Optimization of Network Redundant Technologies Collaboration in IMS Carrier Topology

Filip Burda, Peter Havrila, Marián Knězek, Klaudia Konôpková, Ivan Kotuliak, Ján Murányi, and Juraj Nemeček

Slovak University of Technology, Faculty of Informatics and Information Technologies, Ilkovičova 3, 842 16 Bratislava, Slovakia
{filip.burda,phavrila,marian.knezek,klaudia.konopkova, jan.muranyi,juraj.nemecek}@gmail.com, Ivan.Kotuliak@stuba.sk

Abstract. The Traffic Engineering in IMS network is a hot topic as operators require extensive QoS management in their network. A combination of IP SLA with the Object Tracking and MPLS Traffic Engineering can create automatic solution for applying new rules to the ISP carrier topology. IP SLA provides an opportunity to track specified parameters of the links and devices. In this article, we optimize convergence and load distribution among existing links in the network in automated way. Nowadays, similar solutions work mainly manually. Innovative solution, which finds suboptimal bandwidth utilization automatically, without requirement of the network administrator involvement, is described also.

Keywords: MPLS, Traffic Engineering, Object Tracking, Redundancy.

1 Introduction

IMS (IP Multimedia Subsystem) architecture is creating momentum in the research of telecommunication technologies and data networks. As these two previously separate worlds are fusing into the one converged environment, there are more than enough issues that operators would like to resolve for smooth incorporation of the IMS into their core networks. In our research, we have focused on a fundamental operation of the underlying data routing around the IMS core. In the last generations of telco networks, the quality of service and load-balancing could be native to the whole network. In IP networks, such things are hardly native as data networks and particularly the IP networks are routed in the shortest path first manner. This approach creates limitations on the ability of these networks to utilize the bandwidth of routes other than those declared as shortest paths to the destination. This limitation is currently being focus of world-wide research from which a new concept called the Traffic Engineering is rising as an old solution for new environments, particularly MPLS (MultiProtocol Label Switching). Put together, Traffic Engineering is the manipulation of traffic to fit our network [1].

T. Magedanz et al. (Eds.): TridentCom 2010, LNICST 46, pp. 705–712, 2011.

This article focuses on MPLS Traffic Engineering (TE) technology and its usability in the IMS environment. In our approach, we combine Cisco solutions IP SLA with the Object Tracking and MPLS TE to create unique automatic solution for applying new rules to a changing topology (e.g. in cases of link failures or over utilizations). IP SLA gives us an opportunity to track specified parameters of the links and devices. Consequently, these results can be applied to the Object Tracking for creating entries that will be applied to the routing table upon specified event. The aim is to optimize convergence and load distribution among existing links in the network. Our approach increases availability of services, overall quality of services and tries to easily satisfy SLA (Service Level Agreement – in terms of an actual agreement for quality of service) demands between service provider and customers [2].

The article is organized as follows: Section 2 describes the problem in details and provides existing solutions. Section 3 presents our approach of applying IP SLA to the network. Section 4 describes our lab environment. Section 5 contains obtained results. Concluding results and ideas for future are given in Section 6.

2 State of Art

Traffic Engineering is used to solve a fundamental problem as displayed in Fig 1. For this example of the IP network, all links are OC-3 links with the bandwidth roughly 150 Mbit/s. Now, let us assume that we know that the router R1 sends 90 Mbit/s of data to the router R6 and router R7 sends another 80 Mbit/s to router R6. In the classical shortest path first manner, R2 has link to R5 as next hop towards R6. This will simply result in congestion on the link between routers R2 and R5 and obviously, alternative link through the path R2-R3-R4-R6 remains under full utilization. The possibility of using Traffic Engineering is by manipulating costs. This results in costs equilibrating of all alternative paths and then load-balance between these paths. This solution is usable in small networks, but large scale deployment can be problematic. More sophisticated approach is the Load Sharing, which can better reflect the available resources (e.g. bandwidth) along paths. An alternative is Asynchronous Transfer Mode (ATM) networks, where Permanent Virtual Circuits (PVCs) can be constructed between the end-points and load can be shared between these PVCs and no detrimental manipulation to the link costs is necessary.

