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IMPLEMENTATION OF HIGH AVAILABILITY CONCEPT BASED ON TRAFFIC SEGREGATION OVER MPLS-TE

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ABSTRACT

This paper presents performance analysis of high availability concept based on traffic segregation over Multi-Protocol Label Switching (MPLS) Traffic Engineering (TE). Recent years presents many deployment of Virtual Public Network (VPN) over Multi Protocol Label Switching (MPLS) network. This deployment benefits an organization or group of business for their own private network at a much lower costs compared to traditional point-to-point (P2P) private link. Hence, enterprise benefits from the VPN in reducing cost, increasing scalability and increasing productivity without costing the security of their network. Basic requirement of today systems on the design enterprise network is high availability. Deployment of high availability in load balancing and redundancy on existing service provider backbone network is still a challenging task. This paper presents ensured implementation on the network traffic. It immediately segregates and transparent to customer when the network edge device or access circuit was failures. Virtual Router Redundancy Protocol (VRRP) is configured to support high availability. Two gateways are provided at customer edge router, where one router elected as primary gateway, and another as a standby gateway. This situation presents the backup link which is not fully utilized. Traffic diversity concept is used where Policy Based Routing (PBR) handles the traffic segregation to utilize the traffic at both links. Results on analyzed implementation of high availability concept based on traffic segregation over MPLS-TE are presented.

Keywords: Multi Protocol Label Switching (MPLS), Virtual Private Network (VPN), Virtual Router Redundancy Protocol (VRRP), Traffic Segregation, Policy Based Routing (PBR), load balancing.

INTRODUCTION

Over the past few years, several studies are done on the effect of load balancing and redundancy in MPLS network. One of it is maintaining the load balancing and redundancy by using traffic segregation to meet Service Level Agreement (SLA). Thus, the implementation of TE in MPLS is proven many benefits in tele-traffic and network engineering management. This helps network engineers improves network planning, implementation and managing network.

Most of the enterprise customer in Malaysia demand for higher bandwidth usage for their applications access like video streaming, voice over IP phone and streaming technologies. Even though the high bandwidth offered by service provider, the issue still concerns with the cost. Hence the optimal bandwidth needs to cater with demand of traffic. A limited capacity link between Customer Edge (CE) router and Provider Edge (PE) router can cause congestion and bottleneck issues on the network. Introducing traffic management in the network can help IT engineer to manage their traffic and utilize the entire available link in the network. One method is by implementing Policy Based Routing (PBR) to provide load balancing and redundancy solution. This method is not costly as buying bandwidth management tool.

This paper implements Multi-Protocol Label Switching (MPLS) Traffic Engineering (TE) traffic management to avoid congestion from outbound traffic to Internet Service Provider (ISP). The study on this subject helps to overcome bottleneck issue on network managemen which is due to congestion. The congestion occurred in the network because of the unparallel increased of the bandwidth used between the LAN and WAN connections. Simulation presents ensured implementation on the network traffic. Traffics are immediately segregates and transparent to customer when the network edge device or access circuit failed. The study presents a configuration of Virtual Router Redundancy Protocol (VRRP) to support high availability. Two gateways are provided at customer edge router, where one router elected as primary gateway, and another as a standby gateway. This situation presents the backup link which is not fully utilized. Traffic diversity concept is used where Policy Based Routing (PBR) handles the traffic segregation to utilize the traffic at both links. Results on analyzed implementation of high availability concept based on traffic segregation over MPLS-TE are presented. Outbound traffic is divided and routed via different link. Hence, this increases the throughput at both available links and at the same time reduces bottleneck issue. The implementations of traffic management is improved in better performance in load balancing and redundancy protocol mechanisms.

RELATED WORK

Previous related works are discussed.

Multiprotocol label switching

Multiprotocol Label Switching (MPLS) is an evolution algorithm of forwarding packet through data network by using information in labels attached in each IP packets (Alwayn, 2001). The router will route to next node based on the labels instead performing a route lookup based on next destination IP address from the routing table. This algorithm saved a lot of spending time. MPLS does not intent to replace the IP address. It is designed to insert additional set of labels to IP address and the traffics are classified, marked and policed (Azher, Aurengzeb, & Masood, 2005). MPLS is stated as multiprotocol because it can support multi range of access technologies such as Internet Protocol, T1/E1, Asynchronous Transport Mode, Digital Subscriber Line and frame relay network protocols.

