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Performance Evaluation for Government Wide Area Network (GWAN) Over IP/MPLS

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Abstract- This work investigated and discussed the performance evaluation for Government Wide Area Network (GWAN) which is based on IP/MPLS. More recently, Internet Protocol (IP) networks are employing Multiprotocol Label Switching (MPLS) which is a technique that can be used to improve the performance of IP networks. By using MPLS, data packets can be switched around the network on the basis of labels rather than routed on the basis of destination address. MPLS technology makes it more appropriate for implementing multimedia applications such as voice, video and data. MPLS supports different features like Quality of Service (QoS), Virtual Private Networks (VPNs) and Traffic Engineering (TE) which is the key feature of MPLS. The aim of the study was to determine the resilience of GWAN under different MPLS network parameters such as jitter, packet end-to-end delay, delay variation, packet send and received.

OPNET modeller 14.5 was used as a tool to simulate the GWAN network. The study was carried out by employing voice, video and data traffic in both networks with same parameters. Results obtained are clear evidence that MPLS network gives more throughput and less delay than traditional IP network.

Keywords: Multiprotocol Label Switching (MPLS), Traffic Engineering (TE), Internet Protocol (IP), OPNET, Government Wide Area Network (GWAN)

I. INTRODUCTION

The Government of the republic of Zambia (GRZ) in the recent past adopted electronic government (e-government) to improve its service delivery. E-government refers to the use of Information and Communications Technology (ICT), and specifically the Internet, as a tool to achieve better government [1] [3].Most government around the world are implementing e-government and e-government has become a world phenomenon [1] [2]. To successfully implement e-government, certain pre-requisites have to be in place and a study by Bui et al [1] state ICT infrastructure as the most critical factor for e-government implementation. As part of the building block for e-government, GRZ established a nation-wide ICT infrastructure for the provisioning of high bandwidth connectivity between ministries and agencies for sharing voice, video and data communication throughout the country. This was done to improve the capacity of network traffic transmission

and expand internet coverage in ministry provinces and spending agencies (MPSA) thereby improving government efficiency and effectiveness. In 2012, GRZ embarked on a project to implement a nation wide area network called Government Wide Area Network (GWAN) to interconnect all the government ministries and agencies countrywide. This was in a bid to harmonize and consolidate internet services across the various individual ministries and agencies, which previously had independent internet providers. The government engaged Zambia Telecommunication Company (ZAMTEL) as the Internet Service Provider (ISP). The project was divided into three phases of which phase one was launched in October, 2014.

II. COMPARATIVE ANALYSIS OF IP AND MPLS NETWORK

IP/MPLS is a packet switched network that uses the transmission control protocol based on internet protocol (TCP/IP) enhanced with MPLS standard in networks. MPLS techniques are used to improve the performance of IP networks. In MPLS technology, a specific path is set up for a given sequence of data packets. These packets are identified by the packet label and not by destination IP address, thereby saving the time that a router takes to search the address where the packet should next be forwarded. [4] [6] [9]. MPLS has emerged as the key integration technology for carrying voice, video, and data traffic over the same network [8] [12] [8]. MPLS is not a replacement for IP but is an extension for IP architecture by including the new technology of attaching a label to data packets [7] [14] [16].

A. IP NETWORKS

IP is the first de facto network protocol used in Internet and is based on TCP/IP [5]. The main function of IP is to send the data from the source to destination [9]. Traditional IP networks are unsuitable for connection-oriented applications such as real-time applications. The IP was created as a connectionless network layer protocol that makes no attempt to discriminate between various application types [12]. It is very challenging to implement the real-time application like voice and video in the conventional IP network. IP mostly works on the best-effort service which does not guarantee the delivery of the services [10] [11] [13]. In IP networks datagrams do not follow a fixed path and may arrive at the destination out of order [12]. The main function of IP is to send the data from the source to destination [8] [12]. Data is constructed as a series of packets [13]. In traditional IP networks, routing protocols are used to distribute Layer 3 routing information. Regardless of the routing protocol, packet forwarding is based on the destination address in IP header of each packet. Data is sent in the form of packets and this is routed through a chain of routers and multiple networks to reach the destination [5]. Therefore, when a packet is received by the router, the router takes an independent decision on each incoming packet by determining the next-hop address using the packet's destination IP address along with the information from its own forwarding/routing table [8] [9]. IP network traffic uses Open Shortest Path First (OSPF) protocol which chooses the shortest path from source to destination [11] [13]. As a result, traffic is concentrated across a smaller number of optimized data paths to other links, which frequently remain underutilized [4]. All data flows arriving on various ingress interfaces on the same node that are bound for the same destination are always consolidated across a common path[6] [8] [9].One of the limitations of IP network is that it does not provide guarantee of quality of service, is not scalable and TE is difficult to implement [10] [11] [15] .

