Proceedings of the International MultiConference of Engineers and Computer Scientists 2010 Vol II,
IMECS 2010, March 17 - 19, 2010, Hong Kong

Analysis and Simulation Routing Management MIRA (Minimum Interference Routing Algorithm) for Speedy Traffic on MPLS Network

Rendy Munadi , Akhmad Zaimi , Sofia Naning

Abstract— **MPLS network as IP backbone has capacity constraint and routing mechanism constraint. The latest constraint, which based on Shortest Path First scheme (OSPF), results in best-shortest calculated path. This scheme produces resource with unfair consumed. Some subsets of network may get congested while others remain free. As a consequence, the new routing management scheme is proposed using Minimum Interference Routing Algorithm (MIRA). MIRA puts higher priority on some ingress egress pair according to SLA of some traffics. This new method covers critical links in the network. The critical links identified in 3 ways: Critical Links based on Maxflow, Critical Links based on Threshold, and the Enhancement of Critical Links based on Threshold.**

From the simulation results, it is shown that the performance of new method could be minimized congestion, reducing demand loss about 124.79 Mbps and increasing some parameters of the network performance such as throughput, packet received and delay.

Index Terms— **Critical link, Routing Management MIRA**

I. Introduction

PT Telkom Indonesia Tbk is a Government Company that works in Telecommunication sector PT. TELKOM offers Speedy as internet broadband solution. This service is predicted to become the next revenue generator for the incumbent. In the mean time, another solution is provided for corporate customers which need data and communication connection. Against Speedy, this data communication service only provides private data traffic transaction within the internal customer sites. The provider submits this service based on Layer 3 VPN technology, which is also well known as IP VPN[1].

MPLS network as IP backbone has capacity constraint and routing mechanism constraint. The latest constraint, which based on Shortest Path First scheme, results in best-shortest calculated path. This scheme produces resource with unfair consumed. Some subsets of network may get congested while others remain free. Meanwhile, both internet and data communication service are afforded in the same manner in routing scheme. Lack of precedence in how to route traffic based on QoS through the network [2],[3].

As a consequence, the new routing management scheme is proposed using Minimum Interference Routing Algorithm (MIRA). MIRA puts higher priority on some ingress egress pair according to SLA of some traffics. This new method covers critical links in the network. The critical links identified in 3 ways: Critical Links based on Maxflow, Critical Links based on Threshold, and the Enhancement of Critical Links based on Threshold [8],[10].

Objectives to be achieved in this research are: increased availability and accessibility Speedy to optimize network resource usage. So the discussion will be carried out on the following conditions and restrictions:

1. Traffic routing management design of Speedy only focused on 3 areas DIVRE II: Bekasi, Bogor and Tangerang
2. Routing management is performed by offline calculation by adopting the method of C-SPF in MPLS with the algorithm based on the Minimum Interference Routing Algorithm (MIRA) [12].
3. The observed performance parameters focused on the parameters: throughput, packet received and delay.

II. Basic Concept

2.1 MPLS Traffic Engineering (MPLS-TE)

The common IGP routing protocols engage a weaknesses in the path calculation results. One example, the routing protocol model and the minimum hop shortest path calculations makes the traffic flow through a path with the least number of hops or lowest cost. Cost of a high-level representation of the paths generated, can be a single metric

Manuscript received December 30, 2009. This work was supported in part by Faculty Postgraduate Telkom Institute of Technology in Bandung-INDONESIA and PT Telkom tbk.

Rendy Munadi is with the Faculty of Postgraduate Telkom Institute of Technology (tel, 62-22-7564108, fax.62-22-7565200, e-mail: rnd@ittelkom.ac.id).

Akhmad Zaimi is with PT TELKOM tbk, Magister Student at the Postgraduate TelkomInstitute of Technology (e-mail: djimie@gmail.com).

Sofia Naning H is with the Faculty of Postgraduate Telkom Institute of Technology (tel, 62-22-7564108, fax.62-22-7565200, e-mail: snh@ittelkom.ac.id).

