SIP-Based QoS Management Framework for IMS Multimedia Services

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Abstract
IP Multimedia subsystems are true integration of multimedia services over converged networks to increase the productivity and quality in Next Generation Network architecture. IP Multimedia subsystems are specifically designed to provide the QoS provisioning for multimedia services. In this paper, we study the SIP-based QoS Management architecture and its experimental evaluation for IMS services using SIP based proxy Modules to support the QoS provisioning and to reduce the hand off disruption time over IP access networks. In our approach these modules utilize the DiffServ and MPLS QoS mechanisms to assure the guaranteed QoS for real-time multimedia services. MPLS provides routing techniques and network resource optimization methods while DiffServ provides standardize QoS mechanisms for end-to-end QoS provisioning. To differentiate IMS network, this architecture also enables QoS provisioning for IMS roaming users. To validate our approach, numbers of experiment models are developed on short scale basis. The evaluation of architecture shows that proposed QoS approach improves delivery of IMS services over heterogeneous IP access networks.

Key words:
SIP, QOS, IMS, Multimedia Service

I. INTRODUCTION

IMS is a flexible, packet-based network architecture consisting of an IP-based core network connected to multiple access networks that allows the network operators to provide a converged multimedia services over wireless or wireline networks[3][4]. IMS is an umbrella framework developed by 3GPP [5]. The Original scope of 3GPP was to develop specifications for 3G UMTS but later, scope was amended by including additional networks such as GSM & CDMA cellular networks, cable TV networks, WiFi, WiMAX networks [4][5].

QoS requirements for multimedia applications are intrinsically different from simple network applications [1] as multimedia services require more bandwidth and lossless delivery. IP network treat all traffic in same manner but these networks must have some mechanism to reach the correspondent for communication [13]. Network degradation occurs during the transmission of multimedia traffic over common IP networks due to the restrictions imposed by different access technologies.

IMS architecture also enables the integration of services in a single session and this integration of multimedia services requires additional network resources such as bandwidth, minimum delay and efficient delivery of contents. IMS policy-based QoS mechanism provides the QoS mapping between IMS core networks and underlying access networks but these QoS parameters are renegotiated when user change its point of attachment. QoS provisioning and hand off disruption management are essential for multimedia services to maximize the IMS connectedness with underlying IP access networks specifically for roaming users. IMS 3GPP QoS architecture does not provide any mechanism to exchange SLAs between heterogeneous domains [12]. QoS Management over IMS access networks should be addressed seriously for the efficient delivery of multimedia services because of the increasing demand of multimedia applications such as VoIP, video conferencing and video streaming.

To resolve the mobility and QoS provisioning issues in IMS networking infrastructure, SIP-Based QoS Management Architecture is proposed which improves the reliable delivery of IMS services through SIP-Based Proxy QoS Modules and provides strong communication between core and IP access networks. This QoS management architecture uses SIP QoS modules which implements the standardize QoS techniques. Both DiffServ and MPLS enhance the QoS capabilities on IP networks [17]. The introduction of SIP-based QoS proxy modules make possible to achieve the desired QoS for IMS traffic over heterogeneous IP networks. These QoS modules are based on SIP protocol: a session negotiation protocol provides service connectivity and continuity. To provide advancement in multimedia services delivery, these SPQMs use SCTP protocol because several independent chunks of data can be transferred at once.

The paper has been structured as follows. The brief introduction of IMS is presented in section II. Section III discusses the QoS issues in IMS underlying access networks. Section IV and V describes the related works and SIP-Based QoS Management Architecture respectively and finally section VI draws the experimental results of Model and its validation.

Manuscript received May 5, 2010
Manuscript revised May 20, 2010

II. IP MULTIMEDIA SUBSYSTEMS

IMS is the next generation telecommunication infrastructure designed to provide end-to-end QoS. The primary goal of IMS evolution is to provide the guaranteed QoS to users according to the bandwidth and delay requirements of multimedia applications [23].