B. MPLS NETWORK

MPLS is the latest technology used for speeding up data communication over IP networks by forwarding packets based on labels [8] [10]. MPLS is currently applied to IP-based networks. MPLS technology is extremely beneficial to enterprises. MPLS simplifies the network infrastructure by allowing the consolidation of multiple technologies and applications such as voice, video and data [9] [17]. An MPLS based network consists of routers and switches interconnected via transport facilities such as fiber [12]. The MPLS labels are advertised between routers so that they can build a label-to-label mapping. These labels are attached to the IP packets, enabling the routers to forward the traffic by looking at the label and not the destination IP address. The packets are forwarded by label switching instead of IP switching [7]. The label switching technique is not new. Frame relay and ATM use it to move frames or cells throughout a network. MPLS incorporates a variety of protocols such as IP, Frame Relay and ATM. [6] [8] [11]. MPLS has become popular because of the label switched technique that reduces in overhead information. To enable smooth communication, time taken for packet forwarding or processing plays a vital role [10]. The key feature of MPLS is its Traffic Engineering (TE), which is used for controlling the congestion and managing the networks resources [4] [8]. MPLS provides high speed packet switching, forwarding and great scalability and in addition to this, MPLS provides various features such as Quality of Service (QoS) and Virtual Private Networks (VPNs) [8] [11]. According to vein et al [13] the

premise of MPLS is to attach a short fixed-length label to the packets at the ingress router of the MPLS domain. MPLS works well with real-time applications due to lower network delay by providing efficient forwarding mechanism, scalability and predictable performance of the services. MPLS technology makes the most appropriate tool for fulfilling connection oriented traffic and allows for traffic engineering and bandwidth guarantees (QoS) [6] [9]. MPLS is not a replacement for IP but it's an extension for IP architecture by including new functionalities and applications [8].

III. LITERATURE REVIEW

The use of MPLS in Wide Area Networks for enterprise corporations is expanding. Most service providers are adopting MPLS to improve the network performance for its customers. Research cannot reach its goal without literature review and selection of papers. Selection of papers on works related to MPLS has been done and are reviewed in this chapter.

Jannu and Deekonda [5] looked at OPNET simulation of voice over MPLS with considering traffic engineering. The study used voice packet end-to-end delay performance metric as an approach to estimate the minimum number of VoIP calls that can be maintained, in MPLS and conventional IP networks with acceptable quality. Comparative analysis was done on conventional IP network and MPLS network. Some performance metrics such as voice jitter, voice packet end-to-end delay, voice delay variation, voice packet sent and received were used for simulation. The results analysed showed that MPLS based solution provides better performance in implementing the VoIP application.

Abdel-Azim et al [6] studied MPLS performance evaluation by comparing VOIP and VOMPLS. In their study they used OPNET 14.5 to simulate the results .They started by looking at the signalling protocols for IP networks and MPLS. Session Initiation protocol (SIP) was used for VOIP and Constraint based routing (DR-LDP) which supports TE was used for VOMPLS. The study revealed that according to ITU voice performance is measured based on different parameters like delay, jitter and packet loss. Two scenarios were set up, one for sending voice using SIP-based IP network and the other model using LDP-based MPLS. Results from the two scenarios proved that VOMPLS has greater performance as compared to VOIP which causes some delays in the transmission.

Ezeh et al [7] investigated and discussed the performance of Multimedia traffic (Voice, Video and data) over multiprotocol label switching (MPLS) on Internet virtual private network (VPN) cloud. In this work, the performance of multimedia traffic over MPLS VPN Internet was carried out while making comparison with the conventional Internet Protocol (IP) network. Analytical models for capacity management and on-demand optimization was developed. Various system models with a LSP flow algorithm were derived. OPNET IT guru was used to simulate both networks and the comparison was made based on the metrics such as Point to point Throughput (bits/secs), end-to-end delay (secs) and results showed that MPLS based solution provides better performance in implementing the VoIP application.