Many researches are done on VPN MPLS studies over the past few years. VPN concept is to provide communication within business function that geographically dispersed over a shared public backbone network (De Clercq & Paridaens, 2002). Instead of using dedicated connection, it can be done by using virtual network connection. Research also mentioned that although different VPN are connected to the same PE router, the traffic from specific VPN is not advertised via others VPN because the route is separated using router distinguish (Ben-Yacoub, 2000).

High availability

High Availability (HA) is introduced for a protection against network downtime and data loss during single on failure. Various successful techniques have been discovered to implement HA by providing redundancy and fast recovery when failures occur at any part of the Enterprise Network. Research was discussed on redundancy by providing dual gateway routing protocol (Singh & Raju, 2012). This research focuses on gateway redundancy which overcomes a single point of failure and load balancing. Both gateways of routers are responsible to forward the traffic to overcome utilization of traffic.

Virtual routing redundancy protocol

Virtual Routing Redundancy Protocol (VRRP) is designed to eliminate single point of failure which provides network redundancy for multi-homing setup. This protocol is assign in one of the routers on multi-access LAN as virtual router to forward the receiving packet and other routers standby as backup when its goes down (Blanken & Menten, 2002; Hinden, 2004). It is stated that VRRP can eliminate the router failure and support load-balancing concept by applying multi-subnet using single VRRP groups (Naseer, Bashir, & Hussain, 2009). This paper presented a control mechanism on traffics by forwarding critical traffic to Router A and backup by Router B. Non-critical traffic is forward to Router B and backup by Router A. Hence, by controlling the outgoing traffic, it manages and balances the outgoing traffic. This utilized the mechanism by controlling both link.

Traffic segregation

In network telecommunication, traffic management is the practice to manage, prioritize, control or reduce the packet traffic. In general, traffic management techniques include traffic segregation, traffic policing, traffic shaping, scheduling algorithms and others. The concept service availability is by using traffic segregation (Kyandoghere, 1996). This support impact on equipment failed and fiber cuts by divide and outgoing traffic from LAN customer to different two or more router gateway. A failure of single point of router will not affect the other route on traffic which is under consideration. This mechanism can be done by segregate the traffic to two types of traffic only which are critical traffic and non-critical traffic. Example of non-critical traffic is email application which does not requires real-time transmission and it repeats recovery. The applications which are not able to handle any transmission loss will be considered as critical traffic. By using traffic segregation, we can provide load balancing and route the critical traffic via high service level guarantee and non-critical traffic via the link that have low reliability to control the bottleneck of the link.

Another study related to traffic segregation was done by Tantipongsakul and Khunkitti(Tantipongsakul & Khunkitti, 2009) using Policy Based Routing (PBR)on CE router to control ingress and egress traffic by using the firewall rules. PBR is a technique to make decision based on policies and override the routing protocol decisions. By using PBR, the routing of packet can be set up either to allow or deny the paths based on the proposed network design. This concept is applied to route the congestion traffic to lightly loaded link.

Throughput

The rate of successful data delivered across the link is important to measure the quality of MPLS network in a given period time. Throughput rate is calculated by using the formulas show in Equation (1) (Dixit & Prasad, 2003).

$$Throughput = \frac{TCP\ Window}{Round\ Trip\ Time} \quad (1)$$

RESEARCH METHODOLOGY

This paper presents research method in several phases of scope of work, experimental and analysis.

Scope of work

The scope of work starts with running a test-bed by using the production of ISP MPLS network. A dedicated Metro Ethernet lines is use and evaluates the performance of High Availability. The flow chart of the research of this project is as Figure-1. Three phases of the flow is presented.

- **Phase 1: Literature review**

In the first phase, identification on the industrial standard and problem in MPLS VPN on high availability architecture is done. Method to implement a high availability in load balancing and redundancy network is identified. Comprehensive study needs on the MPLS VPN is done to fully understand the MPLS technology, Virtual Private Network (VPN) architecture, high availability, load balancing, redundancy and traffic segregation before designing experimental lab setup.

