International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 02 | February - 2023 Impact Factor: 7.185 ISSN: 2582-3930

Data Optimization Using SDN in Healthcare Systems

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Abstract - The transferring of the information from the source port to the destination port plays a vital role in our day to day life. The data which is confidential should be send in a platform where the exact data without any loss is received. The insufficient poor quality of data can have a negative impact on real time data processing. The data transmission path should be selected in such a way that the entire data should be received for the usage without any loss in the network link. The data should be received with the accuracy and with less delay. In this way a technology called Software Defined Networking (SDN) plays an important role in managing and controlling the various network conditions. In this way, an approach is being designed in this paper where SDN technology is being used to transfer the data with an appropriate path in order to receive the exact data. It is an application based approach so that the patient medical data is being send using SDN technology.

Key Words: SDN technology, OpenFlow switch, Dijsktra's Algorithm, Hyper Text Transfer Protocol

1. INTRODUCTION

SDN technology helps in managing the network status, traffic condition and to look after the data flow patterns in a network. It has a tremendous feature in the data transmission and communication between the source to the destination. The path selection has major effect on the quality of the data transmission at the destination which can be addressed using the SDN technology.

The path selection for the transfer of data is managed by the SDN controller. The controller is the main core element in the entire process. All the network information resides on the controller and according various policies or rules can be applied in order to achieve the required information.

If any problem has to be solved in the network then the operators can directly check on the controller which contains all the relevant information about every node in a network. The operators can solve the error faster and it is easy to optimize the network.

2. LITERATURE REVIEW

The OpenFlow is based on an Ethernet switch comprised of an internal flow table and an interface to add or remove the flow entries. The aim in this paper was to motivate the networking vendor to add the OpenFlow protocol in their switches and to enlighten the importance of that being used in the networking system. [1]
The author's named Yu Li and Deng Pan had designed a dynamic routing algorithm which basically uses the OpenFlow controller named Beacon for the fat tree network topology. It provides a multiple paths for a single host and depending on the algorithm it searches an optimum path based on the real time data statistics. [2]
Dijkstra's algorithm has being used by the author named to determine the best feasible path from one point to another. The SDN technology is being used for the data transmission and communication. The OpenFlow switch is being used with the SDN controller and according to the match with the flow table the corresponding routing decisions take place. [3]
The author named has designed an Artemis for the online healthcare systems in which the Artemis cloud is being used for gathering the patient medical data from the hospital and to store it in the cloud. According to the comparison with the cloud data certain medication and treatments are given according. [4]
The load balancing algorithm was being used with the SDN technology by the author named. The algorithm helps in computing the path for the data transfer in terms of network traffic and congestion. The queue length parameter was being taken into consideration to determine the network congestion. [5]
The author named had mentioned that insufficient quality of data reception can lead to affect the performance in the healthcare sector. In order to overcome this SDN technology is being used to transfer the data error freely. The configurations and policies are created in the controller which are transferred to the OpenFlow switches through a secure channel. [6]
The medical sensors may require higher bandwidth in terms of real time information and in order to overcome this the author named had proposed a load balancing algorithm based on SDN-SFC for data optimization and to monitor the network remotely. The SA and Greedy algorithm is being used and compared in terms of data transmission time. [7]
The author named has compared two approaches such as proactive and joint routing approach. The proactive approach failed due to breakage of the node which leads to the loss of data and breakage in the link which increases the latency time. The joint routing approach succeed in terms of routing functions used in the network in order to reduce the latency time. [8]
The author named has proposed a design on SDN based Edge Computing in IOT healthcare systems. The data collected is being send to the edge servers for processing. The server is being interfaced with the SDN controller to make routing decision and to enable new policies depending on the need of the user. [9]

3. SYSTEM OVERVIEW

A. Software Defined Networking

The Open Networking Foundation (ONF) developed the Software Defined Networking (SDN) architecture to support various standards of SDN. Software Defined Networking (SDN) is an approach for the networking systems that uses the controllers or application-based programming interfaces

(API's) to communicate with the hardware infrastructure and to control the data network traffic. The separation of the control plane and the data plane where in the OpenFlow switches are being controlled by the software applications and run by the controllers. The network administrator can change the network conditions by providing various policies in terms of priority through the controller. SDN also has the power in terms of security in assigning individual security to each network link.