(OSPF, IS-IS, RIP, and RIPv2) and the composite metric (Interior Gateway Routing Protocol - IGRP and Enhanced IGRP) [3],[9].

Traffic engineering in MPLS LSPs are determined using the head end LSR or referred by source-based routing. Headend LSR networks need the whole picture and information related to traffic engineering. The information required includes: bandwidth, TE metric, maximum bandwidth, maximum bandwidth reserveble, Unreserved maximum bandwidth and administrative group. There are two ways of doing traffic engineering, which is online or offline. Example of online algorithms is MIRA[3],[8],[10],[11].

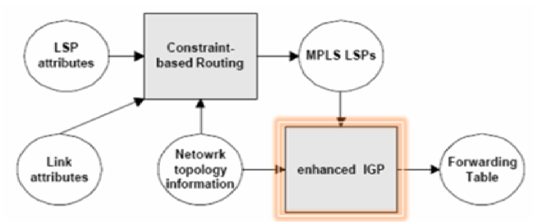

Fig. 1. MPLS-TE: FIB Construction

2.2 Management Routing MIRA

The concept of MIRA is an online algorithm with the basic principle that form the future tunnel to pass traffic through channel that are not critical due to the flow of traffic from different ingress egress. In other words MIRA tries to reduce interference between traffic on the network.

Information required to compute path calculation precisely is size of demand gained from each ingress egress pair in network. But this is difficult to be realized. Instead, the location of ingress egress pair can be exploited to predict the high-loaded paths. Other necessary information such as network topology and the residual bandwidth become the important keys to the success of MIRA algorithm.

LSP can be routed through a link only if the residual bandwidth in the link is greater than demand that will be passed. Then this link termed as a feasible link. A collection of feasible links form feasible network. And the demand will only be directed within feasible network [7],[8].

The following terminologies are used in MIRA[8]:

Interference

The interference only take place if the decreasing maximum flow caused by other traffic flow in the same channel.

Minimum Interference Path

An explicit route that maximize the minimum maxflow between other ingress egress pair [9].

Critical Link

A group of links to the characteristics whenever an LSP is routed over those links the maxflow values of one or more ingress egress pair decreases (denoted by α_{sd}).

$$w(l) = \sum_{(s,d):l \in Csd} \alpha_{sd} \qquad (2.1)$$

The residual bandwidth induces weight of link calculation:

$$w'(l) = w(l) \,/\, R(l) \qquad (2.2)$$

The weight of ingress egress pair is computed to the maxflow or demand value, which formulated as follow:

$$\alpha_{sd} = 1 \,/\, \theta_{sd} \qquad (2.3)$$

Whenever critical links have been identified in the network, those links should be avoided during route an LSP. The next term is routing the traffic based on Djikstra Algorithm or Bellman-Ford.

The following view provides the overall phases of MIRA algorithm [4],[5],[12]:

Input:

A graph *G(N,L)* and a set *B* of residual capacities on each link. An ingress node *a* and an egress node *b* between which a flow of *D* units have to routed.

Output:

A route between node *a* and *b* having a capacity of *D* units of bandwidth.

Algorithm:

1. Compute the maxflow values for all $(s,d) \epsilon \mathcal{P} \backslash (a,b)$
2. Compute the set of critical links C_{sd} for all $(s,d) \epsilon \mathcal{P} \backslash (a,b)$
3. Compute the weight
$$w(l) = \sum_{(s,d):l \in Csd} \alpha_{sd} \quad \forall l \in L$$
4. Eliminate all links which have residual bandwidth less than *D* and form a reduced network.
5. Using Djikstra algorithm compute the shortest path in the reduced network using *w(l)* as the weight on link *l*.
6. Route the demand of *D* units along this shortest path and update the residual capacities.

2.3 Threshold Critical Links

Threshold critical link (Δ-critical link) is a method to identify critical links that laid on network. This method encompasses the threshold value to indicate the criticality of links (residual capacity < demand means critical link) [7],[8].