The IMS was primitively designed to be access-independent. IMS scalable service platform allow the rapid delivery of multimedia services over any IP connectivity networks. The basic requirement of IMS user to access multimedia services is IP connectivity which can be either obtains from home network or visited network [13]. The IMS architecture includes a service framework for providing the essential capabilities to multimedia applications and also implements a layered approach in architectural design so that transport and bearer services can be separated from IMS signaling network and session management services. Figure 2 depicts the functional blocks of IMS architecture as defined in [1]. The main functional element in architecture is Call Session Control Function, handled by three SIP signaling servers. These signaling servers are Proxy CSCF, Interrogating CSCF and Serving CSCF [25]. To reach the correspondent of communication IMS architecture implements the Policy-Based QoS mechanism to guarantees the required QoS. The figure1 represents the policy based architecture used by IMS.

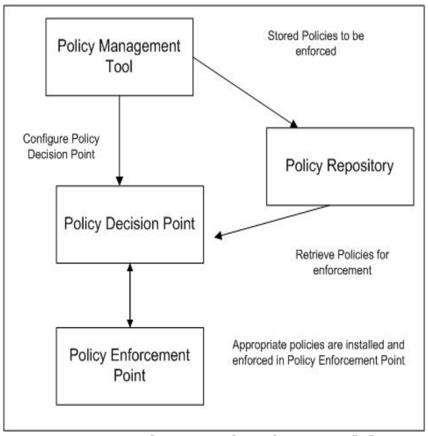

Figure1: Policy Based Architecture [5]

IMS is primarily an enabling technology that does not implement any end-user application but provides standardize platform to turn on these multimedia services and allow operators to build and launch their new services [3]. IMS provides the combination of existing telecommunication services and IP-Based services such as SMS, MMS, video conferencing and web browsing [24]. IMS architecture implements 3GPP2 Policy-Based QoS architecture to ensure guaranteed QoS [1]. Both 3GPP and 3GPP2 authorize DiffServ as primary QoS mechanism because DiffServ is more scalable than IntServ [26]. IMS QoS architecture includes two functions for QoS authorization Policy Decision Point (PDF) and Policy Enforcement Point (PEP). For QoS provisioning in IMS architecture GGSN serves as Policy Enforcement Point and maps the higher layer QoS parameters to layer-2 parameters and PDF on P-CSCF servers as Policy Decision Point [26]. For policy decision and media authorization, PDF employs SBLP in IP-bearer layer [1]. P-CSCF adds authorization token in SIP header and UE use this token to reserve resources according to the multimedia session information. PEP and GGSN negotiate with PDF to create PDP context and reserved the required resources. The comprehensive IMS Architecture is described in [1].

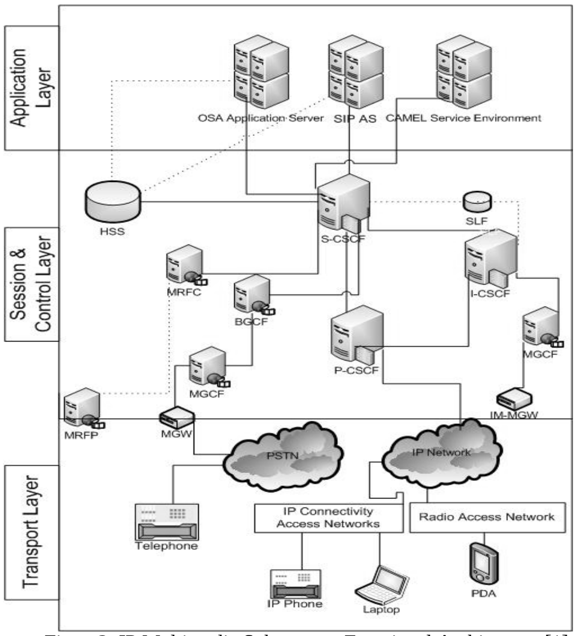

Figure2: IP Multimedia Subsystems Functional Architecture [1]