Porwal et al [8] conducted a study on multimedia traffic analysis of MPLS and non MPLS network. The study compared two scenarios by evaluating IP network without traffic engineering and MPLS network with traffic engineering. In IP networks the protocol OSPF was used and it showed that the use of OSPF in IP networks causes congestion since most links on the network are under-utilized. In MPLS network with traffic engineering is used for effectively managing the networks for efficient utilization of network resources and thus improves network performance for multimedia type applications in heavy traffic environments.

Cyril [9] studied performance evaluation of multicast transmission on MPLS network using Protocol Independent multicast-sparse mode (PIM-SM). In this study a simulation tool called Ns2 was used for performance evaluation. The following parameters were used in the configuration: Simulation time: 10ms Access-link bandwidth: 1.5 Mbps Access-link delay: 10 ms Packet size: 1460 (in bytes) Queue management: Drop Tail in the access link. Total Simulation time was considered 10 unit times. The analyses looked at packet delivery ratio (PDR) and normalized overhead (NOH). The PIM-SM over MPLS network was found to have an edge over the traditional network. The throughput for MPLS with PIM-SM was very much higher in comparison to traditional network. Excellent packet delivery ratio was found in MPLS with PIM-SM as against traditional networks. Also the percentage of dropped packets was substantially reduced. The results aslo proved that MPLS over PIM-SM require smaller congestion window size.

IV. SIMULATION TOOL

Simulation is the process of testing a designed model on a platform which imitates the real environment. It provides the opportunity to create, modify and study the performance of proposed design so that one can predict its strengths and weakness before implementing the model in real environment. The OPNET Modeller has been used to perform the simulation on MPLS and traditional IP network [11] [12].

A. OPNET Modeller

OPNET provides several modules for the simulation comprising a vast universe of the protocols and network elements [8]. It has gained popularity in academia as it is offered for free of cost to institutions and it is also obtained as a student version. The user doesn't need to have any programming knowledge in order to use OPNET; the user can directly concentrate in building and analysing model from simulation. The main feature of OPNET is that it provides various real-life network configuration capabilities that make the simulation environment close to reality [5].The advantages of OPNET compared to other simulators include GUI interface, comprehensive library of network protocols and models, graphical interface to view the results, availability of documentation for the user to develop the network models.

B. Simulation Methodology

To evaluate the performance for GWAN over IP/MPLS network, we have used OPNET Modeler 14.5 to create the topology as shown in Fig.1 and Fig. 2 for both traditional IP and MPLS networks. The simulations consist of two scenarios based on the same network topology. Performance parameters such as jitter, packet end-to-end delay, delay variation, packet send and received are employed in both network scenarios. For MPLS network the routers are MPLS enabled while as for Traditional IP network model MPLS routers are replaced with normal IP Routers which doesn't support MPLS technology. The results from these simulations are used for comparison between the two networks.