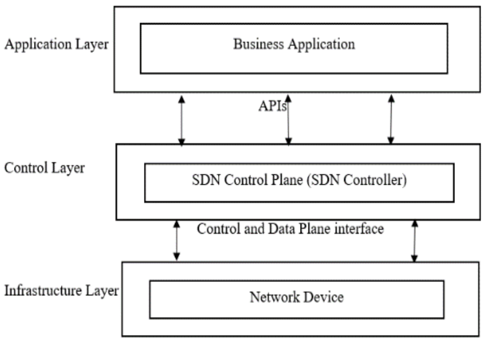

Figure 1: SDN Architecture

The network architecture consists of three layers named as the application layer, control layer and the infrastructure layer. The layers can communicate among themselves using northbound and southbound API's. The applications can communicate to the controller using northbound interfaces while the communication between the controller and the switches using southbound interfaces.

The application layer includes network application such as the intrusion detection systems, firewalls and the load balancers. The control plane acts as the central controller which is used to manage various security policies and data traffic in the network. The infrastructure layer consists of the number of switches in the network which helps in packet forwarding and to control the network traffic.

The main objective of the proposed system is to reduce the manual human efforts as in the process of making perfume to identify and formulate the chemical composition (for synthetic perfumes) always an expert perfumer is required we will use AI and machine learning programming to compute the components, percentage of these components required in the perfume to be manufactured for every specific individual. This method can revolutionize the manufacturing of perfumes in the perfume industry. As perfume industry is already growing in a boom, this method can contribute to progress it further.

B. Mininet

Mininet is a simulation tool used for most of the Software Defined Networking projects. It is used to visualize the switches and routers of software defined networking in a virtualized environment. It runs real code which includes Unix/Linux network application and Linux kernel. The code that we run and develop it in software can be used in hardware devices. Mininet is not sensitive to any programming language so any programming language can be used. It supports the application which use the OpenFlow protocol.

C. RYU SDN Controller

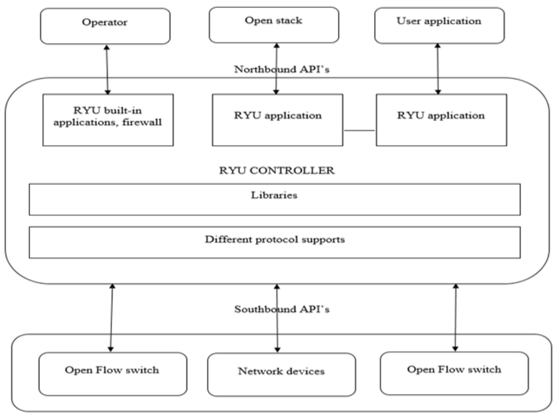

Figure 2: RYU SDN Framework

RYU SDN works as the controlling device in the SDN. The main aim is to control all the switches and networking devices in the networking system. It is programmed using python language and it controls the routing decisions in the network. RYU controller is designed to manage the entire network system and to adapt how the traffic is to be handled. It supports NETCONF and OF-config network management protocols.

D. iPerf

iPerf is a command-line tool that diagnoses network speed issues by measuring the network throughput that a server can handle. It can measure the bandwidth of the network and determine which server is not able to reach the maximum throughput. The below figure illustrates the bandwidth which is being measured by using iPerf. The figure consists of the client and server which can measure the throughput between the two ends. The throughput can be measured bidirectional or unidirectional as Device Under Test (DUT) and runs on various platforms such as Linux, Unix, and Windows.