III. QOS ISSUES IN IMS

Heterogeneous networks are composed by different ISPs: each ISP has SLA to negotiate QoS among IP users [12]. A fundamental requirement of IP Multimedia Subsystem is that a device has IP connectivity to access multimedia services. IP connectivity can be obtained either from the home network or the visited network [13]. IP Multimedia subsystems enables the efficient provisioning of highly integrated multimedia services over heterogeneous networks [12], but unable to provide the guaranteed QoS for roaming users over heterogeneous access technologies. Because visited domains and mobile users have no mapping mechanism to ensure the QoS. There should be an inter-domain mechanism to ensure the QoS and reliable delivery of critical multimedia applications for roaming users. End-to-end QoS architecture of IMS (provided by 3GPP and 3GPP2) does not accomplish the QoS requirements for roaming users in different domains. Mobility and QoS management are essential for multimedia applications for the success of NGN Networks and should be addressed properly. When a number of servers involved in signaling session IMS also bears scalability issues [5]. Also IMS should have some routing mechanism to resolve the load balancing issues and scalability problems.

IV. RELATED WORKS

IMS provide convergence of real time multimedia applications that demand high resources and guaranteed QoS. Numerous solutions have been proposed to ensure the QoS in Multimedia systems. In IMS a Set-Top-Box (STB) is used as an end device which provides the feed back of ensured QoS to IMS architecture. This technique ensures the guaranteed QoS by providing the centralized network control for multimedia users [6]. A centralized QoS Manager is proposed in [12] for decision-making. For critical multimedia applications this centralized manager provides the mobility integration to ensure the QoS. Shun-Ren Yang and Wen-Tsuen Chen [Nov, 2008] has proposed a new SIP multicast-based mobile QoS architecture to reduces the handoff disruption time between roaming users over heterogeneous networks [6]. A comprehensive QoS reservation model preserves the service agreements without degrading the QoS for multimedia users.

SIP extensions [8] are introduced to control QoS for hybrid access and UMTS core networks. In this QoS Mechanism, border proxies' negotiate the QoS for users by adding contexts during registration. Alexander A. Kist and Richard J. Harris provide a QoS provisioning framework for SIP signaling by using the virtual SIP links in advanced carrier evaluation networks [9]. E. Lopes Filho, G. T. Hashimoto, P. F. Rosa PhD has investigated the SIP protocol over SCTP, UDP and PR-SCTP and conclude that PR-SCTP is the distinctive SIP protocol where service degradation and congestion is advantageously negotiated and they proposed that IMS architecture deploys best over SCTP and (Partial Reliability Extension of Stream Control transport protocol) PR-SCTP [10].

In [11] the issues in managing QoS over mobile wireless networks are discussed and proposed a new architecture for managing QoS by introducing the mapping mechanisms for heterogeneous networks. This architecture uses the AQM for wireless entities in access networks and IAQM mechanism for negotiating the QoS parameters in inter-system handover to control QoS over heterogeneous networks.

V. PROPOSED SIP-BASED QOS MANAGEMENT ARCHITECTURE

IMS provide the convergence of multimedia applications over IP-Based networks and implements the 3GPP QoS architecture for QoS provisioning over IP networks [1]. But 3GPP QoS architecture does not provide any mapping mechanism to exchange SLAs between heterogeneous domains [12] and thus introducing hands off disruption time and network degradation.

SIP-Based QoS Management Architecture improves the reliable delivery of IMS services through SIP-Based Proxy QoS Modules and also improves the communication between core and IMS access networks. To manage QoS in underlying access networks these modules implement the Diffserv aware MPLS techniques for the efficient delivery of real-time multimedia services. Diffserv and MPLS enhance the QoS provisioning capabilities on IP Network [17].

SIP Proxy Modules monitor the network to ensure the end-to-end QoS by using MPLS and Diffserv routing schemes. DiffServ & MPLS fulfill the user demands of consistent QoS provisioning for the multimedia services. MPLS Traffic Engineering alleviates the efficient and reliable network operations while at the same time optimizing network resource utilization and traffic performance.

The SIP-Based QoS management architecture is shown in figure 3. The IMS User must have IP connectivity which can be obtained either from home network or visited network [13] to access the IMS services. UE requests required resources from IMS core network using SIP and SDP protocol during session establishment and in access networks SIP proxy Modules provides the desired resources for user applications.

