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Simulation Result of Multi-Protocol Label Switching

Vikram Dixit [1], Braj Bihari Soni [2]
[1]Mtech Scholar, NIIST,vikramdixit_114@gmail.com, Bhopal, India
[2] Asst. Prof. , NIIST, brizsoni@gmail.com, Bhopal, India

Abstract – Multiprotocol label switching (MPLS) networks are packet-based networks that offer considerable advantages, including improved network utilisation, reduced network latency, and the ability to meet the quality of service and strict level agreement requirements of any incoming traffic. Traffic Engineering (TE) is the stage which deals with geometric design planning and traffic operation of networks, network devices and relationship of routers for the transportation of data. TE is that feature of network engineering which concentrate on problems of performance optimization of operational networks. It involves techniques and application of knowledge to gain performance objectives, which includes movement of data through network, reliability, planning of network capacity and efficient use of network resources. MPLS is a modern technique for forwarding network data. It broadens routing according to path controlling and packet forwarding. In this thesis MPLS is computed on the basis of its performance, efficiency for sending data from source to destination.
Keywords: SDWAN, Multi-Protocol Label Switching, Internet Protocol., MPLS

I. Introduction

The need for a variety of new cloud services is increasing across all industries. Cloud services typically have high bandwidth and low latency requirements that a traditional Wide-Area Network (WAN) designed to deliver best-effort service cannot meet [1]. Software-Defined Wide Area Networking (SDWAN) is a viable approach for supporting these new cloud applications (SD-WAN). SD-WAN-based solutions are constantly being deployed due to their potential to improve the user experience and deliver fast, scalable, inexpensive, and flexible communication between diverse network environments. According to a recent Cisco projection, SD-WAN traffic is predicted to expand at a Compound Annual Growth Rate (CAGR) of 37 percent in the next several years, compared to 3 percent for traditional WAN traffic. [7].

By exploiting the corporate WAN and multi-cloud connection, SD-WAN-based solutions have the ability to expand an organization's capabilities. One of the most important features of SD-WAN is that it allows for dynamic path selection amongst connectivity choices including Multiprotocol Label Switching (MPLS), Long Term Evolution (LTE) / Fifth-Generation (5G), and the internet [7]. In addition, SD-traffic WAN's shaping functions enable inbound and outgoing traffic segmentation. Furthermore, SD-WAN enables traffic prioritisation based on user/group regulations as well as the types of applications they utilise. As a result, SD-WAN solutions have the ability to enable enterprises to swiftly and simply access business-critical cloud apps, resulting in high-speed application performance along branch office WAN perimeters [7]. Finally, SD-WAN can improve uplink redundancy to improve user perceptions of Quality of Experience (QoE) and Quality of Service (QoS).

Due to its capacity to give resources sharing flexibility, adaptability, fine-grained control, and network virtualization by decoupling the data plane and the control plane, Software Defined Networks raises a lot of worries nowadays. A controller with the OpenFlow protocol [4] has a global view of the network and may immediately request modifications to any switch as needed. When the first packet of a flow arrives at an ingress switch, a request is sent to the controller, which creates a path to the destination and updates flow tables in switches along that path with matching fields and actions. This is referred to as Hop-by-Hop Forwarding. [4].

A. Wide Area Networks

The management and operation of traditional Wide Area Networks (WAN) are limited by two important factors: (i) cost and (ii) flexibility. Firstly, legacy WAN architectures are built using expensive and specialized vendor equipment. Secondly, as WAN equipment is forced to take control decisions based only on local information, it is difficult to perform global changes in the network configuration accurately, fast and dynamically, thus making legacy WAN architectures rigid and static. Furthermore, the flexibility is also limited in terms of adding new functionality to the WAN deployments, since they are limited to the capabilities provided by specialized network equipment. One of the technologies that tries to overcome these limitations is Software-Defined Networking (SDN), so that the implementation of this paradigm in WAN architectures (i.e., SD-WAN) is meant to be a potential enabler to facilitate the automation of network configurations and, eventually, fully program the network.[10]

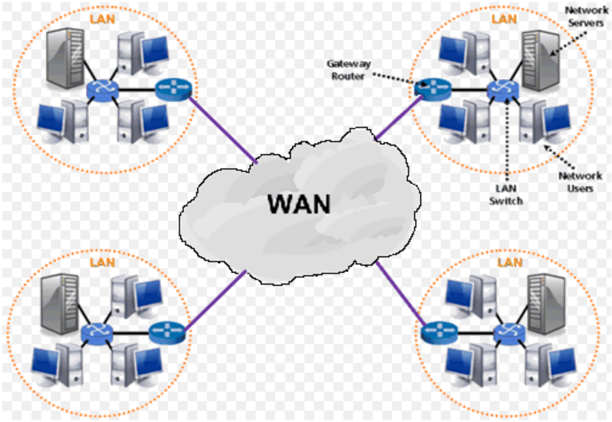

Fig.1 Wide Area Network

SD-WAN is able to conjugate the low cost of Internet access to a good degree of availability by introducing a centralized SDN controller. The SD-WAN overlay architecture is much simpler than current WAN technologies, such as Multiprotocol Label Switching (MPLS), to be dynamically configured to adapt to the network conditions. Based on a software-defined architecture, SD-WAN delegates the control and management to a centralized controller connected uniquely to the edge devices, or Customer Premises Equipment (CPE): this means that there is no need to have direct access to the WAN internal devices (e.g. providers' routers and switches) to operate an SD-WAN system.[11]