VOL. 10, NO. 3, FEBRUARY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

- **Phase 2: Experimental lab setup**

The second phase of this project focused on the experimental lab setup based on the design of MPLS network topology to support load balancing and redundancy. This includes implementing all the appropriate attributes to the network element in order to achieve network design using a production ISP MPLS network by TM IPVPN. Once network setup completed, experimental lab was conducted with traffic segregation and captured all the results which are throughput of the link, path of traffic and end-to-end delay is collected and analyzed.

- **Phase 3: Analysis and discussion**

The final phase presented all the data collection from previous phase is discussed and analyzed. The important parameter evaluations are network bandwidth performance, packet loss, round trip time and TCP throughput. The comparison performance based on improvement load balancing and redundant traffic is analyzed and the optimum topology implementation is decided.

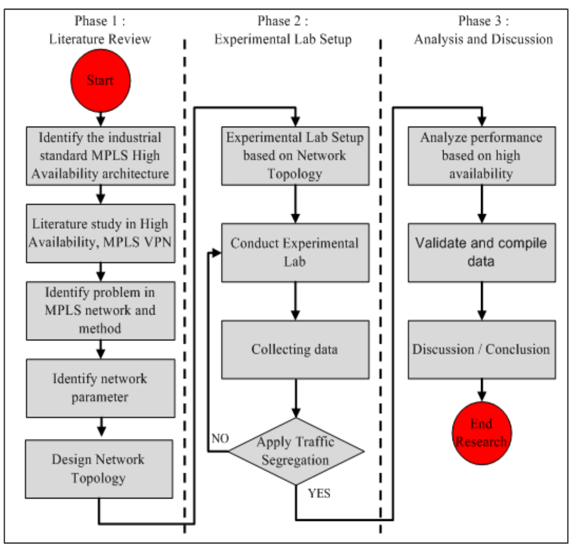

Figure-1. Flow chart of the research.

Experimental test bed setup

A real lab that connecting to an ISP MPLS IPVPN is used in this research. Simulation on multi homing site for HQ and also the branch is done. The network design is as per Figure-2. The lab was setup based on the equipment and specification as Table-1. PCs installed with SolarWind Application to monitor the network performance. For application end-to-end testing, two servers are running at HQ which is FTP FileZilla Server (PC1) and HTTP File Server (PC2). The Customer Edge (CE) router is using Cisco 2811 and connected to TM MPLS. Two customer edge routers at HQ (HQ1 and HQ2) are directly connected to Layer 2 Cisco switch (SW1) and 2 PCs connecting to the switch. These routers are connected to provide edge router at Shah Alam and Kelana Jaya via 2Mbps Metro-Ethernet line. For Branch site, PC3 is directly connected with Layer 2 Cisco Switch and acting as client user. Another 4Mbps Metro-Ethernet line is connecting CE routers (BR) to PE routers in Cyberjaya at branch site. Both Layer 2 switch connected to CE router using straight-through cable and configure as 2Mbps. For PBR setup, crossover cable is used between HQ1 and HQ2 to avoid congestion.

Border Gateway Protocol (BGP) is the configured routes between CE routers to PE routers. Two different applications are sets as HQ site to do the traffic segregation by route the FTP packet via HQ1 link and divert the HTTP packet to HQ2 link. Both applications are transferred with 20MB file.

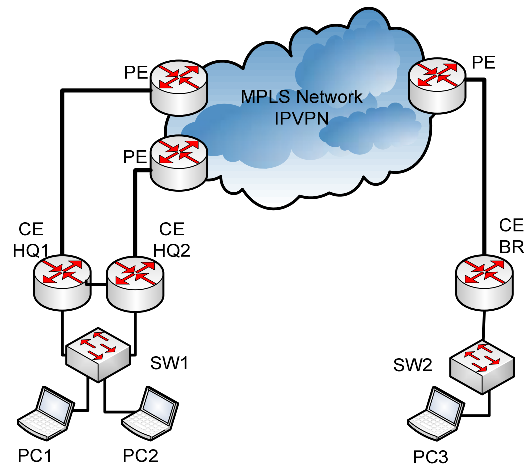

Figure-2. Experimental test lab setup.

Table-1. Requirement of lab setup.