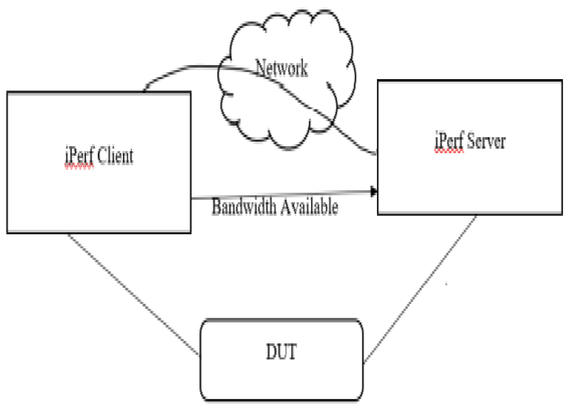

Figure 3: Bandwidth measurement using iPerf tool

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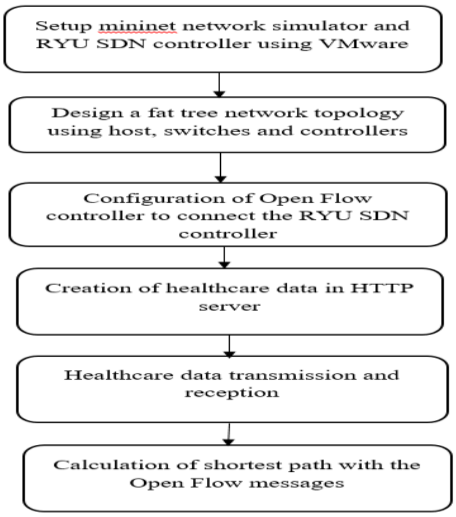
4. BLOCK DIAGRAM OF THE PROPOSED SYSTEM



5. IMPLEMENTATION

The entire setup is done on VMware Virtualization 16 software. The VMware software is used for a certain couple of Linux based virtual machine which will host the mininet software and RYU SDN controller. Both the VMs share the network connectivity with the host Windows machine with the IP address assigned using Dynamic Host Configuration Protocol (DHCP). The Ubuntu 20.04.5 version is being installed with the OpenFlow 1.3version protocol for simulation.

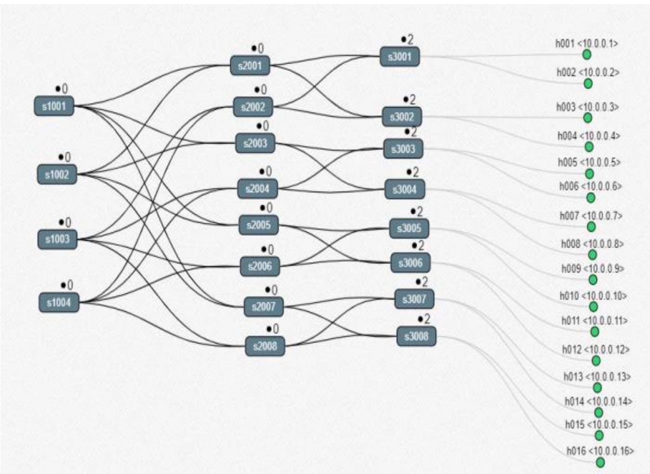


Figure 4: Fat tree network topology

The fat tree network topology is viewed in Spear Narmox which consist of 20 switches and 16 host nodes. The switches are distributed in three layers such as core switch, aggregate switch and edge switch. Each edge switch consist of 2 host nodes due to which it provides high bandwidth. The multipath is provided in the network in order to distribute the network traffic into various components.

RYU SDN controller is been used to control the actions taken by the switches from one node to another node. The RYU SDN controller and mininet is configured using IP address. The controller is used to calculate the shortest path to transfer the healthcare data from source host to destination host. The algorithm used is Dijkstra's algorithm to determine the shortest path.

6. ALGORITHM

The patient medical data is stored in the Hyper Text Transfer Protocol server and OpenFlow messages are used to check whether the packet should be dropped or to forward it. The RYU controller controls all the logic created for determining the shortest path. The ArpHandler class in the RYU Controller is used to initialize the information from the network topology. The create_interior_links function is being used to create the link between the source node and the destination node.

The shortest path is been calculated using Dijsktra's algorithm in terms of delay. If there is no match with algorithm then the data packet is being discarded and if it matches with the MAC address then the message is being pushed forward and printed as the shortest path. It check all the possible path in the link to reach the destination node in terms of delay. The shortest delay is considered to be the best path for the medical data to be transferred.

