Improved QoS Using Novel Fault Tolerant Shortest Path Algorithm in Virtual Software Defined Network (VSDN)

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***Abstract*—In this Era of technology, the Internet has become a primary means of communication and information exchange. According to the world statics (2018) 55.1% of world population use internet. The major drawback in today's Internet is that it there is no guarantee of Quality of Service (QoS) to users. To fulfill the required services Internet Service Providers (ISP) establish a Service Level Agreement (SLA) with the users. This SLA includes different parameters that provide QoS. These QoS parameters are bandwidth usage, reliability, energy consumption, failure detection, elastic resource utilization, cost and many more. Either to maximize the profit or due to Capital Expenditure (CAPEX) and Operational Expenditure (OPEX), ISP tries to establish maximum SLA's which result in degradation of requests services by users. Connection failures occur frequently, which is due to node failure in the network. When a node fails re communication from the source is done, which leads to wastage of energy and time. One of the solutions is mixing of SDN and VN to form VSDN. This paper presents a fault tolerant shortest path algorithm which takes into account matrices like energy consumption, bandwidth usage, saturated links and successful allocation of nodes and examines node risk failures in the allocation process. When a failure in network occurs, an alternate path is used which is unprofitable for ISPs as it leads to less resource wastage and increase in traffic tolerance. The proposed Fault Tolerant Shortest Path (FTSP) algorithm examines the node risk failure and find the shortest path to having higher bandwidth availability and focus on energy saving. Results shows 35.8 % increase in performance of the proposed algorithm w.r.t Bandwidth energy efficient algorithm with comparatively lesser overhead during node failure.**

Keywords—Quality of Service (QoS), Virtual Software Defined Network (VSDN), Service Level Agreement (SLA)

I. INTRODUCTION

The internet has become a primary means of communication and information exchange. Everyone wants to be connected to the Internet. According to world statics [1] in December 2018 there were 55.1% of internet users from the world total population. In January 2019 approx. 4388 million users are connected to the internet either by mobile devices or through smart device. Boston Consulting Group (BCG) predicted, by 2025 in India only there will approx. 850 million internet users. As every person is connected, any delay is the internet service upsets the users. The major drawback in the current Internet is that it there is no guarantee of Quality of Service (QoS) to users. To fulfill the required services Internet Service Providers (ISP) establish a Service Level Agreement (SLA) with the users. This SLA includes different parameters that provide QoS which are bandwidth usage, reliability, energy consumption, failure detection, elastic resource utilization, cost and many more. Either to maximize the profit or due to Capital Expenditure (CAPEX) and Operational Expenditure (OPEX), ISP try to establish maximum SLA's which result in degradation of requested services by users. Which leads to poor delivery of the services requested by the users.

However, when ISPs keep in mind about their profit, they will deliver poor services and hence failure events will occur frequently. Resilience is a key requirement to ensure QoS. Network Resilience defines the capacity of a network to keep minimum specific level of services when failure occur [3]. When few components are used the energy, consumption is minimized. But it cost to resilience as there is no alternate path after failure in the topology. So, both parameters are essential in the network management and planning. To overcome the problem, researchers from both industry and academic proposed many solutions. One of the solutions is mixing of Software Defined Networking (SDN) and Network Virtualization (VN) to form Virtual Software Defined Network (VSDN). Whenever a node fails in the network an alternate path is used which is unprofitable for ISPs as it leads to resource wastage and increase in traffic tolerance. The proposed algorithm examines the node risk failure and find the shortest path to having higher bandwidth availability and focus on energy saving. It will decide which links and nodes will be part of the network in VSDN environment and will also enhance the network parameters like Successful allocation, saturated links, energy consumption to give better performance and will also do better resource allocation.

The rest of the paper is organized as: Brief introduction related to the proposal is given in Section 2. In Section 3 related work is given and then summarized in tabular form. Section 4 formulates the problem and the proposed work has mentioned in section 5. Experimental work has discussed in section 6 and at last in section 7 conclusion of the paper mentioned.

II. BACKGROUND

Today's Network infrastructure is not able to cope with the increasing demands of Inter users. As the control plane and data plane are coupled together in a single node, the

access to the data plane is lost. Also, when a new node is added in the network the Administrator has to manually do the required changes. The solution to all these problems is Software Defined Network (SDN). SDN decouple the control plane from the data plane. And logically centralize the control plane. Noe this centralized control plane is the point of access to Network Administrators, which help them to dynamically manage the network nodes. By SDN visibility is given to the real time responses. Network Virtualization is another approach which allows ISP to dynamically couple virtual heterogenous network. The Mixing of these two approaches gives Virtual Software Defined Network (VSDN). VSDN use network hypervisor [4] which slice (virtual network) the network into layers, which can be separately configured by using required protocols and resources use algorithm to slice the virtual Network. Bandwidth Energy Efficient [3] decide Table 1: Literature Review which node participates in the network and according to the results specify the QoS parameters.

