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Approach to Label Distribution Protocol Signaling using Multimedia Services for Bandwidth Allocation

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Abstract—**The most effective technique in scalable networks is achieved through Differentiated Services Traffic Engineering (DSTE). In the process of implementation, some links are heavily utilized and have little or no bandwidth available while others carry little or no traffic. Without the process of TE, there are possibilities of having under-utilization and over-utilization problems of bandwidth resources along the links. It is necessary to consider the implementation that would avoid the goal of network design and unguaranteed bandwidth delivery. This paper mainly focuses on Performing Evaluation of Label Distribution Protocol (LDP) Signaling using dynamic MPLS Label Switch Paths (LSPs) and Bandwidth Allocation for sustainable Wired and Wireless Networks. This will make provision of bandwidth allocation possible by the implementation of the Constraint-based LDP with basic configurations. The network model designed will be used for this purpose by the means of the simulation approach. The MPLS model flow analysis will be presented to justify the implementation of LDP. It will likely yield to maximize bandwidth utilization, minimize the packet delay/packet loss in the network and support QoS resource management.**

Keywords- MPLS-TE; MPLS-LSP; MPLS-LDP; Bandwidth management; Multimedia services.

I. INTRODUCTION

Fundamental concept in MPLS is that two Label Switching Routers (LSRs) must agree on the meaning of the labels used to forward traffic between and through them. This common understanding is achieved by using a set of procedures, called LDP. This protocol used LSRs to distribute labels in order to support MPLS forwarding along normally routed paths. The most appealing attribute of Traffic Engineering (TE) is the capability to reserve bandwidth across Network. It undergoes the process of routing data traffic in order to balance the traffic load on various links, routers, and switches in the network [1]. In other words, it is a technique that makes better use of the existing bandwidth in a network by moving traffic from over-utilized links to less-utilized links. It is most effective in networks where some links are heavily utilized and have little or no bandwidth available while others carry little or no traffic. The process of implementation that accommodates traffic of different priorities is said to be Differentiated Services-aware [2]. The traffic engineering implementation must consider the traffic requirements on a per-class basis.

Basically, many of the telecommunication industries used a conventional approach to managing bandwidth to support the peak demand of the resource. However, under-utilisation of resources may lead to the bandwidth wastage due to the low demand. The same approach stated in [3,4] is the purpose of supplying bandwidth on a network in order to reserve capacity for users. But the demand is low compared with the operational capacity of the network.

The aim of this paper is to perform the evaluation of Label Distribution Protocol signaling with dynamic Label Switch Paths and Bandwidth Allocation in MPLS Network model. The analytical approach is based on simulation results for proffering a solution to the next generation of Mobile Wireless networks. This could be achieved by the proposed design of MPLS networks to manage bandwidth efficiently as possible for the future wireless networks. It can be implemented by performing dynamic LSP and bandwidth allocation configurations of the MPLS model network as part of Traffic Engineering (MPLS-TE). A brief background of the previous research carried out is in Section II, which entails related work and the proposed technology to be employed. Next, Section III gives implementation of MPLS-TE on the models using performance metrics of multimedia services. Then, Section IV elaborates the results obtained from simulation. Finally, section V gives a summary of the paper.

II. RELATED WORK

Distinct research has been proposed on bandwidth management techniques in the literature [4-13]. In addition, research in the area of Multiprotocol Label Switching (MPLS) technology had been in existence for decades. However, much work has not been employed using this mechanism for the purpose of bandwidth management to solve the critical problem of delay. In addition, this is a technique that would utilize the available bandwidth to meet the requirement of QoS required.

The authors in [4] designed an analytical model for the proposed scheme, which is an agent-based adaptive bandwidth allocation. The analytical model consists of congestion occurrence on the links and links failure using Constant Bit Rate (CBR) and variable bit rate source respectively. Loh et al [5] also proposed an adaptive bandwidth management of different approach using network switching devices for managing the connection between physical ports. In [6], management of bandwidth utilisation technique during communication process between the client and server systems is disclosed. There is a limitation of bandwidth accessibility to applications based on priority.

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The authors in [7] established a communication session from multiples mobile devices with a group of conference servers. The research was done by [8] based on scheduling algorithms for a mixture of real-time and non-real-time of code division multiple access and high data rate personal communication wireless system.