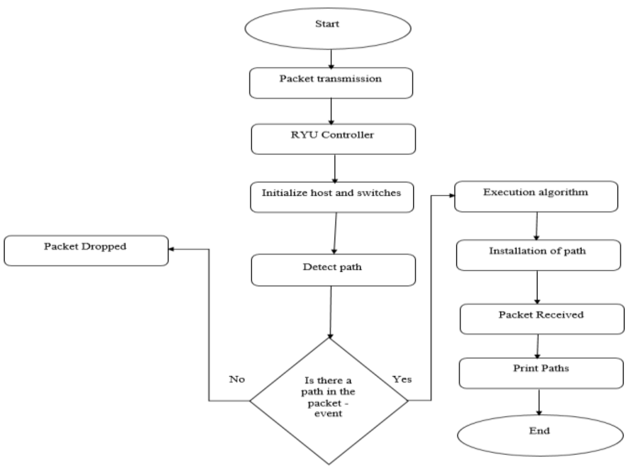


Figure 5: Algorithm Flowchart

7. RESULT

The mininet is being created in the VMware workstation 16. The mininet packages are being installed in the mininet as shown in the figure which is used in the SDN for the topology creation.

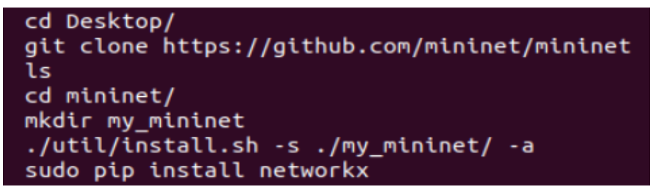


Figure 6: Mininet Package installation

The RYU SDN controller package is installed in the RYU controllers shown in the figure. The communication between the switches and the controller is done by using the default port number 6633.

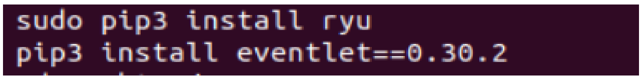


Figure 7: RYU SDN Package installation

The RYU controller stores all the information about the data packets of the network topology in the Software Defined Networking. The figure shows network connection is being established between the 16 host and 20 switches. The links are been set to a particular bandwidth of 0.20Mbit, 0.10Mbit and 0.05Mbit between the switch and the networking device for packet transmission.

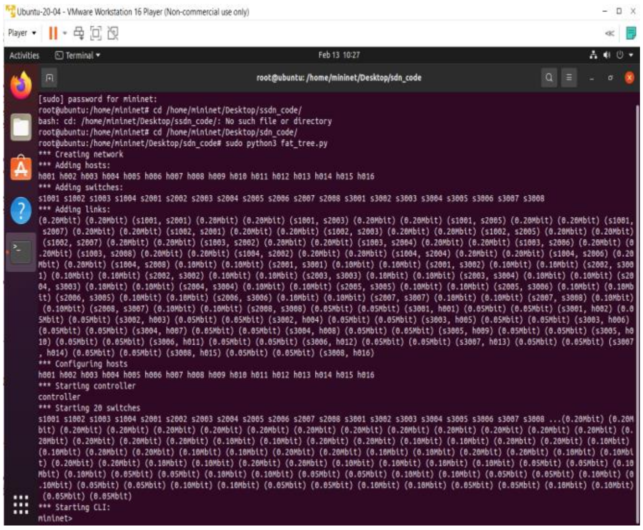


Figure 8: Bandwidth allocated for each link

The network connectivity is checked from one host node h002 to another host node h007 as show in the figure.

Figure 9: Ping from host 2 to host 7

The healthcare data is being stored in HTTP server through which the host node can retrieve the data. The node h002 ask for the medical data of patient 2 as shown in the figure from the node h007 which is stored in metadata.csv file.

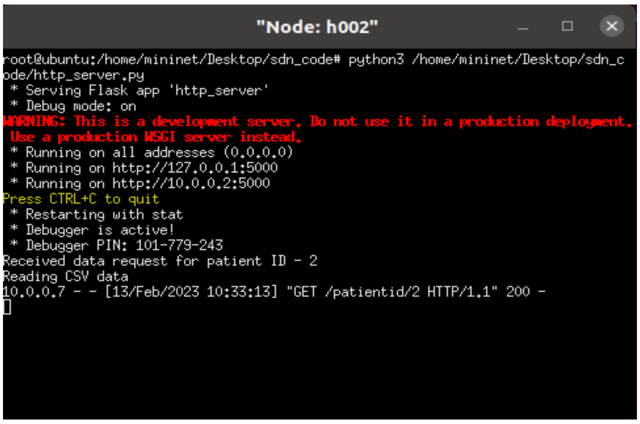


Figure 10: HTTP server request

The node h007 transmits the medical data of patient 2 as shown in the figure with a shortest path in terms of less delay.