B. Going Software-Defined

It is clear nowadays that the digital world is moving towards cloud-based everything. From applications to network communication, the cloud is consuming its rivals at a rapid pace. It is especially interesting how the cloud is going to transform the WAN market with the emergence of SD-WAN - a cloud-centric networking approach, leveraging the software defined networking principles. SD-WAN is one of the hottest topics in networking today and this is due to the fact that it combines the Software Defined Networking, the cloud and the WAN market sectors. [12] With the increasing demand for high-bandwidth network traffic that is expected from technologies like Artificial Intelligence (AI), Internet of Things (IoT) and 5G, it is expected that by 2020 digital enterprises will need more than 5,000 terabits of interconnection bandwidth to function properly. [12] This amount of traffic will require a more scalable and cloud-friendly enterprise network model than the current market leader - MPLS. Businesses will require a flexible, cloud-ready and easily managed network communication service that is highly scalable and inexpensive. SD-WAN is designed to allow enterprises not only to connect their branch offices, as traditional MPLS WAN, but also to provide fast connectivity to all of the necessary cloud applications. Another major point of SD-WAN is its lack of configuration complexity. The separation of the control plane from the data plane, which is the major principle of SDN, allows for a centralized configuration model, which is easily administrated. But is SD-WAN going to completely replace the current MPLS and DMVPN WAN solutions? Probably not. SDWAN, however, is capable of utilizing both the internet and the existing MPLS network in order to offer the best possible WAN optimization for the business. Therefore, SD-WAN and MPLS are able to coexist if there is sensitive traffic that can justify the MPLS cost. Another important aspect is how this new technology will affect the current WAN market. ISPs are used to being the major player in the WAN game and are certainly afraid from the numerous SD-WAN solutions that continue to emerge. Is this new technology going to take the WAN market away from ISPs and place it in the hands of cloud providers? These are certainly very important questions that people in the telecom sector are wondering about. The answers will be responsible for shaping the new look of the WAN sector and the digital world of the future with it.

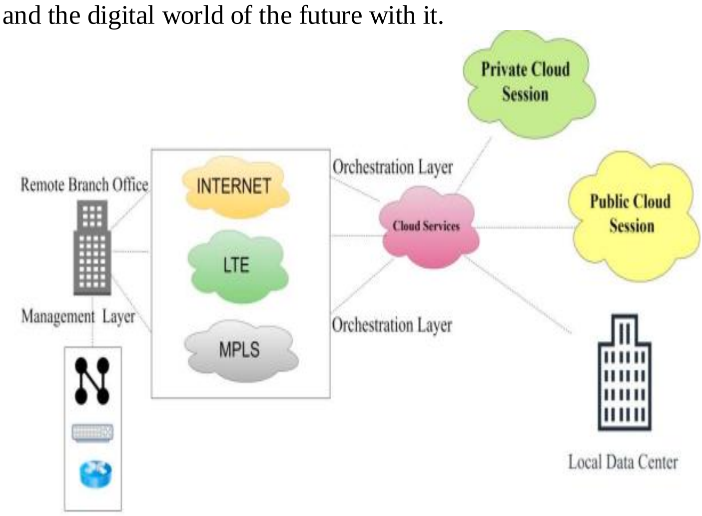

Fig.2 SD-WAN architecture

II. MULTI PROTOCOL LABEL SWITCHING

To overcome most of the issues related to TE and IP Routing, MPLS is used. It is built by Internet Engineering Task force (IETF) to make the internet scalable, fast, carry heavy traffic, manageable and accept new routing architectures. MPLS uses TE which enables the network operators to reallocate packet flows to gain consistent distribution among different links. Making Network traffic to travel on specific directions permits to take the majority of the network capacity while making it easy to give uniform service levels to the users at the same time [12]. MPLS is a modern technique for forwarding network data. It broadens routing according to path controlling and packet forwarding. In MPLS packets are used for sending data. Multi Protocol Label Switching (MPLS) is an IP packet routing technique that routes IP packet through paths via labels instead of looking at complex routing tables of routers. This feature helps in increasing the delivery rate of IP packets. MPLS uses layer 3 service i.e, Internet Protocol, and uses router as forwarding device. The traffic of different customers is separated from each other because MPLS works somewhat like VPN. It does not work like regular VPN that encrypts the data but it ensures packet from one customer cannot be received by another customer. An MPLS header is added to packet that lies between layers 2 and 3. Hence, it is also considers to be Layer 2.5 protocol.