Equipment/Application/Link	Quantity
PCs at HQ to generate traffic/application	2
PC at Branch to receive traffic/access application from HQ	1
HQ Router – Router Cisco 2811	2
Branch Router – Router Cisco 2811	1
ISP Router in TM IPVPN – Shah Alam, Kelana Jaya and Cyberjaya	4
2Mbps Metro-Ethernet line	2
4Mbps Metro-Ethernet line	1
SolarWind Application	1
FTP FileZilla Server/Client	2
HTTP File Server	1

Traffic flow

The flow of the traffic is derived as Figure-3 where any outbound traffic to MPLS network is inspected by route map before forward to destination. From the flow chart, the traffic is either forwarded based on the policies statement or routed protocol decision. A series of experiment by using the same test bed setup is done. This is proved by the effectiveness in the implementation of high availability but without applying traffic segregation. Both applications are running on the same time and the packet is pump into the network. After a while, failover test is done by disconnect the link between CE-PE for HQ1.

VOL. 10, NO. 3, FEBRUARY 2015 ISSN 1819-6608
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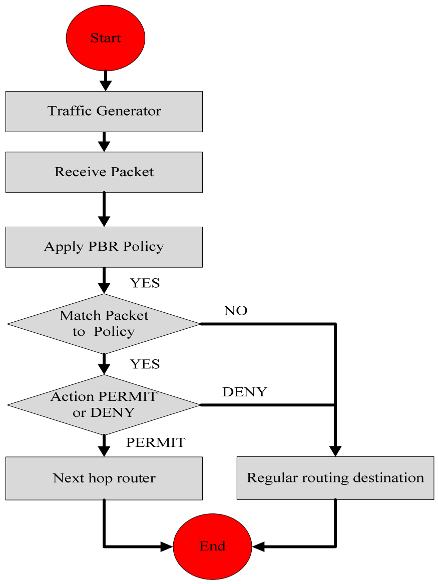


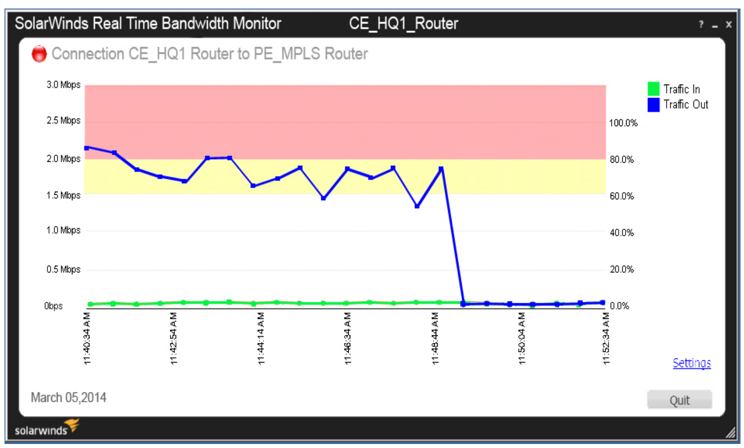
Figure-3. The traffic flow chart.

RESULT AND DISCUSSIONS

Results present before and after Traffic segregation in evaluating the traffic performance by configuring policy based routing.

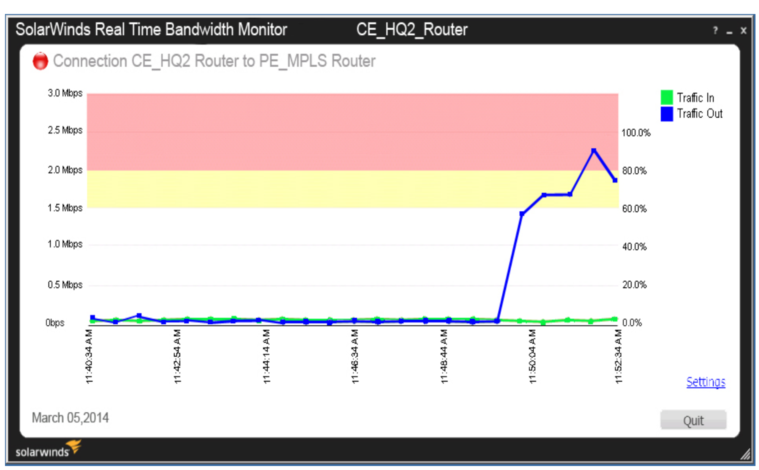
Before implementing traffic segregation

Figure-4 and Figure-5 show the utilization result of link CE-PE router without configure policy based routing. The figure represent the utilization of link at axis y and forwarding time at axis x. The high utilization is defined when the traffic is over than 2.0 Mbps.



