Differentiation of Services in IMS over MPLS Network Core

Filip BURDA, Peter HAVRILA, Marián KNĚZEK, Klaudia KONÔPKOVÁ, Juraj NEMEČEK, Ján MURÁNYI*

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

Abstract Traffic engineering and QoS Fguarantee is crucial point of any operators' network. To evaluate IMS services over MPLS enabled network in case study, we have created a testbed for a service provider. Our service provider distributes various services requiring different traffic priorities together with customer-generated traffic. We have enabled the IMS core to trigger associations based on customer classes with specified server acting as RTP proxy for media flows. The network traffic is shaped to provide MPLS Traffic Engineering tunnels with various priorities towards these application servers in IMS core. This setup allowed us to show that IMS over MPLS network creates scalable and sustainable solution for providing adequately priced priorities together with QoS management for different customer classes based on IMS user profiles.

1 Introduction

IMS (IP Multimedia Subsystem) architecture is behind the current movement, resulting in extensive research of telecommunication technologies and data networks. These two previously separate worlds are fusing into the one converged environment. At this point, there are more than few issues that operators would like to resolve for the smooth incorporation of the IMS into their networks. In our research, we have focused on fundamental operation of the underlying data routing around the IMS core. In the latest generation of mobile networks, the quality of service and load-balancing could be native to the whole network. On the other side, data networks, and particularly the

* Supervisor: Assoc. Professor. Ivan Kotuliak, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

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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. When underestimated, this fundamental principle can have detrimental effects on end-to-end quality [6]. This limitation introduced a new concept as a solution to the data networks called the Traffic Engineering. Traffic Engineering is manipulation of traffic in order for it to fit the network [1].

This article focuses on the problem of scalability of traffic engineering quality of services solutions with IMS core network customer classes. In our effort, we have combined MPLS TE (Multiprotocol Label Switching Traffic Engineering) with an IMS core services to create three customer classes - gold, silver and best-effort, with descending priority. By utilizing different application servers serving as RTP stream proxies for different customer classes, we enabled the surrounding network to be aware of these customer classes. This awareness manifested itself in MPLS tunnels for different customer class and thus enabling simple prioritization of traffic with regard to the MPLS TE tunnels.

The article is organized as follows: Section 2 describes the problem in details and provides existing solutions with MPLS TE and IMS core. Section 3 presents our test-bed network topology with MPLS TE tunnels. Section 4 describes our lab IMS system and its ability to classify customer classes. Concluding results and ideas for future work are given in Section 5.

2 State of Art

Traffic Engineering is used to solve a fundamental problem as displayed in Figure 1. In this example of an IP network, all links are OC-3 links with bandwidth at 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, the alternative link through the path R2-R3-R4-R6 remains underutilized. The possibility of using Traffic Engineering is by manipulating costs. This results in cost equilibration of all alternative paths and successive load-balancing 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. Wanted results can be done through Traffic Engineering in MPLS, when data flows are distributed over multiple links [4].

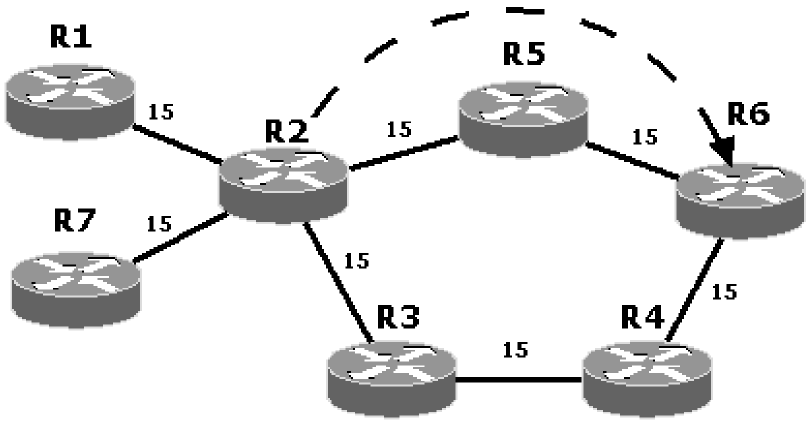

Figure 1. Topology with underutilized bandwidth from router R2 to R6 (dashed line).