III. MPLS Functionality

MPLS process is performed on two types of routers .i.e. Label Edge Routers (LER) and Label Switch Routers (LSR). In figure 8 below, LER which is router 2 (Ingress router) works at the edge of the MPLS network and its interfaces are connected to the other networks. It routes traffic and works as an interface between the MPLS Network and the Layer 2 network. When router 2 receives a packet from the other layer 2 network, it attaches a label and sends the updated packet to the MPLS core network.

The packet will then go through the path which is called Label Switched Path (LSP), going from one to another LER (egress) which is router 8. When the packet is received, the label is then removed from the packet and sent to the concern network. LER which sends the packet to the MPLS core network is called ingress while LER which sends the packet to other dissimilar network is called egress. Both of these ingress and egress routers participate in the establishment of the LSPs before exchange of packets. The LSR (router 3, router 4, router 6 and router 7 in figure 3.2) comes in the core network of MPLS. They contribute in establishing the LSPs (links between two routers) and packet forwarding to the other MPLS routers. LSR receive packets from other connected LSR or LER, analyze its label and then forward the label according to the content of label.

Traffic Engineering of packet switched networks

The The aim of this simulator is to address the traffic engineering of an ISP (Internet Service Provider) core network based on MPLS (Multi-Protocol Label Switching). For a given network and a given set of estimated traffic flows to be supported, the traffic engineering task addressed in this assignment is to select a routing path for the LSP (Label Switched Path) of each traffic flow such that the performance of the network is optimized. The network performance is assessed by the Kleinrock approximation.

The Kleinrock approximation assumes that each network link behaves as a M/M/1 queuing system. It is considered a network composed by a set of unidirectional links (i,j), each one with a capacity μ_{ij} (in packets/second) and a

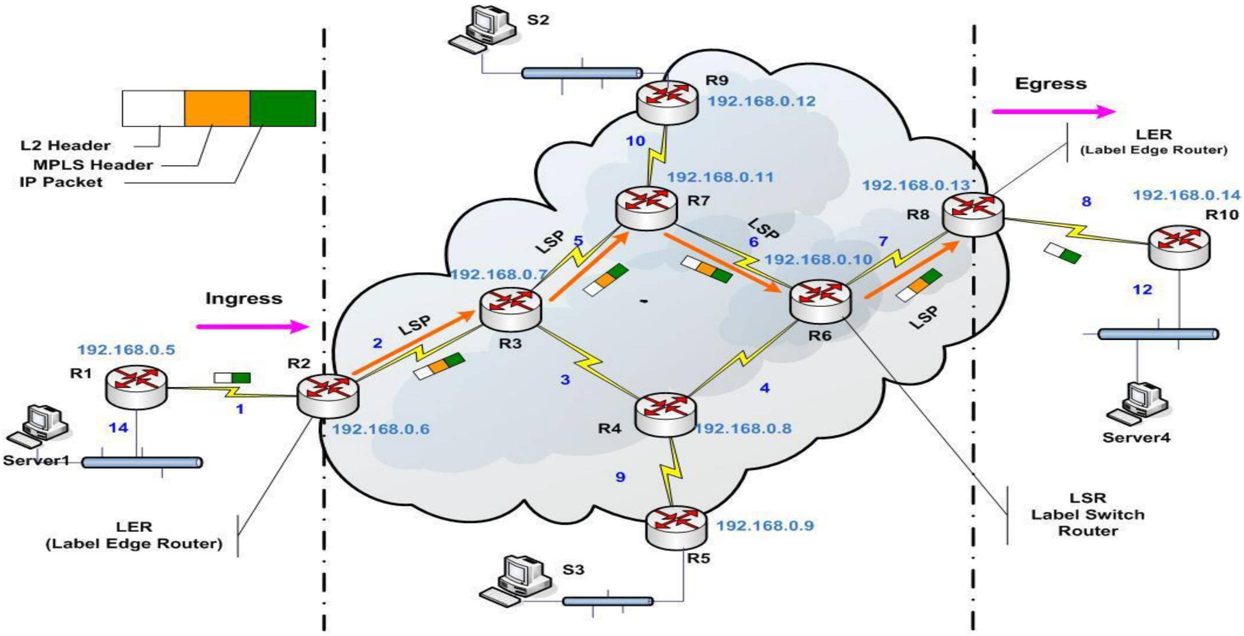

Fig.3 MPLS Functionality

propagation delay d_{ij} (in seconds).