III. Simulation Model

3.1 Simulation Process

Fig. 2 is presenting the stages of simulation process and all aspects will be analyzed based on testing and simulation results [6],[12]. And table.1 lists every nodes in network model that carries customers traffic.

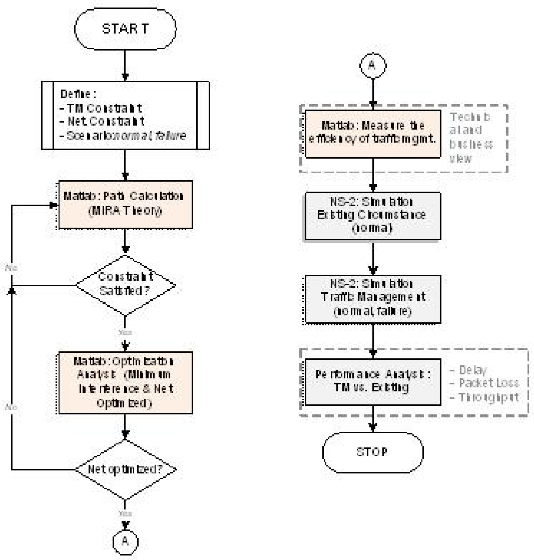

Fig. 2. Stages of Simulation Process

3.2 Network Topology

Fig. 3 shows network topology consists of 3 area (BOO, TAN, BKS) and 39 routers (4 core routers, 6 speedy routers and 1 local gateway router).

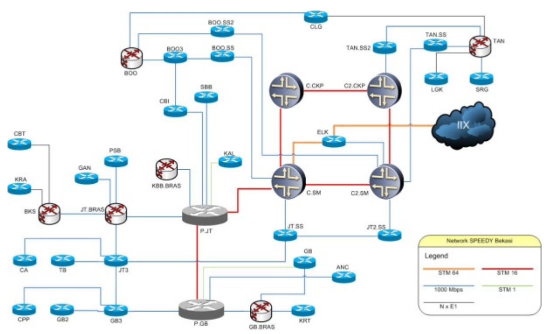

Fig. 3. Network Topology

3.3 System Model

In this research, analysis take place not only on the main path of network model, but also the backup path which can be switched to be main route in case of error in the main path.

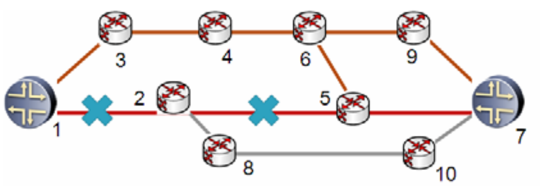

Fig. 4. Recognizing the paths from node 1 to 7

From the network model above (Fig.4), several alternative paths can be obtained:

Normal path: Node 1 – 2 – 5 – 7
Backup path:

- Node 1 – 2 – 8 – 10 – 7
- Node 1 – 3 – 4 – 6 – 5 – 7

3.4 Existing Data

Table.1 Nodes of Speedy and IP VPN

PE-BOO (1)	PE-GB3 (18)
PE-TAN (2)	PE-BOO3 (21)
PE-BKS (3)	PE-CPP (27)
PE-KBB-BRAS (4)	PE-KRT (29)
PE-JT-BRAS (5)	PE-ANC (30)
PE-GB-BRAS (6)	PE-PSB (34)
PE-ELK (13)	PE-KAL (35)
PE-GB (17)	PE-SBB (36)

For Speedy traffic is generated from node 1 to node 6. And rest of nodes produce IP VPN traffic. From this point of view, traffic model from each class of service is evaluated to identify critical links formed by each service.

Analysis of simulation results is achieved by comparing the condition of the network routing management pre and post routing management. The existing routing mechanism is based on OSPF routing protocol and the following result show current Speedy traffic flow from source to destination.