IP SLA is Cisco specific function for supporting monitoring of specific parameters. IP SLA can monitor different constraints of the node, link or path from the routers and taking appropriate actions and informing administrator through SNMP protocol (Simple Network Management Protocol). IP SLA currently monitors various types of delay, jitter, RTT, number of dropped packets, latency, etc. IP SLA is a tool to satisfy the defined constraints in SLA [3].

Object Tracking is another Cisco specific feature. In Object Tracking we are monitoring an object, which is i.e. IP SLA object, status of an interface, status of IP address, presence of the destination network in the forwarding table, metric of the path, etc. Composite objects can be created, where other objects are put together through boolean logic or threshold system [4].

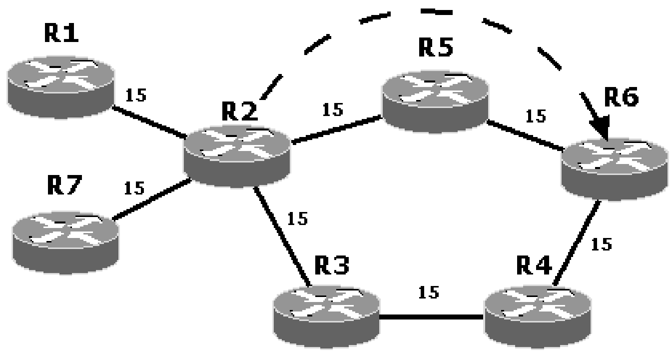

Fig. 1. Example of the IP network with the potential for Traffic Engineering use

Currently, a combination of ATM facilitates management through PVCs and scalability of the IP infrastructure resulted in the MPLS networks as MPLS TE. MPLS enables chaining of the labels in Protocol Data Unit (PDU) and thus the ability of non-bottom labels to have other than routing purposes. The two most common uses for these labels in one PDU are VPN (Virtual Private Networks) and TE tunnels identifications. However, tunnels are still created mostly manually as a part of the network design. Adding new TE tunnels to the network can be accomplished either by the strategic approach by creating full mesh of TE tunnels in parts of the network or by the tactical approach by the monitoring link utilizations and by adding TE tunnels when they are required [5, 6].

There is also an approach based on enabling the premium service classes in the DiffServ over MPLS-enabled network [7]. The advantage of this solution is the implementation as framework. However, DiffServ is mandatory in this case and only chosen parameters are measured. Contrary to DiffServ over MPLS, we would like to track the tens of different parameters [8]. Furthermore, the dependence on the DiffServ is not suitable and we would not like to be limited to some QoS model.

There is also work based on the delivering QoS in the Next Generation Network (NGN) [9]. This paper presents usage of the QoS for NGN end-user applications. Several concepts for allowing the control of QoS levels are discussed. We would like to present the automatic approach without fixed QoS classification and marking.

There is also work based on the modeling and simulating of traffic aggregation over MPLS networks [10]. This work is focused on SIP call setup and SIP operation. We focus not only on SIP signaling, but also on media delivery.

3 Proposed Solution

Basically, monitoring the links and the devices is done by specialized applications. Monitoring is done mostly by the Simple Network Monitoring Protocol (SNMP). There is also possibility of using IP SLA to track some parameters of the links, which are informing the administrator via SNMP. There is a huge variety of parameters, which can be actively monitored from the routes and many ways of how to and when to inform the administrator. However, time between sending the trap message, receiving and reading it by the administrator and taking the appropriate action is too long. If there is no backup plan created, minutes can pass. Automation of this SNMP based process is part of our future efforts.

Our current solution, described in Fig. 2 combines IP SLA with Object Tracking [7, 8] and Object Tracking with the static routes defined in the routing table. We are focusing on the MPLS TE tunnels. The only prerequisite is that the TE tunnels are defined statically in the routing table. In our solution, monitored parameter with IP SLA is mapped one to one with Object Tracking. We are also creating composite tracked object, which changes its state after several conditions are met in the other tracked objects. This composite object is mapped with the static route. After some critical values are detected by the IP SLA, the tracked objects change their state automatically. So when the composite object will change its state, the static route will change its state as well. When the static route goes down, the other static routes with worse preference will take place or the dynamic routes. This is a unique automatic solution. Backup plan takes place automatically. Problems are that increasing number of the IP SLA objects increase also bandwidth and CPU utilization. Even more, also the backup plan must be prepared as a part of the network design. If needed, SNMP messages can be still sent to the administrator and administrators can manually change the policy if necessary.