After disconnect link between CE-PE HQ1 Router

Figure-4. The result before implementing traffic segregation for HQ1 router.



After disconnect link between CE-PE HQ1 Router

Figure-5. The result before implementing traffic segregation for HQ2 router.

VOL. 10, NO. 3, FEBRUARY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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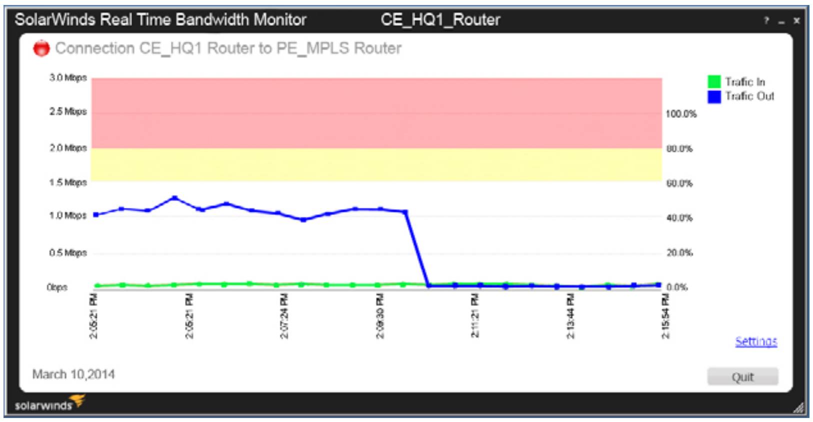
HQ1 router is responsible to forward the traffic to MPLS network due to VRRP protocol. Only one gateway is utilize at single time, and the second router (HQ2) comes in engage when the existing router (HQ1) is goes down. For this architecture, only one gateway is an action, which is inefficient used of the available link. Figure-4 presents congestion is occurs between the links of CE-HQ1 router and PE router due to high traffic generate from LAN to MPLS network. The packet is possible to drop during transmission due to overfilling of packet.

After implementing traffic segregation

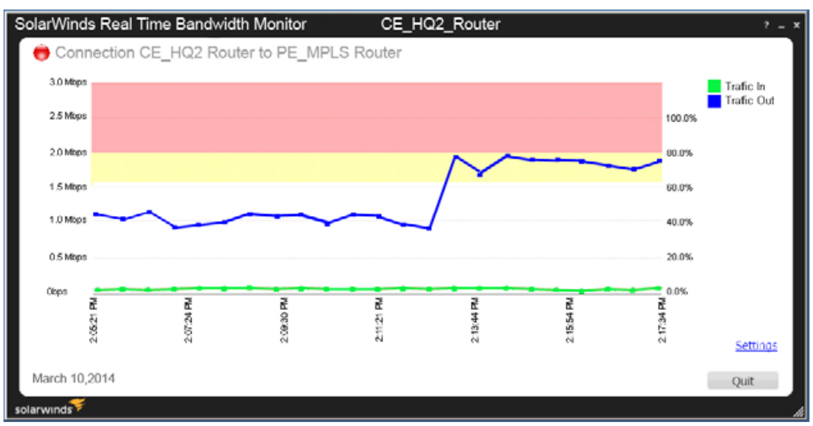
Figure-6 and Figure-7 shows the performance utilization result of link CE-PE router which uses both available gateway by configure policy based of routing. It is clear from the figures that the utilization of the link is improved. Traffic segregation is done by routing the traffic based on application where FTP packet is forward via HQ1 router and HTTP packet is route via HQ2 router to MPLS network. All the resources are forward and the utilization was reduced to half.

Failure occurs when a failure router affects and diverts to active router. Thus, only a piece of the total traffic under consideration is affected. The standard Service Level Guarantee (SLG) offer by TM IPVPN for multi homing is 99.99% where the Mean Time to Repair (MTTR) is equal to 3 hours. Result is refers from service provider website. Thus, the customer experiences on the high utilization when a failure occurs are not the main issue for enterprise in handling problems.



After disconnect link between CE-PE HQ1 Router

Figure-6. The result after implementing traffic segregation for HQ1 router.



After disconnect link between CE-PE HQ1 Router

Figure-7. The result after implementing traffic segregation for HQ2 router.