SPQMs communicate with the IMS access networks and transport networks for end-to-end QoS provisioning. These SIP modules treat the SIP traffic received from IMS core network or SIP Module and forward data to next available module or IMS network. MPLS and DiffServ [14] routing mechanisms are used in SPQM. To support DiffServ over MPLS, packets need to get the proper QoS at each LSR in the network. To manage QoS in MPLS aware DiffServ networks, our architecture uses the modification of LDP.

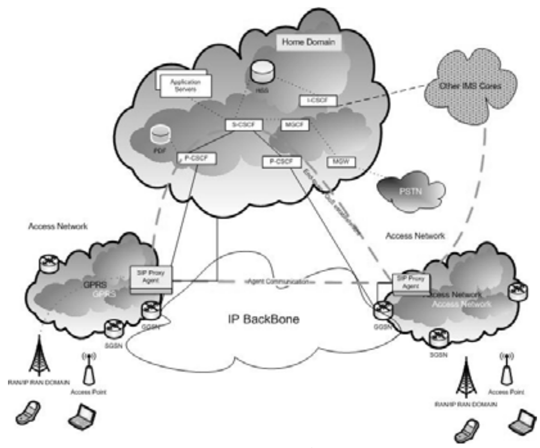

Figure3: SIP-Based Architecture for QoS Management [1]

A. *SIP-Based Proxy QoS Modules (SPQMs)*

QoS provisioning tasks for IMS services over access networks are performed by SPQMs. SPQM receives SIP traffic over IP access networks from the IMS network and requests the network resources by tracking the available resource information for particular session [1]. QoS provisioning in SPQMs is multi-party service negotiation mechanism in which SPQM on both neighbor Access Networks collectively decide end-to-end efficient service delivery. DiffServ and MPLS QoS mechanisms are used to ensure guaranteed QoS [14] for multimedia applications as MPLS is independent technology from underlying access technologies. MPLS performs the traffic engineering by distributing SIP traffic load on all available links instead of using the same route and decrease the handoff disruption time and make effective resource utilization. For differential treatment of SIP traffic of IP Multimedia Subsystems over access networks SPQM implements QoS routing protocols (extensions of OSPF) to support QoS Routing. Link State Advertisement (LSA) gives the available bandwidth on a link [14].

B. SPQM Architecture

SPQMs architecture is composed of two functions.

- SIP-based QoS Monitoring Function
- SIP-based QoS Control Function

1) SIP-based QoS Monitoring Function

Update link state information is used in monitoring function to examine the IMS SIP traffic over access networks. It also maintains identifiers for routing purposes in MPLS aware DiffServ network. To monitor congestion in network these modules maintain information about available bandwidth, transmission delay and also use identifiers for routing mechanism. QMF monitors the network for troubleshooting and also issues commands if any degradation occurs in network.

2) SIP-based QoS Control Function

The routing mechanism used to control the QoS provisioning over access networks is shown in table 1. The two methodologies used for QoS provisioning in SIP modules are:

- Differentiated Services
- Multi-Protocol Label Switching

a) Differentiated Services

Heterogeneous multimedia applications require service differentiation to fulfill the user expectations [18]. DiffServ provide preferential treatment to data packets in order to satisfy the performance requirements of users defined in SLAs. The edge routers classify the data packets into traffic classes and these classes have different service and priority levels. The DiffServ framework defined by IETF provides different levels of delivery services for differentiated traffic flows [20].

Numbers of functional elements are composed to provide per-hop forwarding behaviors, packet classification and traffic conditioning function [18]. Edge routers receive the incoming packet in DiffServ domain and classify packets in order to find there associated SLA. The packet is reshaped or dropped in over-sending situation [22].if packet is not dropped, it is marked with DSCP to determine the Per-Hop-Behavior and then routers store and forward the packet using the appropriate scheduling and queuing mechanisms to core routers .Core routers identify PHB by DSCP. DiffServ uses three forwarding techniques i.e Best Effort, Assured and Expedited Forwarding.

b) Multi-Protocol Label Switching

MPLS is a label swapping technology in which fixed-length label is attached to every packet entering the network [15]. Labels are locally significant identifiers to identify the streams of data [21]. In conventional networks, all routers make an independent decision to route the packet and ordinarily follow the shortest path but in MPLS, first router decides the entire path of packet. MPLS provides the feasibility of implementing the traffic engineering and move the heavy processing to the edge routers. Edge Routers classify and label the packets and interior routers just perform label lookup and swapping [21]. Label stack is used to place several labels.