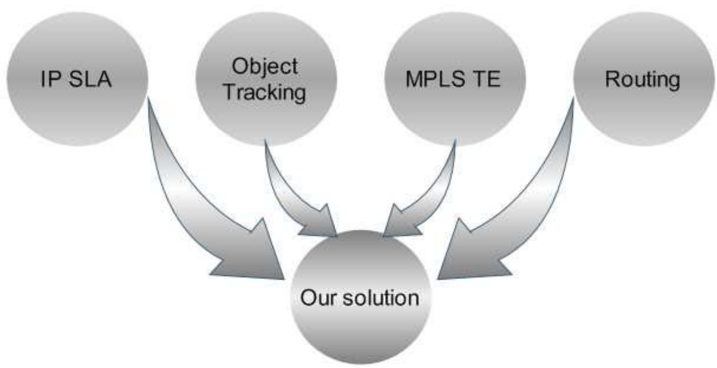

Fig. 2. Proposed approach: combination of IP SLA, Object Tracking, MPLS TE and routing

4 Test-Bed Setup

In Fig. 3, the test-bed of our IMS core with the surrounding redundant carrier network is presented. The carrier network is composed of eight routers with multiple redundancies. We have two exit points in our network to simulate transit ISP network. One exit point is on the far left side, and one on the far right side. IMS core is situated in the network center.

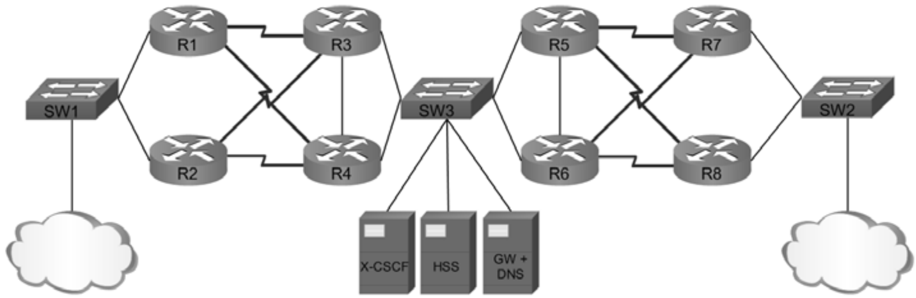

Fig. 3. Testbed scheme

Two MPLS TE tunnels are present on routers R1, R2, R7 and R8. These TE tunnels are created across the whole network, from the one exit point to the other exit point. One TE tunnel on the router R1 is placed across routers R3, R5 and R7 and the second TE tunnel from R1 through R4, R6 to the R8. On the other routers, TE tunnels are placed similarly to this. The first TE tunnel is called primary and the second is called secondary TE tunnel. Primary tunnels are placed among "upper" routers (R1, R3, R5, R7). We assume that on the exit points, the External Border Gateway Protocol (eBGP) will be configured.

The primary TE tunnel is placed in the routing table statically with some preference. The primary and the secondary TE tunnel are learned via dynamic routing protocol, in our case via Integrated Intermediate System to Intermediate System (IS-IS) protocol with worse preference. The static primary TE tunnel is tracked by an object. All the traffic destined for the networks behind the other exit point is going through this static TE tunnel. After some conditions are met, tracked object goes down, which leads to removing this static route from the routing table. After removing this static route, the same dynamically learned primary TE tunnel and also the secondary TE tunnel are placed into forwarding table. The traffic is now load balanced.

For our measurements, the network traffic will enter only the router R1 and is destined to the exit point behind the routers R7 and R8 (c.f. Fig. 3). We assume that customers are already registered and they are initiating voice or video calls. One of the customers is located behind the left exit point and one behind the right exit point. After initiating calls, the bandwidth utilization is rising, which leads to increased Round Trip Time (RTT). Because of 128 kbit/s link between routers, only one call can be established with no quality penalty. After initiating the second call, increased RTT, jitter and also packet loss is observed. Both calls have equally penalized quality.