Currently, a combination of ATM facilitates management through PVCs (Permanent Virtual Circuit) and scalability of the IP infrastructure resulted in the MPLS networks as MPLS TE. MPLS enables chaining of labels in Protocol Data Units (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 Network) 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 a strategic approach - by creating full mesh of TE tunnels in parts of the network, or by a tactical approach - by the monitoring link utilizations and by adding TE tunnels when they are required.

This work is based on [1], where VoIP requirements and deployment is described in great detail.

Several works study the methodology of VoIP deployment. Most of them just simulate VoIP calls and do not pay attention to customer differentiation [2]. We divide our customers into three groups – gold, silver and best-effort customers. As such, we provide a backup plan for gold customers in case the prescribed path is unavailable or quality is markedly degraded.

Another approach is to allow only as much calls with assured quality as the network can handle it. In MPLS network the DiffServ QoS model is used and EF (Expedited Forwarding) class is used for limited number of calls. Any other call is allowed, but it has decreased priority from the AF (Assured Forwarding) family [3]. We are more ravenous, as we try to allow all the calls from gold customers even at the cost of suppressing silver customers, which do not paying for these services in our scenario.

IMS is a new approach in accomplishing convergence of communication networks. It allows users to access a rich set of communication services and multimedia content using already-established, and thus cost-effective, IP networks. Its architecture is designed with two main features in mind.

First, it focuses on providing session control using a standardized set of services called functions. These functions are distributed among various nodes within the network core and each function is responsible for a different set of operations, including authentication, authorization, registration, media handling, routing and service provisioning.

Its second main feature is the architecture's ability to add services to the network in a well-defined and scalable manner. These services are implemented in so-called application servers and can provide a vast amount of features for the network's subscribers to utilize. Even in the current early stages of IMS integration, there are already application servers with the ability to provide presence notification, IPTV streaming, Video-on-Demand or instant messaging services. The amount of services and their integration with other services commonly available over the Internet is expected to rapidly grow in the near future [7]. All this is implemented upon robust and tested protocols of the TCP/IP stack.

Another important feature of the IMS network is its openness and focus on interoperability. The primary communication protocol in the IMS network is the Session Initiation Protocol (SIP). Since this protocol is standard-based, this allows the operator to construct parts of his IMS network using components and software from different vendors, thus forming a more competitive market. From the operator's point-of-view, this feature makes investments in an upgrade to IMS, as opposed to current legacy network architectures and their closed-vendor nature, very feasible.

The last important reason why IMS is expected to supersede any other form of intelligent telecommunication network is the architecture's ability to use legacy networks as part of the domain core. This means the operator does not have to start implementing IMS network from scratch, but can instead evolve his current legacy networks to IP-based in small steps. Rather than being just a technology concept, this feature turns the IMS architecture into a appealing business case which can be financially justified.

3 Topology description

In Figure 2, the test-bed of IMS core with the surrounding redundant carrier network is presented. The carrier network is composed of many routers with multiple redundant links. We have two exit points in our network to simulate transit SP (Service Provider). One exit point is on the far left side, and one on the far right side. IMS core is situated in the network center.

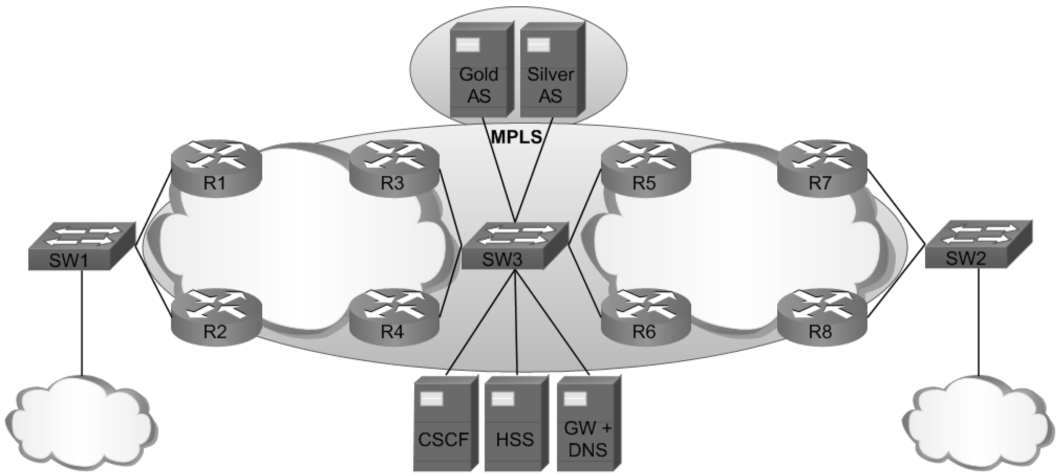

Figure 2. The general transit through SP topology.