Table-2 presents the test bed on comparison of traffic segregation which best implements on enterprise network. This method also is proved based on previous works done by Fazl-e-Hadi (Naseer et al., 2009). This method controlled the outgoing traffic from the LAN to MPLS traffic engineering network. The proposed scheme efficiently allocates the available links by scheduling the route according to applications. The routing is manipulates by configuring policy based routing at customer edge router.

Policy based routing is configured to manipulate the traffic and support load balancing across the available link. Research present, traffic management is used to support load balancing and prevent network overload (Guo, Lee, Metke, & Bansal, 2006).

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ARPN Journal of Engineering and Applied Sciences

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Table-2. Summary test-bed.

The average of link utilization	Scenario 1		Scenario 2	
	Without Traffic segregation		With Traffic segregation	
	HQ1 Link UP	HQ1 Link DOWN	HQ1 Link UP	HQ1 Link DOWN
CE HQ1 – PE	1.97Mbps	-	0.91 Mbps	-
CE HQ2 – PE	0.001 Mbps	1.95 Mbps	0.89 Mbps	1.85 Mbps

Round trip time, packet lost and TCP throughput are directly important mechanism to qualify the video conferencing, voice IP (VoIP) and streaming application where:

- Round trip time to show how smooth is the link to accept more packets of data at a time. In the same time, it will show how much other traffic travel across the link.
- Packet loss is important to ensure all packets of data are successfully reached the destination. Packet loss can occur due to link failure or high level of congestion.
- Throughput is represent how wide is the ‘road’ which the network can move data in bits per second from source to destination.

Typically, low latency, zero packet loss and high TCP throughput can lead to better quality of applications. The accepted value is varied and depends on product manufacturers. Continuous ping command output is applied to analyze the performance of network. The average of packet loss, round trip time and throughput is captured as in the Table-3

Table-3. The average of packet loss, round trip time and throughput.

	Packet loss	**Round trip time** (ms)	**Throughput** (MB/s)
Before implementing traffic segregation	20.10%	549 ms	0.933 MB/s
After implementing traffic segregation	0%	261 ms	1.962 MB/s

Implementation of traffic segregation able to achieve lower round trip time from 549 ms to 261 ms and at the same time maintain zero packets lost, where all packets were successfully received at destination. The average of throughput in Table III represents the value of throughput which achieved to 1.962 MB/s compared to before implementing traffic segregation is 0.933MB/s.

Based on the result gathered, traffic segregation can resolve bottleneck and avoid the congestion link occur between CE router and PE router. With this type of architecture, it becomes easier for enterprise customer to efficiently control the traffic across the link.

FUTURE WORK

Based on the foregoing findings of the research, the following recommendations are to be explored as an extended from this research. Future enhancement of network performance over MPLS Traffic Engineering (TE) is listed as below:

- Implementation of wireless connection for redundant link to service provider network to eliminate issue on physical connection of failure. A comprehensive study will identify the potential physical of failure and investigate how can be mitigated. Redundant architecture provides alternative solution to route the packet data to its destination via 3G, Wimax, VSAT or Microwave network. Some of future works on router configuration to be explored and at the same time support MPLS concept.
- Manage and segregate the available bandwidth on the network based on application demand to cope with congestion. Further study on bandwidth segregate for outbound traffic to MPLS network can be done to utilize the available bandwidth. This concept will allow particular application to obtain its guarantee bandwidth.
- Apart from that, further studies on load-balancing between two or more LAN segments by applying Enhanced Virtual Router Redundancy Protocol. This mechanism more efficient to do load balancing between a few LAN segments without running multiple VRRP on each router. Network administrative can control and manage their LAN segment advertisement to utilize the link.

CONCLUSIONS

This paper implements Multi-Protocol Label Switching (MPLS) Traffic Engineering (TE) traffic management to avoid congestion from outbound traffic to service provider network and overcome bottleneck issue. The congestion occurred because unparallel increased of the bandwidth between the LAN and WAN connections. The implementations of traffic management in overall has improved network performance in load balancing and redundancy protocol mechanism.

From the result, we wrap up that traffic management and load-balancing are the best solution for network architecture design. By having traffic diversity at the multi-homed branches, it can be used to fully utilize the lightly loaded link. The result presents the outbound traffic is divided and route via different link. Hence, this increases the throughput at both available links and at the same time reduce bottleneck issue.

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