For our second measurement we will configure IP SLA objects. We have chosen RTT and average jitter for IP SLA tracking. In the IP SLA object 1 we configure the icmp-echo type of packet with the Type Of Service (TOS) decimal value of 184, which is the decimal representation of EF class. Threshold is configured to the 20 ms for our test purpose. Frequency of sending these packets and controlling the quality of the link is 1 second. The second IP SLA object is configured in the same way as the IP SLA object 1. The threshold value is set to 4 ms, again, only for test purposes. The reaction is configured for an average jitter with the upper threshold of 4 ms and lower threshold of 3 ms. If threshold limits are exceeded, immediate action is taken. Each and every IP SLA object is mapped to its own unique object in Object Tracking (1 and 2). One composite tracked object is created with the boolean logic, designated as object 3. If any object is down, the whole composite object is down. This composite object is used for the static route configuration. Tracked objects 1 and 2 are delayed. If they are not delayed and if one of the IP SLA object fail their test, immediate action is taken. We are delaying the “down” and the “up” state three times the frequency of IP SLA object, which is 3 seconds. If three times in a row the test fails, tracked object is considered to be down. The same rule applies for the “up” state.

5 Performance Results

During measurement, we established the first call. The TE tunnel bandwidth was sufficient for exactly this one call as indicated by acceptable RTT and Jitter characteristics for 128 kbit/s A/S interfaces in Table 1. Next we have established second call. After the second call was established, the RTT measurements started to constantly rise (c.f. Fig. 4). After 4 seconds of both calls in place, call quality deteriorated beyond acceptable threshold (c.f. Table 1). However with our optimization, network was able to detect degrading call quality and dynamically switch traffic patterns in Traffic Engineering manner to accommodate rising demands for network throughput. In optimized environment, after the second call was placed and call characteristics worsened beyond specified threshold, corresponding IP SLA measurement bound to object 1 failed immediately within the next testing period. For the next 3 seconds object 1 was forced to be delayed before changing its state, as a protection against premature backup TE tunnel activation. After this timer expired, object 1 has changed to the down state, also forcing object 3 to go down. This has led to deletion of the corresponding static route in the routing table. The dynamic routes took place immediately, resulting in the creation of the same primary TE tunnel and additional secondary TE tunnel. In this setup, the routers could begin to load balance between these two TE tunnels. In the next half second, given the load balanced environment capable of sustaining two concurrent calls, the quality for the both calls returned to acceptable levels. IP SLA object still hold two TE tunnels up, because with load-balanced solution, jitter characteristics remained above normal in node (c.f. Table 1). After termination of one call, jitter characteristics returned to acceptable values. Therefore IP SLA realized that it is possible to return to a single TE tunnel solution. All the objects changed their state to up and static route was placed back to the routing table. There were no negative effects observed during our experiments.

In Fig. 4, graph of the RTT measurement in time is depicted. Recording of values began when second call was established. It is obvious that our optimization system needed roughly 4 seconds, to detect, propagate, compute, and update routing forwarding information base for rising throughput demands via load sharing TE tunnels.

Table 1. RTP behavior with and without pro-active backup MPLS TE tunnel utilization

	RTT [ms]		Jitter [ms]	
	Without IP SLA	*With IP SLA*	*Without IP SLA*	*With IP SLA*
1 call	51,4	51,4	1	1
2 calls (0-4 s)	~305	~305	1	1
2 calls (after 4 s)	>2000	51,4	4-6	4-6

Consequently, after roughly 4 seconds, our system was able to dynamically achieve sustained acceptable call quality. In comparison to static TE tunnel, that simply became congested. Note that for half a second interval after 4th second, RTT is in a great variation after applying our configuration. During this time, out of sequence packets are arriving, causing these values "jumping" from the upper to the normal RTT level. These packets were discarded by the VoIP clients. Clients were able to communicate after the 4.5 seconds with its expected quality. Without IP SLA, RTT was constantly rising up to the 2000 ms (c.f. Table 1).