In MPLS network, packets enters through the edge routers that contain FEC. Forward Equivalence Class specifies the packet forwarding sequence. After classification of FEC, label is assigned to the packet and forwarded to the next LSR LSR looks up the label and swap it with the label associated to that FEC [21].Label look up and swapping procedure continue until the last router remove the label (shim header) and forward packet to host or next router in adjacent domain by looking up the IP header of packet [5]. The path through which a labeled packets traverse is called Label Switching Path (LSP) [22].MPLS even allows the path establishment in the architecture which operate in disconnected mode [16].

c) MPLS and Traffic Engineering

In conventional IP networks, congestion control is complicated as common gateways always choose shortest path for data transfer [18]. Traffic engineering solves the congestion problem by selecting the less congested paths instead of the shortest paths. Traffic engineering in MPLS networks provides a predefined path for packet forwarding, being established between routers [15]. Traffic Engineering can be stated as the mapping of traffic flows onto existing physical topologies [18]. To avoid congestion and utilization of network resources, traffic engineering balance the traffic load on various links. The performance goals of traffic engineering are categorized as resource or traffic oriented [5].

VI. IMPLEMENTATION & EXPERIMENTAL EVALUATION

The aim of this simulation is to evaluate the QoS management architecture over IP Multimedia Subsystems to provide desired QoS for the IMS multimedia traffic over IP access network so that the SIP-based QoS routing modules can achieve predictable QoS results [1]. The environment consists of ns-2 network simulation software in Linux operating system. The results obtains from simulated model are being compared with the existing QoS architecture. Two common multimedia applications (Data, voice) are being used to simulate the architecture.

A. Simulation Experiments

In this section, the simulation experiments are described, used with MPLS and DiffServ QoS mechanisms and to compare the simulation scenarios with simple network without SIP QoS Modules. Moreover, we present results that depict the improvement in network efficiency due to improved bandwidth sharing in SIP QoS Modules compared to general QoS Models in IMS. We conduct a set of experiments and compare the QoS results and the total bandwidth utilization under various scenarios. These statistics depict a realistic representation of an IP Multimedia Subsystem's goal of providing best QoS, keeping in view the applicable rules for multimedia traffic and bandwidth utilization. Moreover, it is important to consider the bandwidth associated with the accepted multimedia requests since it is possible for a less efficient scheme to accept a large number of small bandwidth requests compared to a more efficient scheme which accepts fewer requests which comprise a greater amount of bandwidth.

QoS routing algorithm proposed in [1] is used for simulations; the algorithm proposed therein for the computation of bandwidth and utilization of paths is integrated with these QoS modules. The simulation experiments are conducted on a SIP network topology for IMS. The computation of primary and QoS routes for a multimedia request depends on the simulation scenario. In case of SIP, for each request, if it is possible to route the requisite according to the QoS requirements, then the request is immediately accepted; otherwise another attempt is made to place the request by calculating the other routes, failure of which results in the rejection of QoS request.

TABLE1: SIP-QOS-ROUTING FOR QCF [1]

Algorithm: SIP-QoS-Routing for IMS

% New SIP Session for IMS Core
while (QoS request == available) do
if PDF (Yes)
Process User Request for Multimedia Services
end while
% IMS traffic over Access Networks
a) IMS Packets arrives at the IP Access Network
While(packets== SIP)
Enable SIP-QoS Module
• Remove Packets header
• Insert SIP-QoS header
Else Process other packets
b) Compute the shortest path between two nodes
c) Process SIP Packets to next SIP module
d) Update the link state information.
end while
Else Process Other available data

The Table1 shows the routing Mechanism for IMS SIP traffic over Access Networks. IMS network allows services to users when user QoS requests are accepted according to the available resources and When SIP data arrives at the Access network, the SIP Modules are enabled for SIP traffic, then these modules handle that traffic by providing the best path utilization and required resources to data. When both SIP and other data arrives at these modules, it gives priority to the SIP traffic and then process the other available data.