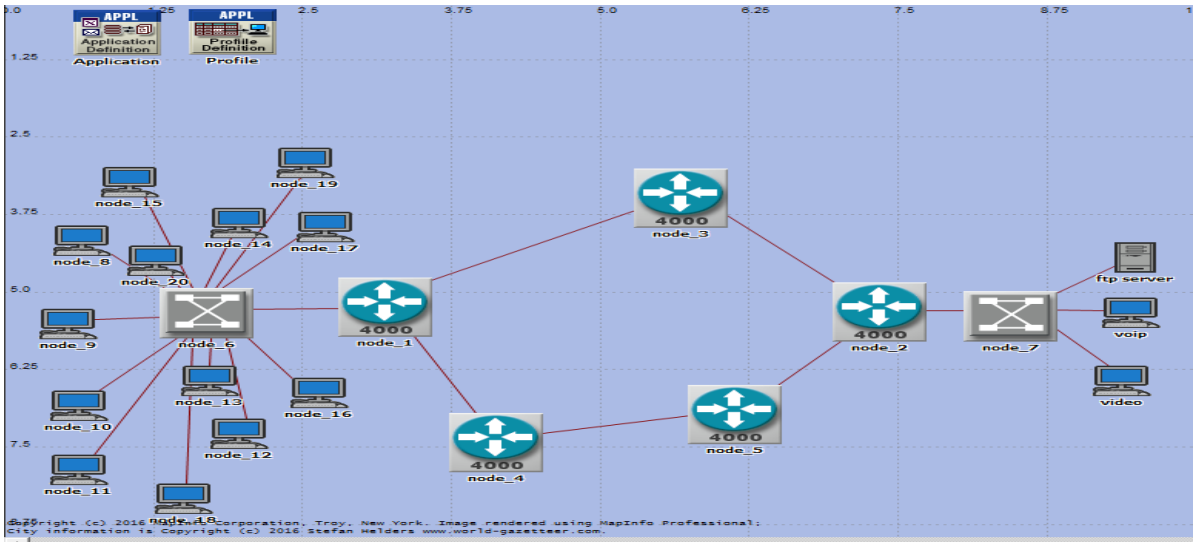

Figure 1: Traditional IP simulation Network

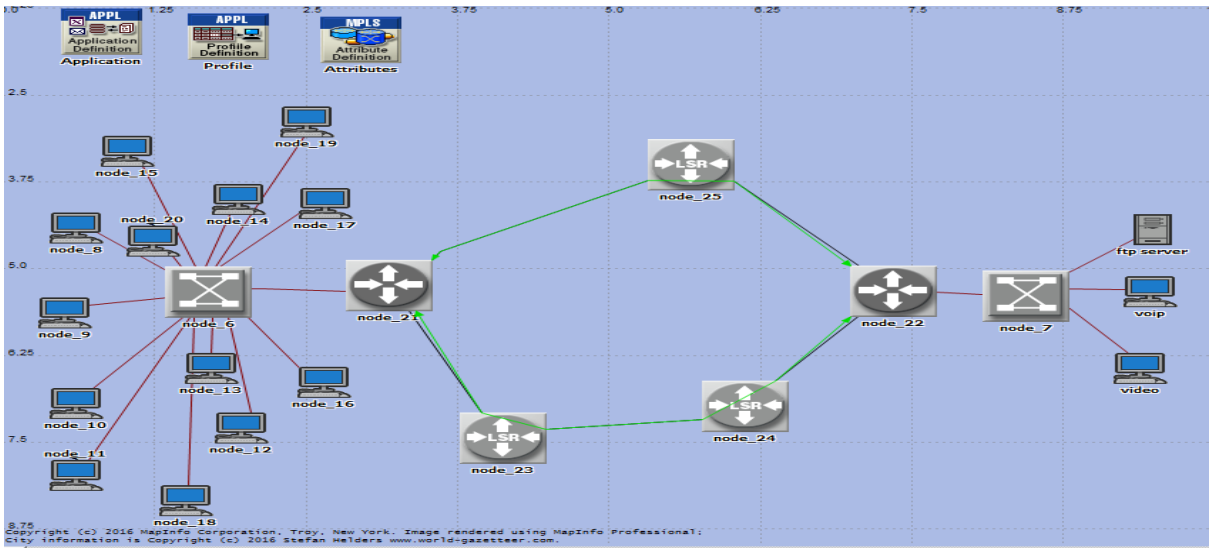

Figure 2: MPLS simulation network

V. ANALYSIS AND RESULTS

For each scenario the duration of simulation is 600 seconds. In the simulation the traffic starts at 100th second and ends after 600 seconds. (100 second is considered because in the simulation, the start time of traffic application from source to destination is at 100 second).