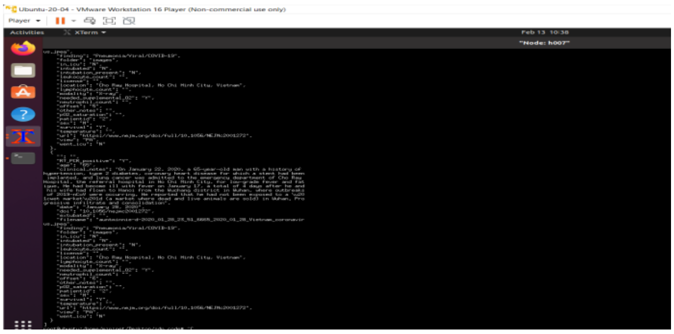


Figure 11: Medical data transmission

The shortest path from host node h002 to host node h007 is calculated as show in figure. It consist of 4 path for the data transmission from source to destination. The path with a less delay is considered to be the shortest path to reach the destination. The path following the switches [3001, 2002, 1003, 2004, 3004] with a delay of 231 which is to be least among other so it is considered to be the shortest path for the transfer of data.

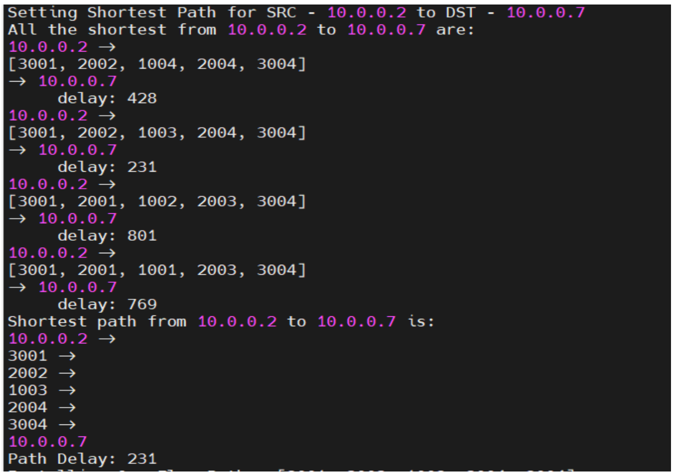


Figure 12: Calculation of Shortest Path

The OpenFlow messages are exchanged between the OpenFlow switch and the controller and accordingly it manages the data path as shown in figure.

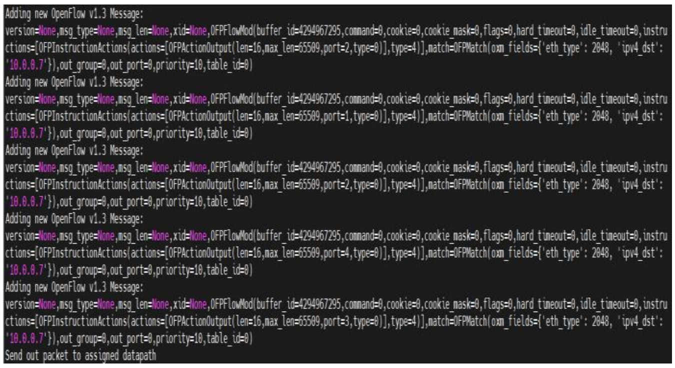


Figure 13: OpenFlow messages

The reception shortest path is also being calculated for the data to be received at the host node h007 from host node h002 as shown in figure. It consist of 4 path for the data transmission from source to destination. The path with a less delay is considered to be the shortest path to reach the destination. The path following the switches [3004, 2004, 1003, 2002, 3001] with a delay of 231 which is to be least among other so it is considered to be the shortest path for the transfer of data.