Table.2 Path Upstream Speedy

Source	Destination	Hop
1	13	1 – 23 – 10 – 9 - 13
2	13	2 – 19 – 10 – 9 – 13
3	13	3 – 5 – 7 – 9 – 13
4	13	4 – 7 – 9 – 13
5	13	5 – 7 – 9 – 13
6	13	6 – 8 – 7 – 9 – 13

Table.3 Path Downstream Speedy

Source	Destination	Hop
13	1	13 – 9 – 10 – 23 – 1
13	2	13 – 9 – 10 – 19 – 2
13	3	13 – 9 – 7 – 5 – 3
13	4	13 – 9 – 7 – 4
13	5	13 – 9 – 7 – 5
13	6	13 – 9 – 7 – 8 – 6

Three factors will be analyzed: Network parameters, accessibility level and influent of routing management to need link up grade.

IV. ANALYSIS AND DISCUSS

4.1 Modeling Routing Management System

4.1.1 Residual Network

In the table below shows the residual capacities of the network.

Table. 4 Residual Capacities on Each Links

	1	2	3	4	5	6	7	…	39
1	0	0	0	0	0	0	0	…	0
2	0	0	0	0	0	0	0	…	0
3	0	0	0	0	905	0	0	…	0
4	0	0	0	0	0	0	725	…	0

ISBN: 978-988-18210-4-1
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

5	0	0	368	0	0	0	1688	…	0
6	0	0	0	0	0	0	0	…	0
7	0	0	0	224	1197	0	0	…	1740
.	.	.	.	.	.	.	.	…	.
39	0	0	0	0	0	0	716	…	0

4.1.2 Ingress Egress IP VPN

In the table 5 below shows the mapping of ingress egress pairs in the network.

Table.5 Ingress Egress Pair VPN IP

Node	**Demand (Mbps)**	**Destination Node**							
		2	**13**	**18**	**21**	**27**	**29**	**34**	**35**
1	183.25	x	x	x		x	x	x	x
2	252.78		x	x	x	x	x	x	x
3	172.88	x	x	x	x	x	x		
4	165.96	x	x	x	x	x	x		
5	191.13	x	x	x	x	x	x		
6	349.412	x	x	x	x			x	x
17	224.156	x	x	x	x			x	x
30	105.632	x	x		x	x		x	x
36	114.32	x	x	x	x	x	x	x	

Table.6 Size of Demands for Each Ingress Egress Pairs (Mbps)

S	Node *Destination*							
	2	13	18	21	27	29	34	35
1	18.87	0.55	77.51		33.53	51.86	0.55	0.55
2		12.64	105.91	36.15	36.15	36.15	25.28	0.76
3	28.87	17.29	68.11	28.87	1.21	28.87		
4	27.71	1.16	27.71	27.71	1.16	80.82		
5	31.92	1.34	31.92	31.92	1.34	93.08		
6	34.94	58.35	105.17	58.35			58.35	34.94

From the distribution model showed above, the IP VPN service consumes network resources about 24,87%.

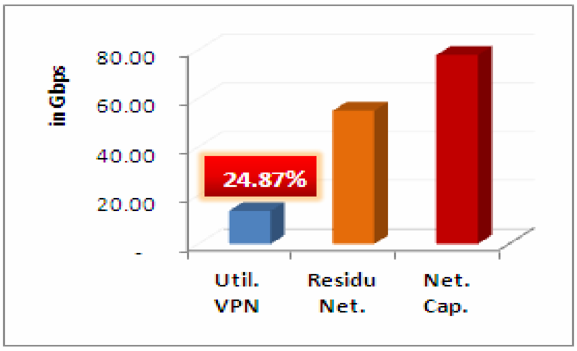

Fig. 5. IP VPN Utilization

4.1.3 Weight of Ingress Egress VPN IP

The next step is calculating the weight of ingress egress pair based on formula 2.3. And the result shows in the table below.