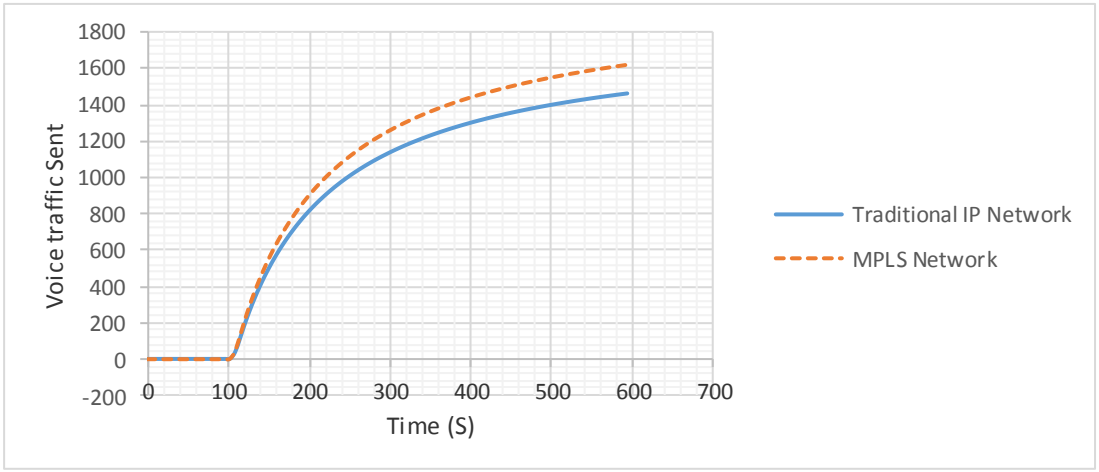

Figure 3: Voice traffic sent (packet/sec)

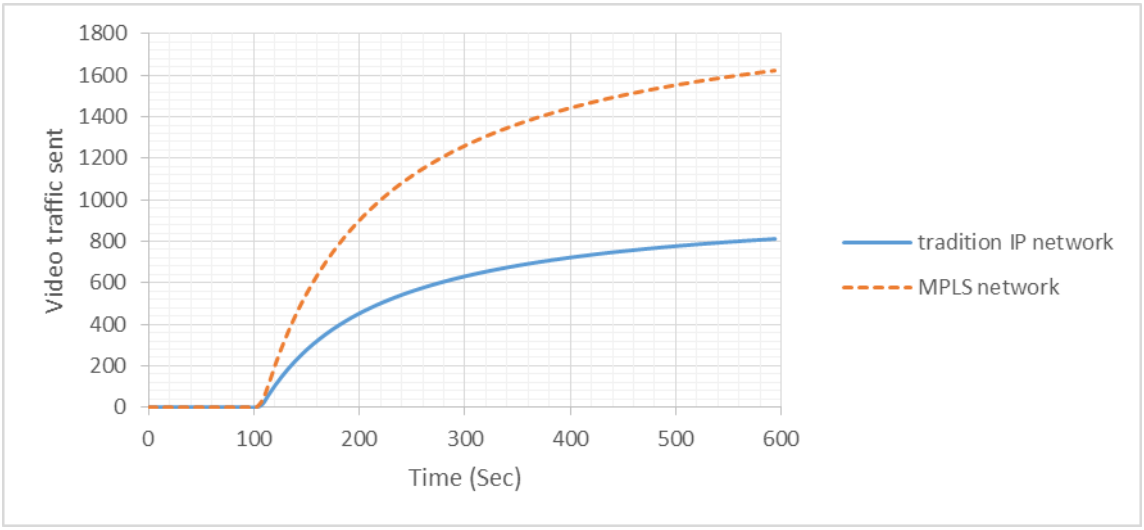

Figure 4: Video Traffic sent (packet/sec)

Figure 3 and figure 4 gives the average number of packets sent in both MPLS and traditional IP networks. Simulation results shows that MPLS model gives more throughput than the IP model. We observe that there is an increase in the performance when voice and video traffic is transmitted using MPLS transmission. MPLS delivers the packets with high transmission speed and lower delays.