In our laboratory environment, we have a limited number of devices, and that is why we will adjust the topology as in Figure 3. We will further describe our laboratory adjusted topology.

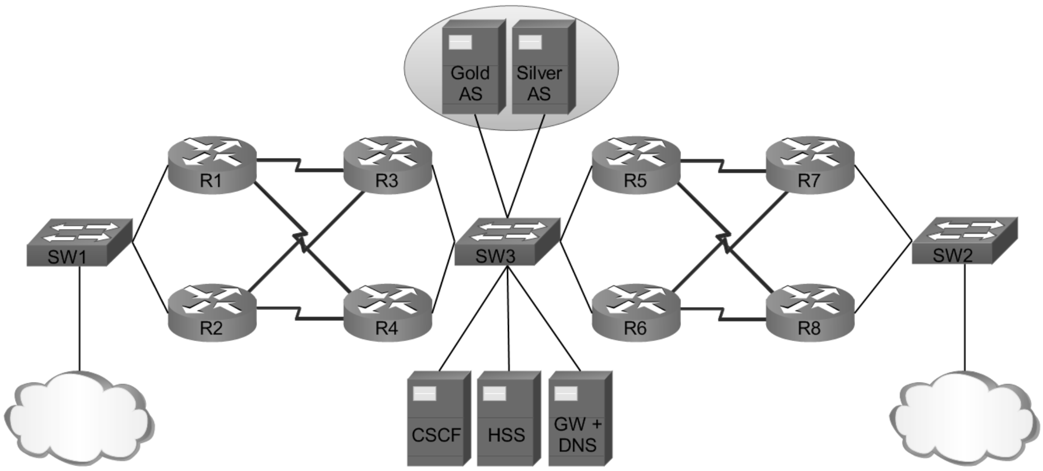

Figure 3. Our proposed prototype of general transit through SP.

We create 24 TE tunnels, 8 primary TE tunnels for gold customers, 8 backup TE tunnels for gold customers and 8 silver TE tunnels. The primary gold TE tunnels are from routers R1 to R3, from R2 to R3, from R7 to R5, from R8 to R5 and vice versa, because TE tunnels are unidirectional. These links will be used by silver customers: from router R1 to R4, from R2 to R4, from R7 to R6, from R8 to R6 and vice versa.

Links used by silver customers are also backup TE tunnels for gold customers. Therefore tunnels for gold customers and TE tunnels for silver customers share the same paths. For a better imagination see Figure 4. TE tunnels are situated from every redundant exit point to the network center, where we have the IMS core.

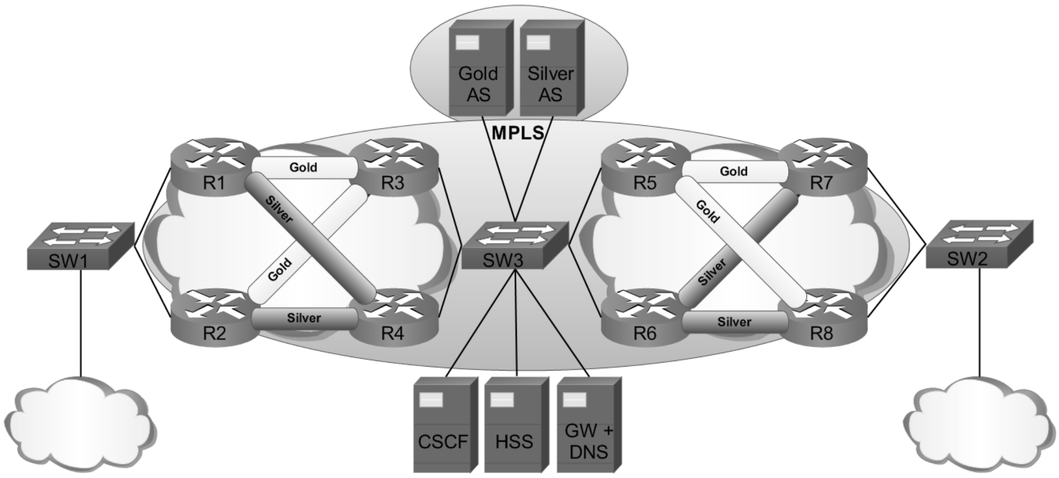

Figure 4. Our MPLS TE tunnel implementation in prototype topology.