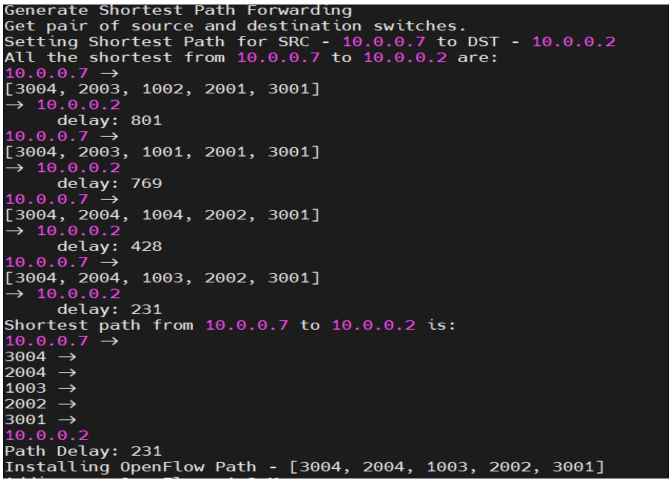


Figure 14: Calculation of Shortest Path

The OpenFlow messages according to the flow table is being displayed in the figure.

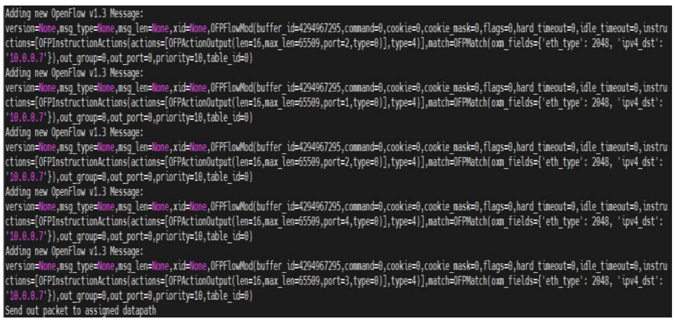


Figure 15: OpenFlow messages

8. CONCLUSION

Dynamic understanding of the network conditions makes it easy to take action and to improve the network performance. SDN technology is being used which supports most of the traditional network to change it in a programmable way that it enables virtualization of large wide area networks. OpenFlow protocol is been used to dynamically add flow entries to the network devices like switches and routers that can communicate using the protocol to manage the network.

The links in the network are been assigned a certain bandwidth such as 0.20Mbit, 0.10Mbit and 0.05Mbit where the data transfer with less traffic. We have stimulated a fat tree network topology using mininet tool. The RYU controller is used to routing the data packet and to calculate the shortest path form the source node to the destination node. The healthcare medical data is being stored in the Hyper Text Transfer Protocol (HTTP) server and accordingly the transmission of the medical data takes place from the source client to the destination client. The shortest path is being calculated using Dijkstra's algorithm in terms of delay simultaneously with the transmission of the medical data to the destination client.

Further the project can be implemented using various shortest path algorithm such as Bellman-Ford algorithm and Floyd Warshall algorithm for various fat tree network topology with different controllers. The project can be further implemented into a Wide Area Network (WAN) with large number of host and switches used in a network.

9. ACKNOWLEDGEMENT

I take immense pleasure to express my gratitude towards those who have motivated me during the entire project. I would like to thank my project guide Dr. Kiran V. Ajetrao and co-guide Prof Mr. Nitin Nagori for their support and guidance throughout my project.

10. REFERENCES

[1]N. McKeown, T. Anderson, H. Balakrishnan, G. Parulkar, L. Peterson, J. Rexford, et al., "OpenFlow: enabling innovation in campus networks," SIGCOMM Comput. Commun. Rev., vol. 38, pp. 69-74, 2008.

[2]Li, Yu, and Deng Pan. "OpenFlow based load balancing for fat-tree networks with multipath support." In Proc. 12th IEEE International Conference on Communications (ICC'13), Budapest, Hungary, pp. 1-5. 2013.

[3]J. Jiang, H. Huang, J. Liao, and S. Chen, "Extending Dijkstra's shortest path algorithm for software-defined networking," The 16th Asia-Pacific Network Operations and Management Symposium, 2014, pp. 1-4, doi: 10.1109/APNOMS.2014.6996609.

[4]H. Khazaei, N. Mench-Bressan, C. McGregor and J. E. Pugh, "Health Informatics for Neonatal Intensive Care Units: An Analytical Modeling Perspective," in IEEE Journal of Translational Engineering in Health and Medicine, vol. 3, pp. 1-9, 2015, Art no. 3000109, doi: 10.1109/JTEHM.2015.2485268.