George provides a stimulating idea in [9] for the service providers to manage their network efficiently by improving the QoS to the customer. Further issues were also mentioned as to allocate limited bandwidth with fairness to the users and the application of network management to monitor and control the traffic of multiple applications, although, there are still a lot of controversial issues yet to be resolved such as increasing network capacity and metered pricing.

Bandwidth management in the next generation of packet networks is investigated [11]. According to the authors, there are issues surrounding the bandwidth management for next-generation voice and multimedia over packet networks. End-to-End QoS requirements for PSTN-grade voice and multimedia service and how it might be best supported over a packet network infrastructure were investigated [12]. However, the question of (how much bandwidth do each of multimedia services really require?) still unanswered.

Radio Resource Management (RRM) is the system level control of radio transmission characteristics in wireless communication systems [13, 14]. In order to achieve an improved and efficient utilisation of resources, adaptive RRM schemes that can adjust the radio communication parameters dynamically to the QoS and throughput requirements are considered. These schemes are particularly considered in the design of wireless systems [15-17], in view of maximizing the system spectral efficiency without sacrificing the system performance.

III. MPLS TRAFFIC ENGINEERING (MPLS-TE)

MPLS is one of the tools that can be used to implement traffic engineering. An MPLS network is of the type that gives preferential treatment to certain types of traffic, which needs to have TE-configured differently from a network that does not [2]. The dynamic LSP can be configured with explicit or Constraint-based Short Path First (CSPF) routes. This will calculate an optimum explicit route (LER), based on specific constraints. A virtual network is formed by the MPLS-LSPs, which allocate bandwidth to the logical links to meet performance requirements. The bandwidth allocation of high priority traffic is managed between the network nodes. At the beginning of the simulation, all dynamic LSPs are signaled using RSVP or Constraint-based LDP (CR-LDP).

A. Differentiated Services MPLS Traffic Engineering (DSTE)

In the past, packet switch networks have been supporting multimedia applications for those that integrate audio, video, and data. There are two different approaches developed to provide adequate QoS: Integrated services and Differentiated services [18-20]. The Differentiated Service MPLS Traffic Engineering (DSTE) is an aspect which combines the capabilities of QoS and DSTE capabilities of MPLS to allocate bandwidth and control QoS for various virtual networks (also known as the class of service in DSTE) [18]. The allocation of bandwidth to each class type and provision of bandwidth protection and QoS can be implemented using admission control. There are three "bandwidth constraint models" which have been experimental [18-19] to control bandwidth allocation/protection within the DSTE framework.

It is illustrated that with the implementation of the previous bandwidth constraint models, Russian Doll Model (RDM) yielded poor results since the pre-emption is not enabled. While in the case of analysis and simulation, results of Maximum Allocation with Reservation (MAR) and Maximum Allocation Model (MAM) bandwidth constraint models varied. With the MAR bandwidth constraints model perform better than the MAM bandwidth constraints model [18].

B. Forwarding Equivalence Class (FEC)

It is necessary to precisely specify which packets may be mapped to each LSP. This is done by providing FEC specification for each LSP. The FEC identifies the set of IP packets which may be mapped to that LSP. If a packet matches multiple LSPs, it is mapped to the LSP whose matching prefix is the longest. If there is no one LSP whose matching prefix is longest, the packet is mapped to one from the set of LSPs whose matching prefix is longer than the others. The MPLS architecture [21] allows an LSR to distribute FEC label binding in response to an explicit request from another LSR. This is known as Downstream On Demand label distribution. It also allows an LSR to distribute label bindings to LSRs that have not explicitly requested them [21, 22].

C. Label Distribution Protocol (LDP)

In the label distribution protocol, there is Label Switch Router (LSR) discovery mechanisms, which implies that protocol will initially discover the label switch routers in the surrounding through the LSR mechanisms. It is used between nodes in an MPLS network to establish and maintain the label bindings. In order for MPLS to operate correctly, label distribution information needs to be transmitted reliably, and the label distribution protocol messages pertaining to a particular Forwarding Equivalence Class (FEC) need to be transmitted in sequence.

Two LSRs which use LDP to exchange label/FEC mapping information are known as LDP Peers. Label distribution can be performed with one's local label distribution peer by sending label distribution protocol messages which are addressed to the peer [23]. There are two ways of label distribution peering namely: explicit peering and implicit peering. In an explicit peering, labels are distributed to the peer by sending label distribution protocol messages, which are address to the peer. While implicit peering does not send label distribution protocol messages, which are addressed to one's peer rather to remote label distribution peers [23].