We assume that on the exit points, the External Border Gateway Protocol (eBGP) will be configured. The primary TE tunnels for gold customers are placed in the routing table and backup TE tunnels are not signaled yet. All the TE tunnels, for gold and silver customers, are placed in the routing table via a dynamic routing protocol, in our case via the Integrated Intermediate System to Intermediate System (IS-IS) protocol. When the primary TE tunnel for gold customers fails, prescribed backup TE tunnel will be signaled and created. Convergence time is a little bit longer, because a backup path must be created and demands must be signaled first. Protection or fast reroute options are other options, but they are not widely implemented and are not supported in our devices. Their convergence time is much shorter.

Because of the limited bandwidth on the links, it is possible that the backup TE tunnel will force out the TE tunnel for silver customers, if the required constraints of the links are not satisfied. When the primary path renews, the backup path is shut down and traffic flows return to prescribed paths.

For the purpose of monitoring and managing available bandwidth on the links in MPLS environment, we are using a 3rd party external tool. This tool interactively changes the requirements for bandwidth demands for TE tunnels, thus having sufficient reserved bandwidth at all times. It is imperative that real time traffic flows in MPLS [5] receive required bandwidth and therefore monitoring is essential.

4 IMS Core Implementations

Our IMS network is based on an open source project called Open IMS Core. The implemented network consists of several separate physical machines, each running an unique service used to guarantee control over existing sessions or executing other tasks related to IMS architecture functionality. These individual parts of the IMS core network can be seen in Figure 2.

The CSCF machine provides session control functions within our IMS domain. It is built using an open-source SIP Express Router software (SER). Combined with the HSS these two components form the core of our IMS network.

The HSS machine's software is implemented using an open source MySQL database and a Diameter server created using the Java programming language.

The Application Servers (AS) are primarily based on SER. For hardware requirements reduction, multiple Application Servers are running on one physical machine. Due to this setup, AS instances are separated by using several IP addresses on this one physical machine, with one address for each individual Application Server.

The Gateway + DNS machine provides DNS services and other supportive tasks required by both network subscribers and the IMS core.

QoS provisioning in our network can be done in numerous ways. In our solution, we focus on providing QoS for RTP streams using two main tools.

Firstly, a RTP stream for each call is processed by a special Application Server called Gold AS and Silver AS. These ASs are responsible for modifying the contents of the SDP protocol fields in individual SIP INVITE messages, so that all parties included within a dialog send RTP not directly, but through these AS servers. The destination IP of RTP packets for such dialogs origination from our subscribers will therefore contain the IP address of the AS and thus the SIP User Agents will not communicate directly with each other.

Secondly, each customer has a specific service profile (IMS user profile) depending on the required level of QoS. These profiles are sets of conditions and destinations for incoming SIP messages. Based on the caller and the requested service, we can specify AS to handle session creation and management. Using two unique AS (Gold and Silver), one for each customer class, we can distinguish and classify user traffic based on the unique source or destination IP address of our AS in the RTP packet. Since our network offers two types of customer classes along with best effort, we have two AS instances attached to two different service profiles.

Using this method, we are able to provide several different levels of QoS guarantees by simply provisioning different service profiles for customers with a different customer class.

5 Conclusions

In this paper, we have briefly explained MPLS Traffic Engineering solution with regard to prioritize QoS differentiated multimedia traffic by defined IMS core customer classes. The testbed was created for simulation of transit service provider which was able to provide gold, silver and best-effort priority customer classes based solely on IMS user profiles. By using a combination of MPLS Traffic Engineering and IMS with several application servers acting as RTP proxies for voice calls, we were able to make the whole MPLS backbone recognize these customer classes. Consequently, the network is able to provide QoS management using MPLS Traffic Engineering tunnels with various priorities. This setup allowed us to create scalable and sustainable solution for providing price adequate priorities to different customer classes based on IMS user profiles.

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