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COMPARATIVE ANALYSIS IP NETWORK AND MPLS NETWORK USING NS2 SIMULATOR

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Abstract. *In a modern data network, the main problem is the reliable delivery of information using the packet switching method. One of the networking technologies is MPLS (Multiprotocol label switching), a technology that guarantees reliable message delivery, as well as high transmission speed and minimal delays. Traffic control allows you to control the route that data packets take by passing through a standard routing model using routing tables. Switching traffic management is based on building routes using labeled switching paths (LSPs) between routers. An LSP is a virtual circuit oriented connection in Frame Relay or ATM. LSPs are also similar to one-way tunnels, in which packets arriving along the path are encapsulated in a wrapper and switched along the entire path without the influence of intermediate nodes. LSPs provide more granular control over how packets are forwarded on the network. An LSP may use a set of primary and secondary paths to provide reliability. In this work, on the basis of a simulation model, a comparative analysis of data transmission networks based on IP and MPLS networks is carried out.*

Keywords: *network, multiprotocol label switching, packet switching, architecture, routing.*

I. INTRODUCTION

To date, the pace of development of the telecommunications industry is one of the most rapid. Along with a slowdown in the growth of the client base of telecom operators, there is an increase in traffic (Big Data) due to the introduction of new technologies and an increase in the share of services based on IP technologies. Given these trends, telecom operators are introducing new services, which leads to the transition of telecommunications networks to multi-service. Currently, users of multiservice networks are increasingly interested in services such as cloud computing, online games, and access to various multimedia web services.

But the methodology for ensuring the requirements for the quality of service of heterogeneous traffic is not completely resolved. One of the options for ensuring efficient traffic transmission with support for QoS (Quality of Service) parameters is the use of MPLS (Multi Protocol Label Switching) technology. This technology is constantly being improved in the direction of adapting to the conditions of traffic transmission in networks, providing QoS support.

MPLS (Multi Protocol Label Switching) is a label-based fast packet switching technology in multiprotocol networks. MPLS is developed and positioned as a way to build high-speed IP backbones, however, its scope is not limited to the IP protocol, but extends to the traffic of any routable network

protocol. MPLS is based on the label exchange principle [1]. Any transmitted packet is associated with one or another network layer class (Forwarding Equivalence Class, FEC), each of which is identified by a specific label. The label value is unique only for the portion of the path between neighbors in the MPLS network, which are called Label Switching Routers (LSRs). The label is transmitted as part of any packet, and the way it is associated with the packet depends on the link layer technology used. The LSR router receives topological information about the network by participating in the routing algorithm - OSPF, BGP, IS-IS. Then it begins to interact with neighboring routers, distributing labels that will be used for switching in the future.

II. MAIN PART

Multiprotocol Label Switching (MPLS) is a protocol-agnostic routing technique designed to speed up and shape traffic flows across enterprise wide area and service provider networks.

MPLS allows most data packets to be forwarded at Layer 2 - the switching level - of the Open Systems Interconnection (OSI) model, rather than having to be passed up to Layer 3 -- the routing level. For this reason, it is often informally described as operating at Layer 2.5.

MPLS was created in the late 1990s as a more efficient alternative to traditional Internet Protocol (IP) routing, which requires each router to independently determine a packet's next hop by inspecting the packet's destination IP address before consulting its own routing table. This process consumes time and hardware resources, potentially resulting in degraded performance for real-time applications, such as voice and video.

In an MPLS network, the first router to receive a packet determines the packet's entire route upfront, the identity of which is quickly conveyed to subsequent routers using a label in the packet header.

In an MPLS network, each packet gets labeled on entry into the service provider's network by the ingress router, also known as the *label edge router* (LER). This is also the router that decides the LSP the packet will take until it reaches its destination address.

All the subsequent label-switching routers (LSRs) perform packet forwarding based only on those MPLS labels -- they never look as far as the IP header. Finally, the egress router removes the labels and forwards the original IP packet toward its final destination.

When an LSR receives a packet, it performs one or more of the following actions:

- **Push:** Adds a label. This is typically performed by the ingress router.
- **Swap:** Replaces a label. This is usually performed by LSRs between the ingress and egress routers.
- **Pop:** Removes a label. This is most often done by the egress router.

The Fig. 1 illustrates how a simple MPLS network works.