1. Scenario1

In this Scenario, the Access network contains the nine routers to process the network traffic and data. The Links between theses routers are expressed in three bandwidths i.e 1MB, 2MB and 3MB. When source sends SIP data to destination, the route established between these routers are different in all the three times according to the available paths and resources. IMS SIP traffic is processed through the SIP LSPs. These SIP LSPs implements the QoS Module and process the SIP traffic for best QoS. The LSP routers establish different paths for traffic but after applying the QoS on these LSPs efficient and effective utilization of resources is achieved. After SIP QoS negotiation, SIP Modules Performs the Marking, Policing and Shaping on the incoming SIP packets [14]. QoS Modules calculate unreserved and available Bandwidth between nodes in established path.

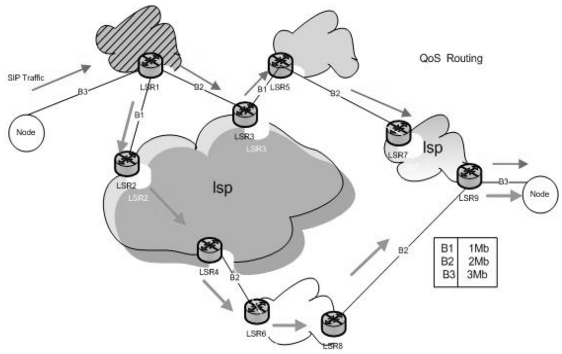

Figure4: Simulation Scenario1

A. Route establishment

First route established for SIP Traffic is 1_3_5_7_9 for traffic1. The link bandwidths are B2, B1, B2 and B3. The second path established for SIP traffic 2 is 1_2_4_6_8_9 for traffic 2 after calculating the available bandwidth and 2nd route is established. Similarly 3rd route is established 1_3_4_6_5_7_8_9 for traffic 3.

B. Observations

It is observed that when the links are available for processing traffic, the route is established in minimum time and it processed data efficiently. After resource reservations the other paths takes more time to establish routes. 1st route establish the shortest path for packet traversing but after that it also traverses the SIP packets for unreserved path and available bandwidth.

C. Analysis of Scenario1

The Table 2 shows the simulation results for the scenario 1. The totals Number of SIP packets sent by the source and received by the destination include the session establishment packets and also data packets. The Average throughput for SIP data is 87% and link utilization is

99.64%. This shows that the number of packets lost in this case are minimum as resources are available for data.

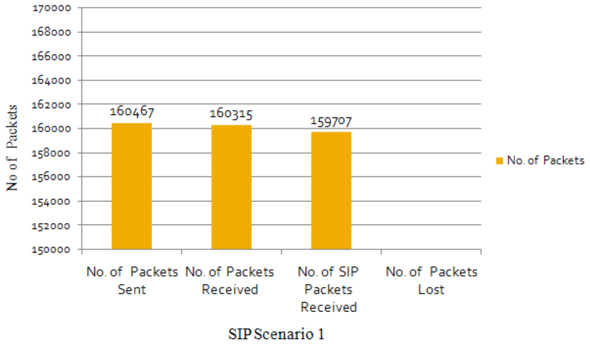

Figure5: Analysis of Scenario1

2. *Scenario2*

Simulation Scenario 2 contains the two SIP Servers that receive the SIP data from IMS core Network. The aim of this simulation is to send SIP data from IMS core to Other IMS core network through SIP QoS Modules implemented on access networks. The network contains the four routers to process data on network. On these routers we enable the QoS Modules for SIP traffic. Both SIP Servers start sending traffic at time 1.06. This setup also contains the other sources for sending UDP data on same link. UDP Traffic Service starts at time 0. Voice and data is sent at same link for observing the performance of SIP QoS Modules for SIP traffic and UDP traffic.