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The network supports S packet flows s = 1,...S, each one with a packet arrival rate λs (in packets/second) and a routing path composed by the links (i,j) defined in set Rs. The total arrival rate on connection (i,j) is:

$$\lambda_{ij} = \sum_{s:(i,j)€=R_s}^{n} \lambda_s$$

and the total traffic supported by the network is:

$$\square = \sum_{s=1....S}^{n} \lambda_s$$

Then, by the Kleinrock approximation, the network average delay is:

$$W = \frac{1}{\square} \sum_{(i,j)}^{n} \frac{\lambda_{ij}}{\mu_{ij-\lambda_{ij}}} + \lambda_{ij} d_{ij}$$

and the average delay of each flow s is:

$$Ws = \sum_{(i,j)\epsilon R_s}^{n} \frac{1}{\mu_{ij-\lambda_{ij}}} + \lambda_{ij} d_{ij}$$

IV. Result

In this scenario there's a MPLS (Multi-Protocol Label Switching) network of an ISP (Internet Service Provider) with the topology presented in figure below, where the gray nodes are transit nodes (they just provide connectivity between the other nodes), thick connections have a bandwidth capacity of 10 Gbps and the other connections have a bandwidth capacity of 1 Gbps.

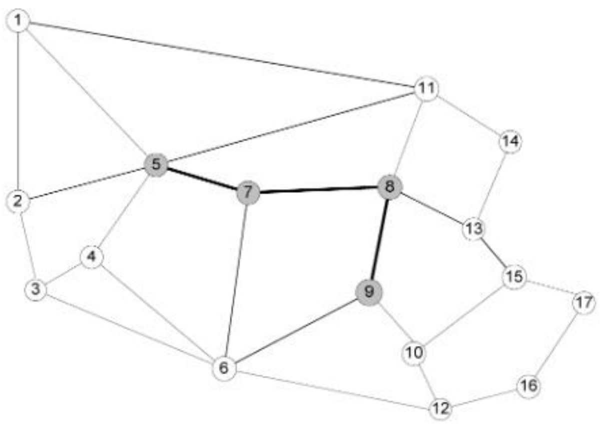

Fig. 4 Topology

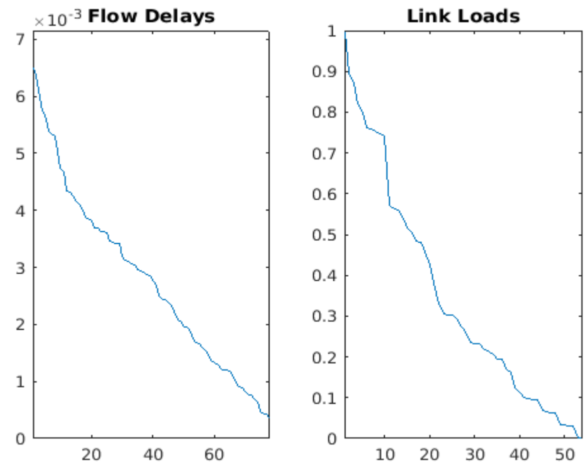

Figure 3 shortest path

Example of a simulation solution_a.m where the criteria to create each route flow is the shortest path between the nodes. The graphs show the flow delays and link loads of the node's connections.

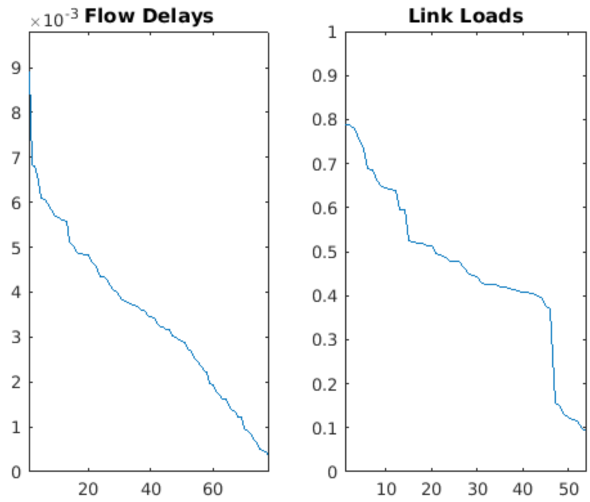

Fig. 5 Lowest connection load

Computes the same simulation, but with the criteria minimizing the connection load.

In this example, when compared to *1. Shortest Path" the link loads are lower by sacrificing flow delays.

V. Conclusion

The MPLS is a better technique for traffic engineering.

- MPLS takes less time to send data to the destination
- MPLS is efficient than IP networks
- MPLS will be efficient if applied in the current internet architecture

MPLS is a modern technique for forwarding network data. It broadens routing according to path controlling and packet forwarding. In this thesis MPLS is computed on the basis of its performance, efficiency for sending data from source to destination.

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