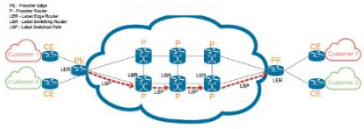

Fig. 1. MPLS network architecture

III. SIMULATION AND MODELING

The simulation tool that was applied in this work was based on Network Simulator Version 2.34 (NS 2.34).

The network model shown in Figure 3.1 - Figure 3.8 are the performance figures obtained for MPLS and regular IP networks. It can be seen from the graphs that when transferring IP traffic using MPLS technology, there is an increase in performance.

The Fig 2. describes the traffic flow in the IP network at beginning moment of simulation. As we know, during the flow of traffic, this IP network uses the same path even if there is congestion. The following tables show the modeling topology for IP network.

TABLE I. IP NETWORK CONFIGURATION

Item	Setting
Node type	IP capable
Bandwidth between all link	1 MB
Link propagation delay	10 MS
Queuing type	Drop-tail
Link type	Duplex
Source Node	Node 0 and Node 1
Destination node	Node 8 and Node 9

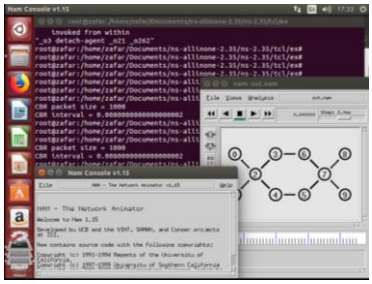

Fig. 2. Screenshot of compilation NS2 simulation model

The Table II show the parameters of simulation topology for an MPLS network.

TABLE II. MPLS NETWORK CONFIGURATION

Item	Setting
Node type	0,3,6,7 and Node 8 are IP capable node And 1,2,4,5 Node9 are MPLS capable node
Bandwidth between all link	1 MB
Link propagation delay	10 MS
Queuing type	Drop-tail
Link type	Duplex
Source Node	Node 0 and Node 1
Destination node	Node 8 and Node 9

For the MPLS network scenario, the duration of the simulation is 180 seconds. In this scenario here, we create two traffic from node 0 to node 8 and from node 1 to node 9. The first traffic starts at 20 seconds and ends at 140 seconds of simulation time. The second traffic starts at 30 seconds and ends at 150 seconds of simulation time. The same scenario is created for the IP network. As we know, in MPLS a network path is not fixed as an IP network. So here we show a different flow of trajectories at different times.

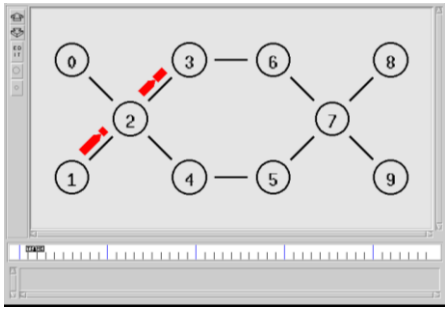

Fig. 3. Screenshot of traffic flow in MPLS network at T= 21 sec.

After 20 seconds (Fig.3), data packets are transmitted from the Source, which is node 0, to the destination, which is node 8 (MPLS switching), after 30 seconds: traffic started from the source, which is node 1, to the destination, which is node 9 (indicated by the RED line). Now two traffic is generated in the network. One from node 0 to node 8 and the other from node 1 to node 9.

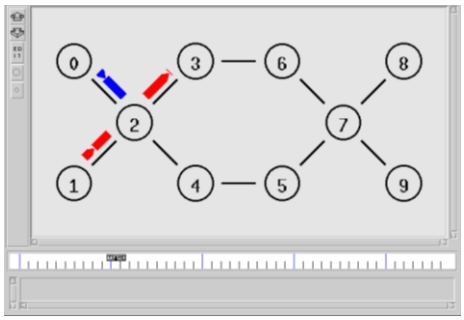

Fig. 4. Traffic flow in MPLS network at T= 43 sec.

As we mentioned above, the MPLS network changes the path if the network path becomes congested. So here, after changing the path, a package removal was triggered

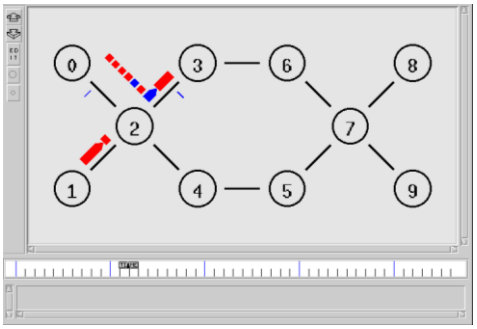

Fig. 5. Screenshot of traffic flow in MPLS network at T= 47 sec.