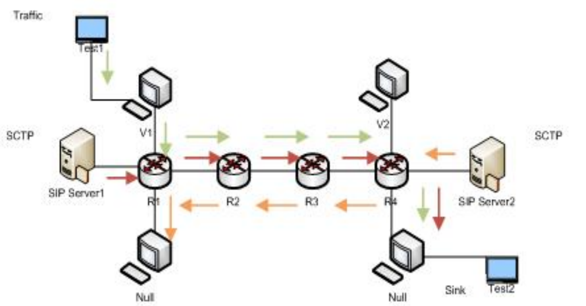

Figure 6: Sample Simulation Topology

A. *Route establishment*

Both SIP servers start sending data to sink at 1.09ms through the access network [IP Backbone], and the UDP server starts its traffic at time 0 ms. Route establishment for SIP Traffic is shown by figure 6. The link bandwidths are 255MB for each router. The traffic flow for UDP traffic path established is also shown in figure.

B. *Observations*

It has been observed that when the links are available for processing traffic, the route is established in minimum time and it processed UDP data efficiently. But when SIP servers start sending data the QoS Modules prioritized the SIP traffic as compared to the UDP data. QoS Module also manages the bandwidth for SIP data traffic so it provides the best QoS for IMS services. Average throughput for bandwidth utilizations for SIP traffic is 92.39Kbps.

C. *Analysis of Scenario 2*

The Table2 also shows the simulation results for the scenario 2. The Total Number of SIP packets send by the source and received by the destination includes data packets for IMS Multimedia voice services and also UDP data traffic. The Average throughput for SIP traffic is 99.52% and link utilization is 99.90%.

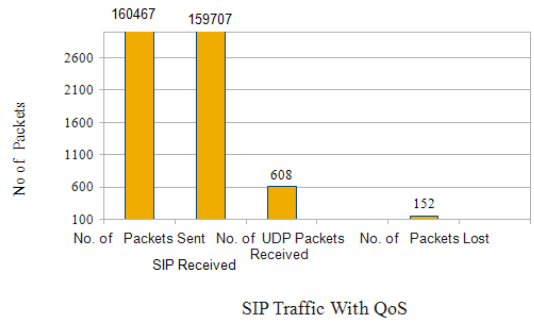

Figure 7: Analysis of Scenario2

Figure 7 shows the total number of packets sent, received, lost and SIP data packets reached to destination. This graph also represents the Total number of UDP packets processed by the network. The results show that these modules can provide better QoS services to the IMS SIP traffic as compared to the UDP traffic over MPLS and Diffserv network. Multimedia services require more resources as compared to the simple data traffic. Numbers of SIP packets traversed are more than the UDP packets. So the results show that SIP-Based QoS Modules are more efficient for transmission of multimedia traffic of IMS over IP Access Networks.

Table 2: Throughput for SIP Traffic with QoS SIP module

Packet output	Scenario1	Scenario2	Comparison data
Packets Received	10249	160315	1817
SIP Packets Received	9000	159707	153478
Packet lost	37	152	200
Average throughput	99.64%	99.90%	98.70%
Average Throughput of SIP Data	87.50%	99.52%	97.71%

3. *Comparative Analysis*

In this section we will compare our approach with simple QoS mechanism over Access networks. Table2 represents the results of SIP data processing over Access networks with SIP-Based Modules disabled and enabled.

Simulation results of simple QoS scenario show that the total number of UDP packets traversed by the network is more than the QoS enabled scenario. The average throughput of link is 97.71%. The Total number of packet lost is more as compared to the SIP-Based QoS scenario where packet lost are just 152.

A. Observations

It has been observed that the simple QoS provides the same services to all the traffic but multimedia traffic requires more resources for the efficient delivery of application. After implementation of QoS SIP modules, multimedia services acquire priority.

By comparing the both scenarios we conclude that the overall performance of SIP Data sent through QoS SIP Module provides better utilization of bandwidth and paths. These Modules not only use the available links but also utilize unreserved links. IMS traffic through SIP Module is now more valuable and well-organized.