Table.7 Weight of Ingress Egress Pair IP VPN

S	**Node Destination**							
	2	**13**	**18**	**21**	**27**	**29**	**34**	**35**
1	0.05	1.82	0.01		0.03	0.02	1.82	1.82
2		0.08	0.01	0.03	0.03	0.03	0.04	1.32
3	0.03	0.06	0.01	0.03	0.83	0.03		
4	0.04	0.86	0.04	0.04	0.86	0.01		
5	0.03	0.75	0.03	0.03	0.75	0.01		
6	0.03	0.02	0.01	0.02			0.02	0.03

4.1.4 IP VPN Path

Regarding to the pre-defined ingress egress pair model, the number of candidate paths (main path and backup) is about 251 candidate paths of IP VPN.

Table.8 Sample of Candidate Paths

S	**D**	**Cost**	**Dmnd**	**Hop**
1	2	0.4	18.87	1 – 23 – 10 – 19 – 2
1	2	0.51	18.87	1 – 21 – 22 – 9 – 10 – 19 - 2
1	13	0.22	0.55	1 – 23 – 10 – 9 – 13
1	13	0.31	0.55	1 – 21 – 22 – 9 – 13

Later, the total of 251 candidate paths need to be reviewed to detect any of links that potentially critical and should be kept away from being supplied by the traffic.

4.1.5 Critical Link

As previously mentioned, the critical links are analyzed using three methods, namely:

1. First method assuming all links that formed a path is considered as critical link.
2. Second method assuming a link is being critical if the residual capacity less than threshold value. In addition, the weight of main path is granted four times of weight ingress egress pair that passed over it. While the weight backup path is identical to weight of ingress egress pair.
3. Third method is similar to the second method. The difference lies on the allocation of network resource (only reserved by main path).

The following comparison shows the performance of three methods:

Table.9 Comparison of Three Methods

Criterion	**Methods**		
	I	**II**	**III**
Init. Capacity	105,624.86	105,624.86	105,624.86
Critical link analysis (CL) • Resource consumpt.	28,264.98	28,264.98	15,735.13
• Percentage	26.76%	26.76%	14.90%
• Residual. network	77,359.88	77,359.88	89,889.73
Number of CL	1286	154	41
Unique CL	68	14	6

ISBN: 978-988-18210-4-1
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

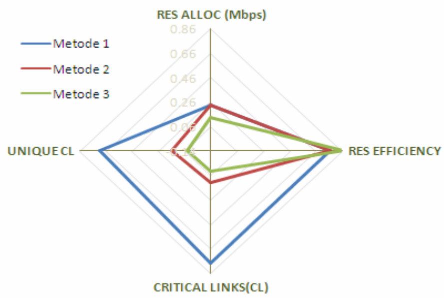

Fig. 6. Comparison of Critical Link in Spider Chart

From the results of the comparison above shows that the third method is more effective in analyzing the critical link in the network. Resource allocation of the least among other methods that network resources will be used more optimally. Here's the link analysis results with the third method that potentially critical and should be avoided:

Table.10 Critical Link based on Method 3

Hop		Weight Link	Main Path	Backup Path
Node	Node			
6	8	0.1257	2	0
7	4	0.0124	2	3
8	6	3.8515	8	6
9	7	0.0439	0	2
10	19	7.2534	6	6
19	2	7.1050	2	4

4.1.6 Weight of Network

The weight of non-*critical link* is given by value 0.0001. And the weight of critical link is calculated based on formula 2.1.

Table.11 Weight of Network

	1	2	3	4	5	6	7	…	9
1	0	0	0	0	0	0	0	…	0
2	0	0	0	0	0	0	0	…	0
3	0	0	0	0	0.1	0	0	…	0
4	0	0	0	0	0	0	0.1	…	0
5	0	0	0.1	0	0	0	0.1	…	0
6	0	0	0	0	0	0	0	…	0
7	0	0	0	0.1	0.1	0	0	…	0.04
…	…	…	…	…	…	…	…	…	…
9	0	0	0	0	0	0	0.1	…	0

4.1.7 Link Affinity

The application of link affinity is purposed to simplify path calculation and mapping of network model based on the capacity.