At time T= 47 seconds (Fig.5), when both traffics follow the same path, packets are dropped. But at this time in the MPLS network, change this congested path and follow another available path and stop dropping packets to improve network performance. This is described in Figure 6.

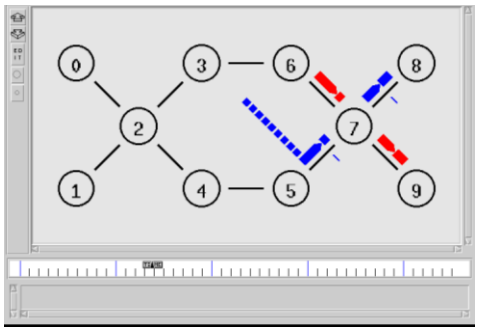

Fig. 6. Traffic flow in MPLS network at T= 86 sec.

When we run the simulation for the above two scenarios, we find that on the IP network, the traffic took one path (0-2-3-6-7-8), (1-2-4-5-7-9), which is the shortest path. But when we run the same simulation on an MPLS network, the traffic goes through many paths (0-2-5-6-7-8-9), (1-2-3-4-8), (1-2- 5-6-8), (1-2-5-4-8), (0-2-5-4-6-7-9). Comparing the numbers above, you can see that MPLS follows paths that are underused if the shortest path is overloaded.

Referring to the above figures, we can say that the performance of MPLS network is better than IP network. This result is obtained thanks to the MPLS network, which uses all paths to the recipients from the source, which is the main functional element of this network. The IP network has reached its steady state when the path (0-2-3-6-7-8), (1-2-4-5-7-9) is saturated. Then the IP network starts dropping packets, but the MPLS network reaches a steady state after all its paths are saturated, then starts dropping packets in the MPLS network.

IV. EXPERIMENTAL RESULTS

After modeling both networks, we find the following result.

A. Receive Pkt coefficient (interval - 0.02)

According to Table III, we got the result that the packet loss rate in MPLS technology decreased by 32.34%. During startup, the performance of both an IP network and an MPLS network is the same, because during startup, both networks create an information database called routing tables in IP networks, but in MPLS networks, this is done using a label information base (LIB).

TABLE III. TOTAL NUMBER OF RECEIVED PACKET AT IINTERVAL 0.02

Type of Network	Simulation Time	Total No. of received Packet	Defere nce	Ratio (%)
IP Network	2 min	5473	1770	32.34
MPLS Network	2 min	7243		

Based on the above table, it can be seen that the total number of packets received at the destination nodes in the IP network is 5473. In the MPLS network, the total number of packets received at the destination nodes is 7243.in MPLS network packets are received more due to the functionality MPLS technology where packets are sent from many paths which are (0-2-5-6-7-8-9), (1-2-3-4- 8), (1-2-5-

6- 8), (1-2-5-4-8), (0-2-5-4-8-6-7-9) while the IP network only sends a packet along one path (0-2-5-6-7-8-9), (1-2-3-4-8-10).

IV. CONCLUSION

The following graph (Figure 7) shows the average throughput of an IP network and an MPLS network. The green line shows the throughput of the MPLS network and the red line shows the throughput of the IP network. As shown in the chart

According to Figure 7, the MPLS network performed better than the IP network. We can say this because of the core functionality of MPLS, which is to use all available paths in the network from source to destinations. The main purpose of this article is to analyze the performance based on the total number of received packets, packet drops and end-to-end delay of a conventional IP-based network and an MPLS-based network. Conventional IP-based networks have many limitations, such as routing tables, which take longer to create and become more complex and labor intensive.