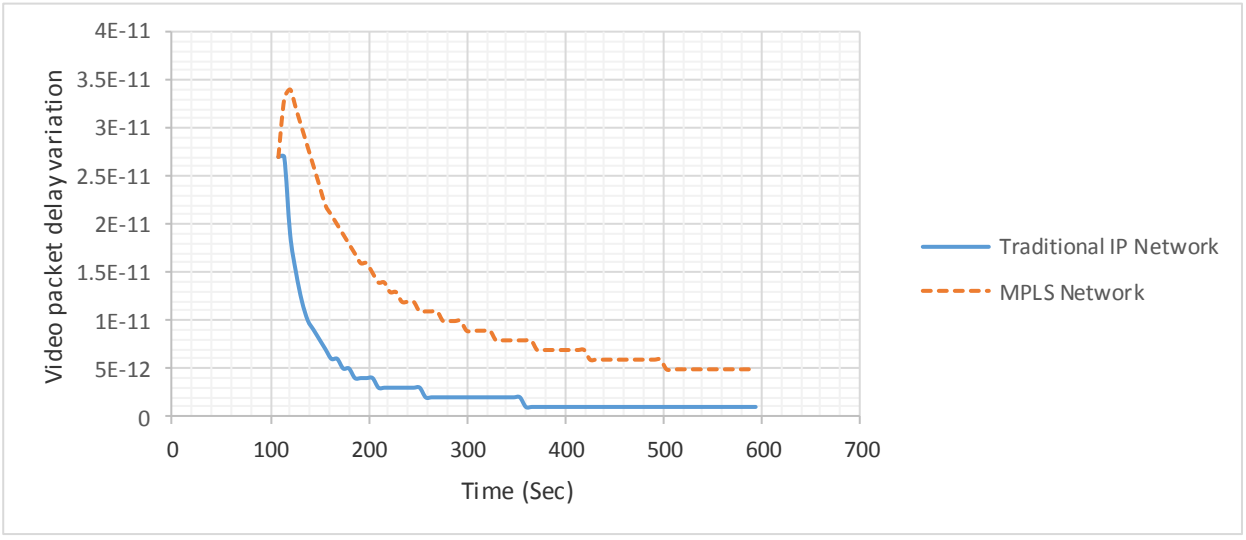

Figure 5: Video packet delay (packet/sec)

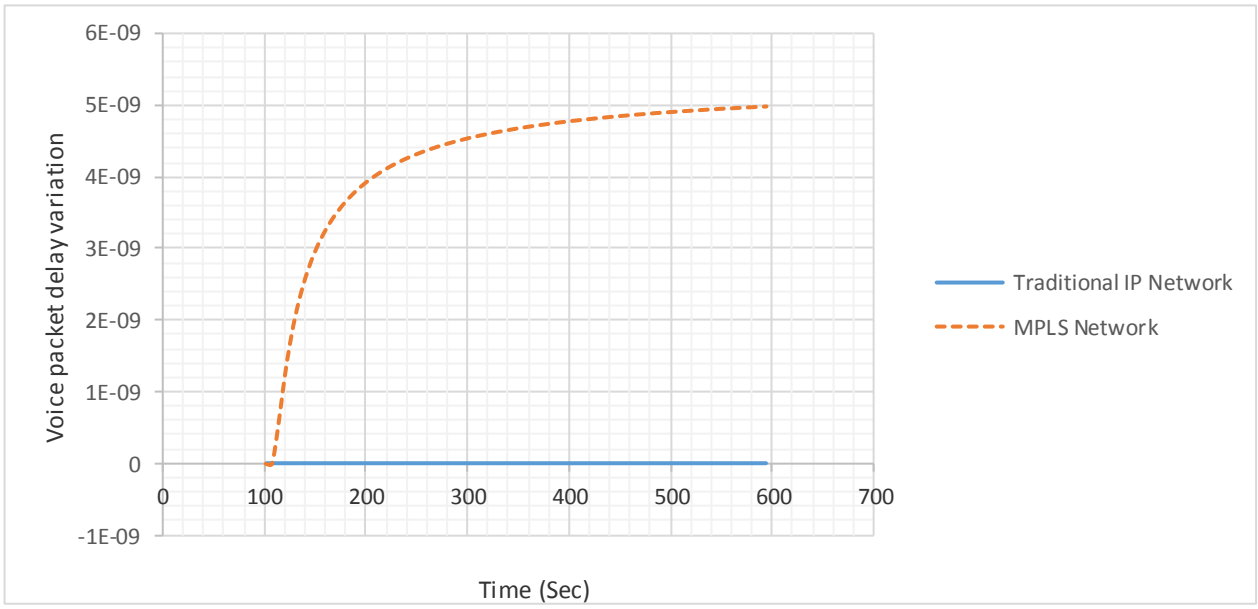

Figure 6: Voice packet delay variation (packet/sec)

Figure 5 and Figure 6 analysis was for packet delay variation for voice and video for both networks. The figure is direct evidence that MPLS network has much less delay variation than traditional IP network.

VI. CONCLUSION

In this dissertation performance evaluation for GWAN over IP/ MPLS network is made by employing the performance parameters such as jitter, packet delay variation, packet End-to-End delay, packet send and received. OPNET modeller 14.5 is used to simulate the GWAN network. The Based on the simulation results it can be concluded that MPLS provides best solution in implementing voice, video and data applications as compared to conventional IP networks because MPLS takes less processing time in forwarding the packets due to label switching, MPLS suffers minimum delay and provides high throughput compared to conventional IP networks. The GWAN network will be able to overcome most of the challenges that traditional IP network suffers since GWAN is based on MPLS. More research should be conducted on the GWAN network.

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