4.1.8 Demand Constraint

The last stage in path computation in MIRA is determining any links with capacity less than demand then eliminate them from network model.

4.2 Output Analysis

With a series of routing management preparation form a weighted graph. Further step is calculating downstream path for Speedy traffic focused on BOO, TAN, BKS areas.

And the results are:

- *Source* node 13 – *destination* node 1:
Node 13 – 9 – 10 – 23 – 1
- *Source* node 13 – *destination* node 2:
Node 13 – 9 – 10 – 12 – 20 – 2
- *Source* node 13 – *destination* node 3:
Node 13 – 9 – 15 – 14 – 5 – 3

The advantage of determining the path with MIRA is able to avoid the links that are critical in the network. Another case with OSPF path calculation results (table.3), shows the exploitation of the critical link was occurred.

- Downstream: source node 13 – destination node 2 passes through critical links: 10 – 19 and 19 – 2.
- Downstream: source node 13 – destination node 3 passes through critical link: 9 – 7.

In the following table shows the benefit of MIRA in resource optimization compared to OSPF routing protocol.

Table.12 Network Resource Optimization MIRA (Mbps)

Criterion	OSPF	MIRA
Net. residual cap.: - Pre traffic Speedy flow - Post traffic Speedy flow	90,628.04 89,861.94	90,628.04 89,628.59
Net. res. usage	766.10	999.46
Demand Size	890.89	999.46
Demand Loss	124.79	0.00

4.3 Network Performance

From the performance point of view, MIRA is capable increasing network performance, including throughput and packet received parameters.

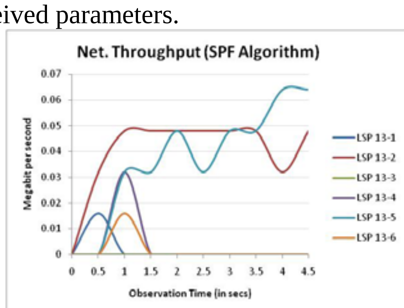

Fig. 7. Network Throughput OSPF

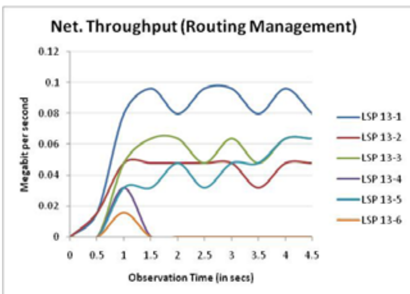

Fig. 7. Network Throughput MIRA

Fig.6 and 7 shows that the network throughput obtained (in average) by using MIRA method is higher than OSPF method, mainly for LSP 13-1, LSP 13-3 and LSP 13-5 a long observation time.

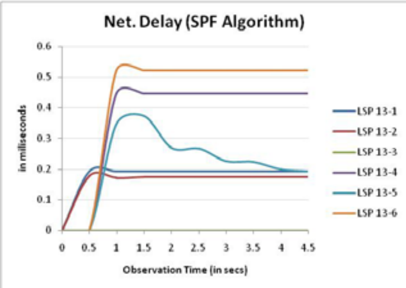

Fig. 8. Network Delay OSPF

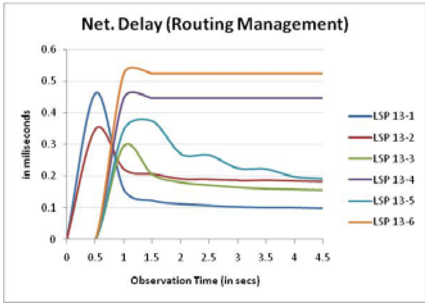

Fig. 9. Network Delay MIRA

Fig.8 and 9 shows that the improved delay network by using MIRA method only on LSP 13-1 around 0.05 msec, but the others LSP not changes.