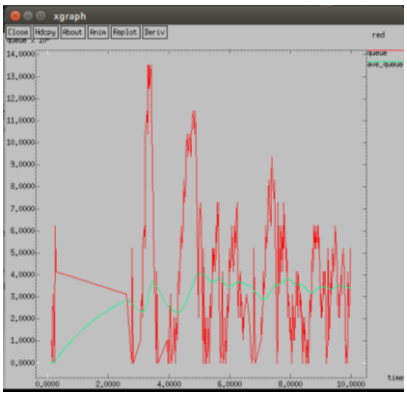

Fig. 7. Average Bandwidth (Mbps) V/s Time (sec)

MPLS technology has been proposed to reduce these limitations. MPLS technology speeds up the flow of traffic and also provides better service through the use of labels for real-time applications. In this thesis, the performance of an MPLS-based network was evaluated and compared with the performance provided by traditional IP-based networks using NS-2.34 simulation. The performance analysis is evaluated using an approach in NS2 that calculates some performance metrics that can be supported in MPLS and IP networks, and these performance metrics are end-to-end delay, packet drops, and total received packets. Based on the results of this simulation, it can be concluded that the implementation of a real-time application in an MPLS network provides the best solution compared to conventional IP networks, since routers in MPLS require less processing time when forwarding packets, this is more suitable for applications, and a network based MPLS provides the lowest latency and provides high throughput compared to conventional IP-based networks.

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СРАВНИТЕЛЬНЫЙ АНАЛИЗ IP-СЕТИ И СЕТИ MPLS С ИСПОЛЬЗОВАНИЕМ СИМУЛЯТОРА NS2

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Аннотация. *В современной сети передачи данных основной проблемой является надежная доставка информации методом коммутации пакетов. Одной из сетевых технологий является MPLS (многопротокольная коммутация по меткам), технология, гарантирующая надежную доставку сообщений, а также высокую скорость передачи и минимальные задержки. Управление трафиком позволяет контролировать маршрут, по которому проходят пакеты данных, проходя через стандартную модель маршрутизации с использованием таблиц маршрутизации. Управление коммутационным трафиком основано на построении маршрутов с использованием помеченных путей коммутации (LSP) между маршрутизаторами. LSP — это соединение, ориентированное на виртуальные каналы, в Frame Relay или ATM. LSP также аналогичны*

односторонним туннелям, в которых пакеты, поступающие по пути, инкапсулируются в оболочку и коммутируются на всем пути без влияния промежуточных узлов. LSP обеспечивают более детальный контроль над тем, как пакеты пересылаются в сети. LSP может использовать набор первичных и вторичных путей для обеспечения надежности. В данной работе на основе имитационной модели проводится сравнительный анализ сетей передачи данных на базе сетей IP и MPLS.

Ключевые слова: *сеть, многопротокольная коммутация по меткам, пакетная коммутация, архитектура, маршрутизация.*

NS2 SIMULYATORI YORDAMIDA IP TARMOG‘I VA MPLS TARMOG‘INING QIYOSIY TAHLILI

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Annotatsiya. *Zamonaviy ma’lumot uzatish tarmog‘ida asosiy muammo - paketli kommutatsiya orqali ma’lumotlarni ishonchli yetkazib berishdir. Bunday tarmoq texnologiyalaridan biri MPLS (Multiprotocol Label Switching) bo‘lib, bu texnologiya xabarlarni ishonchli yetkazib berishni, shuningdek, uzatishning yuqori tezligi va minimal kechikishlarni kafolatlaydi. Trafikni boshqarish sizga marshrutlash jadvallari yordamida standart marshrutlash modelidan o‘tish orqali ma’lumotlar paketlari oladigan marshrutni boshqarish imkonini beradi. Trafikni kommutatsiya qilish marshrutizatorlar o‘rtasida belgilangan kommutatsiya yo‘llari (LSPs) yordamida marshrutni qurishga asoslangan. LSP - bu Frame Relay yoki ATM-da virtual sxemaga yo‘naltirilgan ulanishdir. LSPlar, shuningdek, bir tomonlama tunnellarga o‘xshaydi, ularda yo‘l bo‘ylab kelgan paketlar inkapsulyatsiya qilinadi va oraliq tugunlar ta’sirisiz butunlay almashtiriladi. LSPlar tarmoqda paketlar qanday uzatilishi ustidan batafsil nazoratni ta’minlaydi. LSP ishonchlilikni ta’minlash uchun birlamchi va ikkilamchi yo‘llar to‘plamidan foydalanishi mumkin. Ushbu ishda simulyatsiya modeli asosida IP va MPLS tarmoqlari asosidagi ma’lumotlarni uzatish tarmoqlarining qiyosiy tahlili olib boriladi.*

Kalit so‘zlar: *tarmoq, ko‘p protokolli yorliqli kommutatsiya, paketli kommutatsiya, arxitektura, marshrutlash.*