D. MPLS Model Scenarios with OPNET

OPNET simulator is very useful when working with complex networks with a big number of devices and traffic flows, or in networks where a little change could be critical [2]. Prior to any change in the implementation, it is possible to predict the behaviour and to verify the configurations of the devices [2].The label-forwarding in MPLS begins at the ingress edge router called Label Edge Router (LER router) in which the label is assigned and imposed by the IP routing process. This is followed by the swapping of labels on the contents of the label forwarding table in the core using Label Switch Router (LSR). At the egress edge router, the label is disposed and a routing lookup is used to forward the packet. Therefore, LSR forms the basis for labeled packets forwarding (label swapping) while Edge LSR labels IP packets and forwards them into the MPLS domain, or removes labels and forwards IP packets out of the MPLS domain.

All the routers (LERs and LSRs) along the route are defined by the LSP using an MPLS_E-LSP_DYNAMIC object to provide the linkages. Then, an update of the LSP details is obtained before the simulation. This simulation uses signaling protocol (LDP-TE) to establish an LSP from source to destination. Network models in Fig. 1 and Fig. 2 shows the baseline MPLS and modified with MPLS LSP configuration. This makes the provision of bandwidth allocation on LSPs created from LSR1 to LSR2, LSR3, and LSR4. The same procedure is applicable to other LERs. In other words, the LDP configuration leads to the distribution of bandwidth on logical links of the LSRs. Each connection request has a unique LSP identity (ID) assigned by the ingress LER1 in the IP-MPLS operating point.

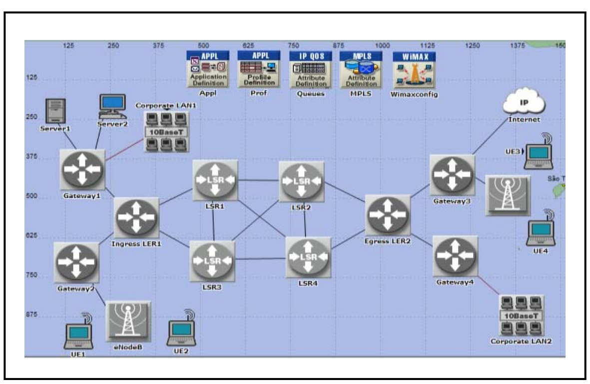

Figure 1. Baseline MPLS Network model

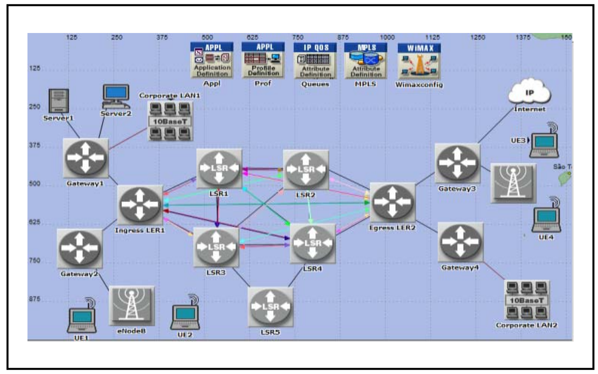

Figure 2. Implementation of MPLS with LDP between nodes

E. Bandwidth Estimation and Allocation Analysis

Consider a network of capacity C, which is distributed by J types of connection. The connections could be a voice or video conference call as shown in equation (1). Let nj the number of connections of type j = 1,…….,J:

$$S = \sum_{j=1}^{J} \sum_{i=1}^{n_j} BW_{ji,} \qquad (1)$$

This implies that:

$$M_j(s) = \log \mathrm{E}\left[e^{sBW_{ji}}\right] \qquad (2)$$

$M_j(s)$ is the properties of the log-moment generating function, which represents equation (2).

BW_{ji} is the bandwidth requirement of the i connection of type j . Also, it represents an independent random variable.