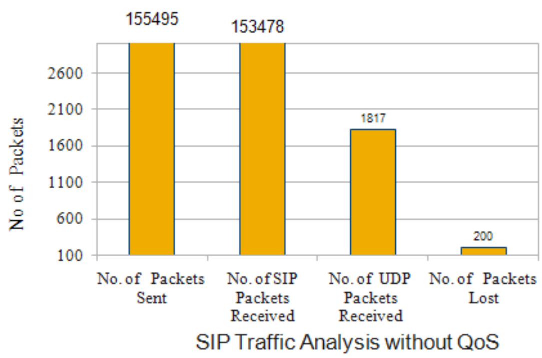

Figure 8: SIP traffic analysis without QoS

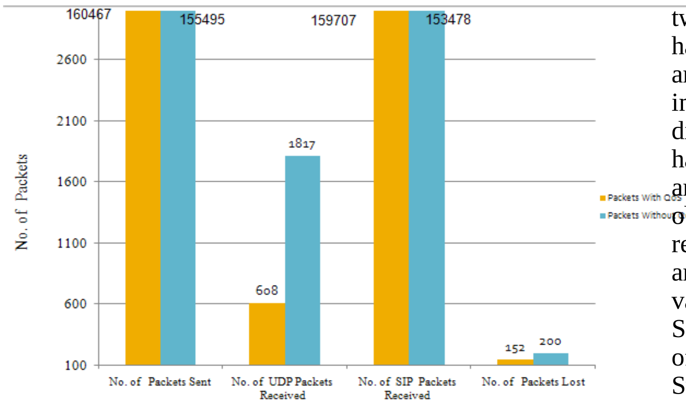

Figure 9: Comparison

4. Simulation Results

Scenario1 shows a case where only SIP traffic is present in the network from source to node destination and figure of sceanrio2 shows a case where UDP traffic and SIP traffic is present in the network from source to destination. The bandwidth used for network traffic is measured from the source to destination. It has been observed that UDP is getting negatively affected on a significant increase in SIP traffic. The overall performance of SIP Modules shows that SIP traffic with SIP modules provides the better performance as compared to the QoS disabled scenario. It has been observed that SIP module provides the best path and reduces congestion over access networks. The proposed architecture efficiently utilizes the available bandwidth over link.

Figure 9 shows the overall performance of SIP modules over different defined scenarios. The results show that the SIP QoS modules provide better performance in all the given scenarios. The modules give best results MPLS and DiffServ QoS mechanism.

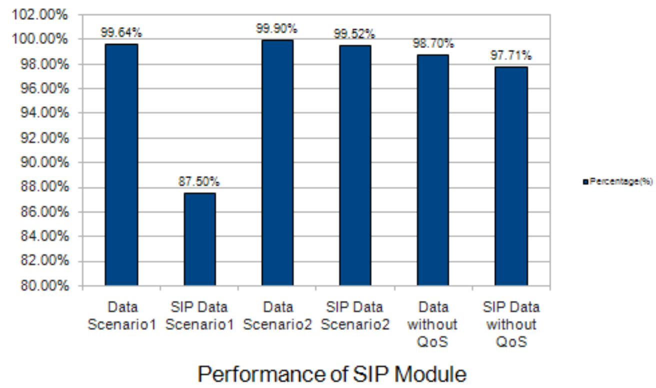

Figure 9: Performance of SIP Modules

VII. CONCLUSION AND FUTURE WORK

QoS Modules have been proposed for handling IMS data traffic with integration of Diffserv & MPLS in this paper. The performance of SIP modules has been checked using two different network Scenarios. The simulation results have shown that the performance of the proposed architecture is better in both scenarios due to implementation of SIP QoS modules. The Comparison of different architectures shows that the proposed architecture has provided better results as compared to existing architecture. Based on Simulation experiments, it has been observed that SIP module provides the best path and reduces congestion over access networks. The proposed architecture efficiently utilizes the available bandwidth on various links.

SIP based QoS Module can be further improved by the use of integration of Integrated Services, Multi-Protocol Label Switching, Resource Reservation Protocol and Differentiated Services mechanisms

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