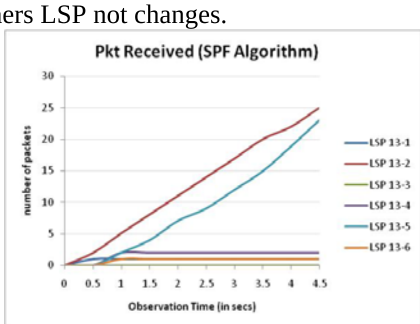

Fig. 10. Packet received OSPF

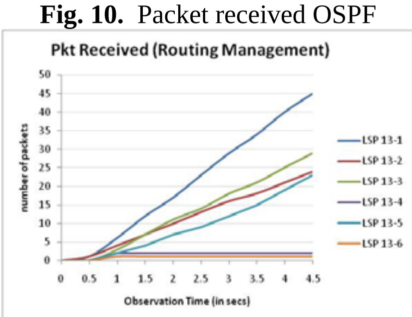

Fig. 11. Packet received MIRA

Fig.10 and 11 By using MIRA method, shows that the obtained packet loss will decrease (packet received will increase) a long observation time especially on LSP 13-1 and LSP 13-3.

V. CONCLUSION

Regarding to the analysis results coming from a series of testing, this paper concludes the following:

1. Implementing MIRA as routing management platform reduces the occurrence of traffic interference and thus network congestion should be minimized.
2. The network optimization (through critical link analysis) could be achieved by managing routing of traffic in the network.
3. Routing management with MIRA is proficient to leverage network performance, even throughput, received packet and delay.

ACKNOWLEDGMENT

The authors would like to thanks the Telkom Institute of Technolgy (IT Telkom) and PT Telkom tbk in Bandung for their financial support. They also express their sincere thanks and appreciation to all colleagues at IT Telkom for their kind help and useful suggestions.

REFERENCES

[1] PT. Telekomunikasi Indonesia, "*KD.38: Standar Layanan Speedy Broadband Access*", Indonesia, July 2006

[2] Biao Gao, Yibin Yang, Charles Chen, "*Implementing A Constraint-based Shortest Path First Algorithm in Intelligent Optical Networks*", MAHI *Network*s, May 2003.

[3] Daniel O. Awduche, Bijan Jabbari, "*Internet Traffic Engineering using multi-protocol label switching (MPLS)*", Invited Paper, Computer *Network*s, 2002.

[4] D. Awduche, J. Malcolm, J. Agogbua, M. O'Dell, J. McManus, "*Requirement for Traffic Engineering Over MPLS*", RFC 2702, September 1999.

[5] E. Rosen, A. Viswanathan, R. Callon "*Multiprotocol Label Switching Architecture*", RFC 3031, January 2001.

[6] Gaeil Ahn, Woojk Chun, "*Overview of MPLS Network Simulator: Design and Implementation*", Department of Computer Eng., Chungnam National Univ., Korea, 2000

[7] Ina Minei, Julian Lucek, "*MPLS-Enabled Applications: Emerging Developments and New Technologies*", John Willey and Sons, Ltd., England, 2005.

[8] Koushik Kar, Murali Kodialam, T. V. Lakshman, "*Minimum Interference Routing of Bandwidth Guaranteed Tunnels with MPLS Traffic Engineering Applications*". Available: CiteseerX Website, citeseerx.ist.psu.edu/ viewdoc/download?doi=10.1.1.37.4403

[9] L. Andersson, G. Swallow, "*The Multiprotocol Label Switching (MPLS) Working Group decision on MPLS signaling protocols*", RFC 3468, February 2003.

[10] Alcatel, , "*Traffic Engineering Solutions for Core Networks*", Technical Paper, June, 2002

[11] The International Engineering Consortium, "*A Comparison of Multiprotocol Label Switching (MPLS) Traffic-Engineering Initiatives*". Available: www.iec.org.

[12] The CSPF Algorithm. Available: OMNetPP Website, http://www.omnetpp.org/doc/INET/neddoc/cspf-algorithm.html