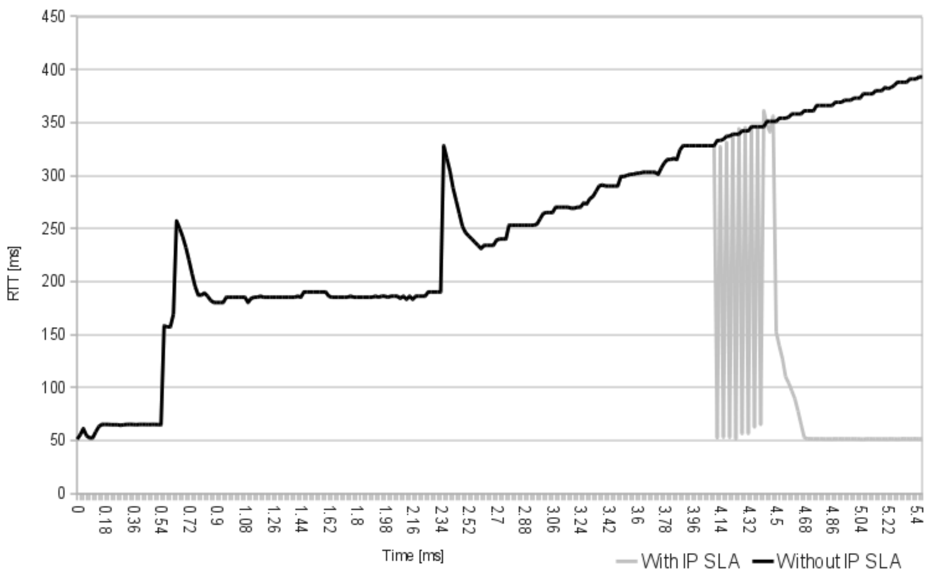

Fig. 4. Comparison of the RTT evolution in time for system with and without IP SLA

6 Conclusion

Nowadays, there are some approaches for optimizing the cooperation of the network IMS core. These approaches work manually, no automatic solution is available. We have proposed innovative solution, which finds suboptimal bandwidth utilization automatically, without requirement of the network administrator involvement. However in this stage, some backup plans are required for immediate response.

We have demonstrated that the IP SLA with the Object Tracking can be effectively combined with the other technologies like MPLS TE. Especially, after link failure or link overload, it can reroute traffic in fully automated way to alternative routes. Even that this approach eliminates need for administrator action, it is still rather slow. Therefore, the open problems for the next research are the optimization of TE tunnel creation and the strategies for their deployment.

Acknowledgments. This work was supported by the Grant No.1/0243/10 and 1/0649/09 of the Slovak VEGA Grant Agency and by the project ITMS 26240120005. We would like to thank Tatrabanka foundation grant for supporting this project.

References

1. Osborne. E., Simha, A.: Traffic Engineering with MPLS. Cisco Press (2002) ISBN 1-58705- 031-5
2. Evans, J., Filsfils, C.: Engineering a multiservice IP backbone to support tight SLAs. Computer Networks 40(1), 131–148 (2002)
3. Cisco Systems, Inc.: Cisco IOS IP SLAs Configuration Guide. Technical report (August 2008)
4. Cisco Systems, Inc.: Configuring Enhanced Object Tracking. Technical report (March 2009)
5. Awduche, D.O., Jabbari, B.: Internet traffic engineering using multi-protocol label switching (MPLS). Computer Networks 40(1), 111–129 (2002)
6. Szviatovszki, B., Szentesi, A., Juttner, A.: Minimizing re-routing in MPLS networks with preemption-aware constraint-based routing. Computer Communications 25(11-12), 1076–1084 (2002)
7. Alshaer, H., Elmirghani, J.: Enabling novel premium service classes in DiffServ over MPLS-enabled network. International Journal of Network Management 18(5), 447–464 (2008)
8. Chen, H., Cheng, B., Su, H.: An objective-oriented service model for VoIP overlay networks over DiffServ/MPLS networks. Computer Communications 30(16), 3055–3062 (2007)
9. Mustill, D., Willis, P.: Delivering QoS in the next generation network – a standards perspective. BT Technology Journal 23(2), 48–60 (2005)
10. Rong, B., Lebeau, J., Bennani, M., Kadoch, M., Elhakeem, A.: Modeling and Simulation of Traffic Aggregation Based SIP over MPLS Network Architecture. In: Proceedings of the 38th Annual Symposium on Simulation, pp. 305–311 (2005) ISBN, ISSN:1080-241X, 0-7695- 2322-6