In equation (3), given C and information about the number and type of connections, the bound implies that for any $s \geq 0$.

$$\log \mathrm{P}(S > C) \leq \log \mathrm{E}\left[e^{s(S-C)}\right] = \sum_{j=1}^{J} n_j M_j(s) - sC \qquad (3)$$

This is useful for the decision of whether another call of class k can be added and retained the quality of service guarantee. If A is given to be acceptance region or boundary:

$$A = \left\{ n \in \Re_+^J : \sum_{j=1}^{J} n_j M_j(s) - sC \leq -\gamma \right\} \qquad (4)$$

This will result in,

$$(n_1, \ldots, n_j) \in A \Rightarrow \mathrm{P}(S > C) \leq e^{-\gamma} \qquad (5)$$

Equations (4) and (5) show region (A) of a new connection that can be accepted, without violating QoS guarantee that $\mathrm{P}(S > C) \leq e^{-\gamma}$.

$$\sum_{j=1}^{J} n_j M_j(s) - sC \le -\gamma \qquad (6)$$

$$\alpha_j(s) = \frac{M_j(s)}{s} = \frac{1}{s}\log \mathrm{E}\left[e^{sBW_{ji}}\right] \qquad (7)$$

Rewriting equation (7) becomes,

$$\sum_{j=1}^{J} n_j \alpha_j(s) \le C - \frac{\gamma}{s} \qquad (8)$$

The symbol $\alpha_j(s)$ is the estimated bandwidth of a source of class j as shown in equation (7) and equation (8). The admission control simply adds the effective bandwidth of a new request to the effective bandwidth of connections already in progress and accepts the new request if the sum satisfies a limit. It is observed that there is likely to be a variation of effective bandwidth of a connection over resources of the network.

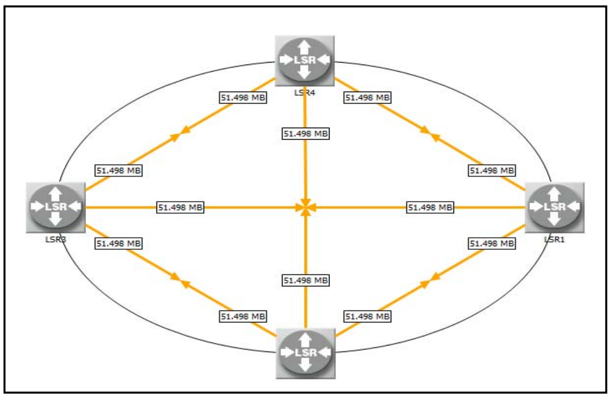

Figure 3. Circle view of bandwidth distribution using MPLS LSPs

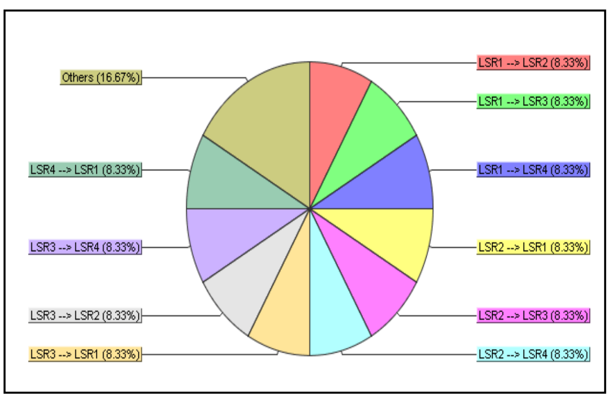

Figure 4. Percentage of bandwidth utilisation in MPLS LSPs

All the signaling messages generated by a request will contain the identification (ID): the reply to the signaling messages will also have this ID. It can be observed that the estimated bandwidth value of 51.498 MB is evenly distributed and still have a reservation on the links as shown in Fig. 3 and Fig. 5. Similarly, the percentage of bandwidth utilisation using mesh LDP configuration is shown in Fig. 4 and Fig. 6. From utilization of bandwidth, Fig. 6 shows better utilisation of bandwidth with reservation of 28.57 % as compared with reservation of 16.67% in Fig. 4. This indicates that moderate bandwidth utilization can be used to control congestion in the network.

