. 1-5.

Kawatra R.,2002. "A multiperiode degree constrained minimum spanning tree problem", *European Journal of Operational Research*, vol. 143, pp 53-63.

Krishnamoorthy, M., A.T. Ernst and Yazid M Sharaila ,2001.'Comparison of Algorithms for the Degree Constrained Minimum Spanning Tree', *Journal of Heuristics*, **Vol. 7**, no. 6, pp. 587 -611.

Kruskal, J.B.,1956. 'On the Shortest Spanning Tree of a Graph and the Travelling Salesman Problem', *Proc. Amer .Math .Soc.*, vol. 7, pp. 48-50.

Narula,S. C., and Cesar A.Ho.,1980. Degree-Constrained Minimum Spanning Tree',*Computer and Operation Research* , **Vol. 7**,pp. 239-249.

Prim, R.C.,1957. 'Shortest Connection Networks and Some Generalizations', *Bell Syst. Tech Journal*, vol. 36, pp 1389-1401.