[5]Huang, T. (2015). Path Computation Enhancement in SDN Networks. Master of Applied Science, Program of Computer Networks, Ryerson University, Toronto.

[6]A. Izaddoost and C. McGregor, "Enhance Network Communications in a Cloud-Based RealTime Health Analytics Platform Using SDN," 2016 IEEE International Conference on Healthcare Informatics (ICHI), 2016, pp. 388-391, doi: 10.1109/ICHI.2016.69.

[7]T. -M. Li, C. -C. Liao, H. -H. Cho, W. -C. Chien, C. F. Lai and H. -C. Chao, "An e-healthcare sensor network load-balancing scheme using SDN-SFC," 2017 IEEE 19th International Conference on e-Health Networking, Applications and Services (Healthcom), 2017, pp. 1-4, doi: 10.1109/HealthCom.2017.8210833.

[8]Satchou, Gilles & Nogbou Georges, Anoh & N'Takpé, Tchimou & Oumtanaga, Souleymane. (2018). Optimization of the latency in networks SDN. International Journal of Computers Communications & Control. 13. 824-836. 10.15837/ijccc.2018.5.3316.

[9]J. Li et al., "A Secured Framework for SDN-Based Edge Computing in IoT-Enabled Healthcare System," in IEEE Access, vol. 8, pp. 135479-135490, 2020, doi: 10.1109/ACCESS.2020.3011503.

[10]S. C. Nguyen, X. Zhang, T. M. T. Nguyen and G. Pujolle, "Evaluation of throughput optimization and load sharing of multipath TCP in heterogeneous networks," 2011 Eighth International Conference on Wireless and Optical Communications Networks, 2011, pp. 1-5, doi: 10.1109/WOCN.2011.5872966.

[11]Wang, R., Butnariu, D., & Rexford, J. (2011, March). OpenFlow-based server load balancing gone wild. In Proceedings of the 11th USENIX conference on Hot topics in management of internet, cloud, and enterprise networks and services (pp. 12-12). USENIX Association.

[12]M. Koerner and O. Kao, "Multiple service load-balancing with OpenFlow," 2012 IEEE 13th International Conference on High Performance Switching and Routing, 2012, pp. 210-214, doi: 10.1109/HPSR.2012.6260852. [13] S. S. Kulkarni and V. Badarla, "On multipath routing algorithm for software defined networks," 2014 IEEE International Conference on Advanced Networks and Telecommuncations Systems (ANTS), 2014, pp. 1-6, doi: 10.1109/ANTS.2014.7057278.

[14]H. Ren, X. Li, J. Geng and J. Yan, "A SDN-Based Dynamic Traffic Scheduling Algorithm," 2016 International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery (CyberC), 2016, pp. 514-518, doi: 10.1109/CyberC.2016.103.

[15]F. M. Shuker, "Improvement of Routing Protocol for IoT Network Using SDN/OpenFlow," 2019 1st AL-Noor International Conference for Science and Technology (NICST), 2019, pp. 54- 57, doi: 10.1109/NICST49484.2019.9043814.

[16]Peng, F., & Cao, T. (2021). Software-Defined Network Resource Optimization of the Data Center Based on P4 Programming Language. Mobile Information Systems, 2021.

[17]https://www.techtarget.com/searchnetworking/definition/software-defined-networking-SDN

[18]OpenFlow Switch Specification [Online], https://www.opennetworking.org/softwarede defined -standards/specifications/, Accessed: June 25, 2016.

[19]http://mininet.org/overview/, Iperf, http://iperf.fr/, May 2014.

[20]https://docs.opendaylight.org/en/latest/downloads.html.

[21]https://www.sdxcentral.com/networking/sdn/definitions/what-the-definition-of-software defined-networking-sdn/what-is-sdn-controller/openflow-controller/what-is-ryucontroller/#:~:text=Ryu%20Controller%20is%20an%20open,adapt%20how%20traffic%20is%2 0handled.

[22]https://biztechmagazine.com/article/2013/10/understanding-different-layers-routing-andswitching

[23]https://www.geeksforgeeks.org/dijkstras-shortest-path-algorithm-greedy-algo-7/

[24]https://brilliant.org/wiki/dijkstras-short-path-finder/