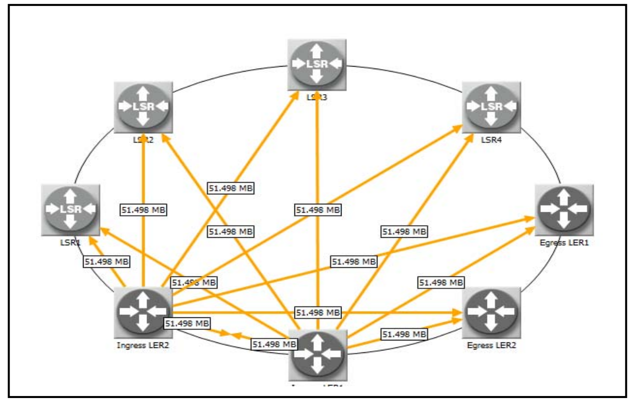

Figure 5. Circle view of bandwidth distribution using MPLS LSPs

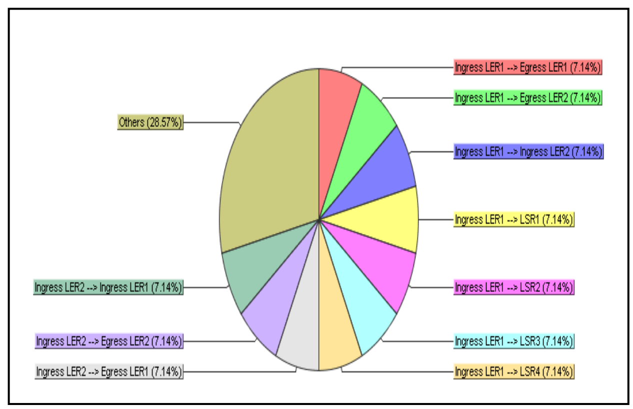

Figure 6. Percentage of bandwidth utilisation in MPLS LSPs

IV. RESULTS AND DISCUSSIONS

It can be seen that the MPLS model was simulated in order to verify its performance with LDP configuration using multimedia services. This served as the baseline for the further change in configurations. All the results obtained are tentative to improve for further research work by way of validation and refinement. The output of the performance indicates that there is an absolute packet delivery from ingress operating point to the egress endpoint. As for the results of the implementation, the MPLS baseline and modified MPLS networks with two seed scenario (seed 128 and seed 110) using configurations of voice and video conference are used which yielded results as shown from Fig. 7 to Fig. 14.

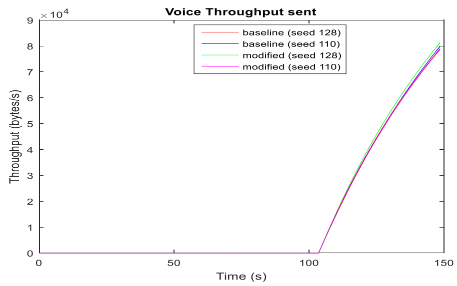

Figure 7. Average Voice Throughput sent.

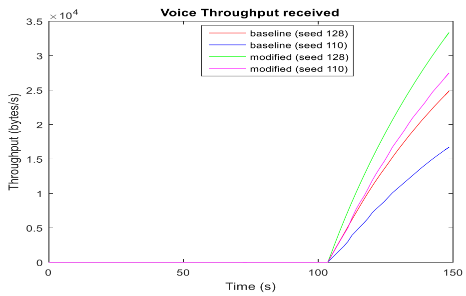

Figure 8. Average Voice Throughput received.

A close linear relationship exists between baseline and modified model for the average voice traffic sent from the source of information (Ingress) in Fig. 7. There is an absolute variation in the result of traffic received at the destination (Egress) point. Higher throughput is experienced in the modified network. This is due to the label distribution protocol being configured at the core routers (LSRs) to allocate bandwidth uniformly as shown in Fig. 8.

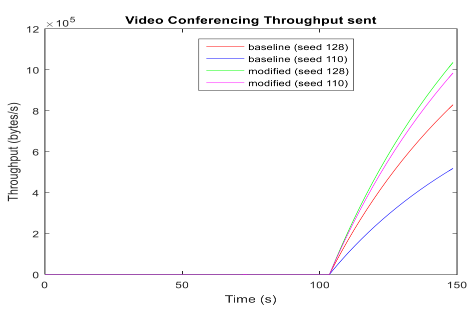

Figure 9. Average Video conferencing Throughput sent.

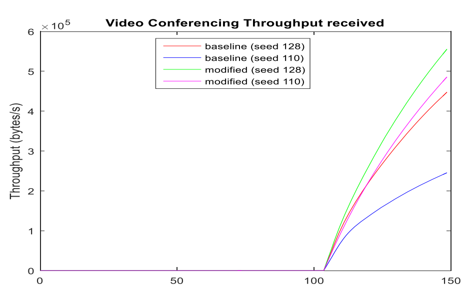

Figure 10. Average Video Conferencing Throughput received.

As shown in Fig. 9, the video traffic sent spread out considerably with a slight difference of 30 kbps for the network with LDP configuration while a wide gap of 360 kbps can be seen on the baseline. There is a tremendous increase in the transmission of packets from one end of the ingress LER to another end of the egress LER. This indicates that more traffic on the distributed links in the core network.

As can be seen from Fig. 10, all the throughput received increase rapidly to an average of about 550 kbps and 490 kbps for video conferencing configuration. There exists a considerable difference of the received traffic having average values of 440 kbps and 240 kbps respectively. This is an indication of constant traffic flows.

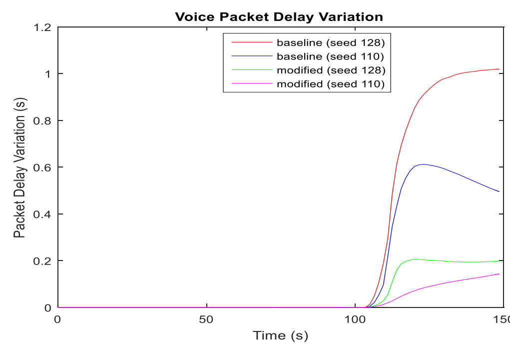

Figure 11. Average Packet delay variation (voice)

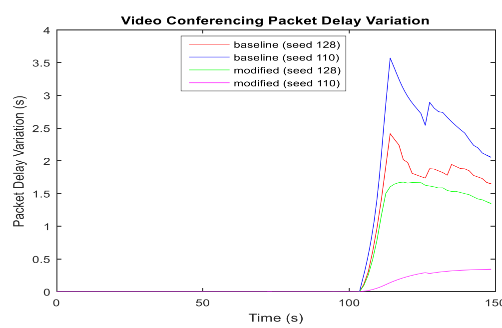

Figure 12. Average Packet delay variation (Video Conferencing).

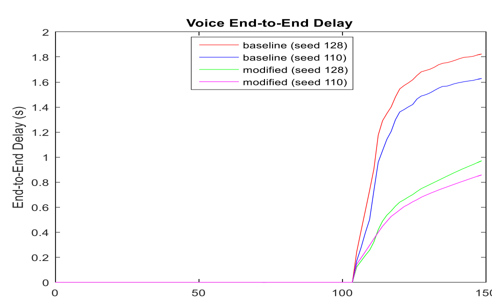

Figure 13. Average End-to-End delay (Voice).

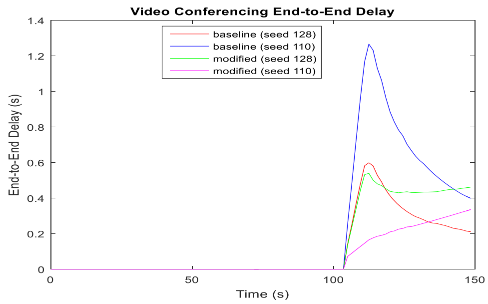

Figure 14. Average End-to-End delay (Video Conferencing).

Fig. 11 and Fig. 12 illustrate the packet delay variation (jitter) while Fig. 13 and Fig. 14 shows packet end-to-end delay for both video and voice traffics. As for the packet delay variation, there are steady and low values resulting from the modified network with LDP of the average peak of about (0.2 s / 0.18 s) for voice and (1.4 s / 0.4 s) for video as compared with the baseline without LDP configuration. However, the baseline result for video appears to decrease sharply. Subsequently, end-to-end delay appears to follow the same pattern in which that of the voice reduced approximately (1.0 s / 0.81 s) and for video has the peak of (0.6 s / 0.3 s) respectively.

V. CONCLUSION AND FUTURE PLAN

In conclusion, some of the proposed bandwidth management techniques had been reported in the literature review. The approach we used in this piece of research is similar to that reported in [1]. Therefore, a thorough study of the performance of the MPLS technology using label distribution protocol for the allocation of bandwidth in virtual networks are implemented. This would sustain the future exponential increment in user demand with adequate allocation of bandwidth. This is verified using simulation results of MPLS using LDP configuration, which eventually has moderate performance due to low values of end-to-end delay, low queue delay, and high throughput.

The use of MPLS technology to implement bandwidth management in the future mobile wireless network is reliable and profitable due to its valuable cost to both operators and service providers. Then the critical problem of delays such as end-to-end delay, queue delays, and packet delay variation would be drastically reduced. However, it will be an additional cost to deploy MPLS technology to the existing network, instead of eliminating existing IP technology completely together with the facilities.

Further analysis of the MPLS traffic engineering (MPLS-TE) in combination with Software Defined Networking (SDN) will put into consideration for the adequate allocation and reservation of bandwidth to the next generation of mobile and wireless networks. More verification, validation, and refinement of the model designed would be required to meet the requirements of the data rates and minimum bandwidth specification for 5G technology.

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