TABLE I. LITERATURE REVIEW

Reference	*Environment*	*SLA*	*Parameters*						
			Bandwidth usage	*Energy Efficiency*	*Power consumption*	*Cost reduction*	*Reliability*	*Elastic resource allocation*	*Node failure detection*
Zang et al. [11]	SDN	×	×	✓	×	×	×	×	×
Wang et al. [12]	SDN	×	×	✓	×	×	×	×	×
Wang et al. [13]	VN	×	×	✓	×	✓	×	×	×
Carvalho et al. [13]	VN	✓	average	×	✓	×	×	×	×
Mahadevan et al [6]	Generic network	×	✓		Up to 16%	×	✓	✓	✓
Gomes et al. [7]	VN	✓	×	×	×	×	✓	✓	✓
Gomes et al [10]	VSDN	✓	✓	high	×	×	✓	✓	✓
Chiaraviglio et al. [8]	Green network	✓	high		Up-to 35%	✓	×		
Kim et al. [14]	SDN	×	high				✓	✓	✓
Gomes et al. [9]	VSDN	✓	high	✓	×	×		×	×
Gomes et al. [3]	VSDN	✓	high	✓	×	×	✓	×	×
Gomes et al. [26]	VSDN	✓	✓	✓	×	×	✓	✓	✓
Singh et al. [27]		✓	✓	×	×	Upto 26.65%	✓	×	×
Yang et al. [28]	SDN	✓	✓	✓	×	×	✓		✓
Gaolei et al. [29]	SLA-aware QoS mechanism	✓	✓	✓	×	×	✓	✓	×
Proposed work	VSDN	✓	✓	✓	✓	×	✓	×	✓

III. RELATED WORK

This section summarizes the work done by the researchers to achieve QoS by using different approaches. The literature review is presented in a tabular form in table1. In the table column ‘environment’ presents the network environment in which the protocol was used. SLA column specifies if the protocol negotiate SLA between the ISP and users. The column ‘parameters’ gives the behavior of the protocol in the form of network parameters where bandwidth usage means does the protocol put effort on efficient usage of bandwidth, energy efficiency of the protocol is presented in the next column, reliability column check whether the protocol is reliable or not. In ‘power consumption’ column the overall reduction of power by the algorithm is studied and last column ‘failure detection’ present, whether the protocol work on the of fault or not.

IV. PROBLEM FORMULATION

Issues Extracted from the literature survey are as:

1) Effect of failure of node is not much covered by the researchers.

2) Effect of node risk failure is also not covered in the literature.

3) SDN integration with VNs is majorly ignored by the researchers.

The proposed work in this paper will overcome the issue of node failure providing better performance for QoS parameters including bandwidth usage and finding an efficient path for communication.

V. Proposed Simulation Methodology

The proposed fault tolerant algorithm focusses on the node failure in VSDN network. Whenever a node fails, the proposed algorithm finds the shortest having higher bandwidth and utilize the energy. It uses the Dijkstra algorithm to find the path. The fault tolerant algorithm uses link weight. The equation is given (1) as

$$w = log\left(\frac{BW}{BW_r}\right) + \frac{E_c(BW)}{E_c(BW+BW_r)}$$

B_w = available bandwidth of link.
Bwr = bandwidth requested by user.
Ec(x) = energy consumption of link.

Balance between energy efficiency and bandwidth is given in equation (1). log (BW/BWr) identifies the impact of requests bandwidth under available bandwidth. The other part of the equation (1) gives the measurement of energy consumption. The relation between the bandwidth and energy consumption is given in [5]. Bianzio et al. Explained that when the speed of the link is 1000Mbps, 600Mpbs or 1 Gbps then the power consumption is 0.48, .09, 1.7 (in watts) respectively. To find the fault tolerant shortest path Dijkstra algorithm is used. It counts the number of times each link used to be part of the path. By this, a record is kept which will save the bandwidth.

An overview of the proposed fault tolerant shortest path algorithm is presented in Algorithm1 as:

STEP 1: For all links L do *//L set of all links in the network*

STEP 2: If l >=Bwr *//particular link in network*
assign l=weightage according to eq (1)
STEP 3: else
assign l= ∞
end for

STEP 4: Set all nodes=unprocessed //unprocessed nodes are those which are not included for transmission

STEP 5: If nodes= processed
End the process

STEP 6: Else
Do
From the unprocessed nodes, find nodes having link weightage with lower sum.

STEP 7: If
The selected node does not possess the bandwidth requested then
Do
Using Dijkstra shortest path algorithm reroute the node and go to step 6

STEP 8: Else
Update the selected node.

Step 1 and 2 assign weight to the links using Eq (1). step 4 to step 5. The shortest path is selected with lowest weight. At step 7, if path does not get the required bandwidth Dijkstra algorithm used (that is when a node fails). Step 8 update the value with minimum weight. By this algorithm ISP provides the users their requested services also getting maximum benefit.

VI. Simulation Results and Discussions

Two experimentations are done within this context. First, working of the proposed algorithm at node failure is shown.

In the second experimentation a comparison is made between the proposed and existing algorithm for performance evaluation. Gomes et al [3] presented Bandwidth Energy Efficient Algorithm which was discussed in problem formulation section. For the Simulations Matlab was used. The parameters used for simulations are given in table 2.

TABLE II. Simulation Parameters.

Symbol	*Value*	*Description*
destination. x.y	100, 50 (resp)	destination on x-axis and y-axis
TX_energy	50*0.00001	transmitting energy receiving energy
RX_energy	50*0.00001	
free_space	10*0.00000001	free space data
DA_cost	5*0.00001	aggregation time it
simulation_time	1000	simulates
Source	1	from where packet generate(starts)
Number of nodes	10,20,…,100	nodes taken for comparison

In Figure 1. yellow diamonds are the source and destinations. For this communication 30 nodes are taken. As discussed earlier, the nodes are chosen randomly in the communication. A node failure is shown in figure 2 during the communication. Whenever a failure occur the algorithm will reroute the path using Dijkstra algorithm. It will choose the path with higher band width. Also, will focus on energy saving. Rerouting of path is shown in Figure 3. And at last successful communication is done which is shown in Figure 4.

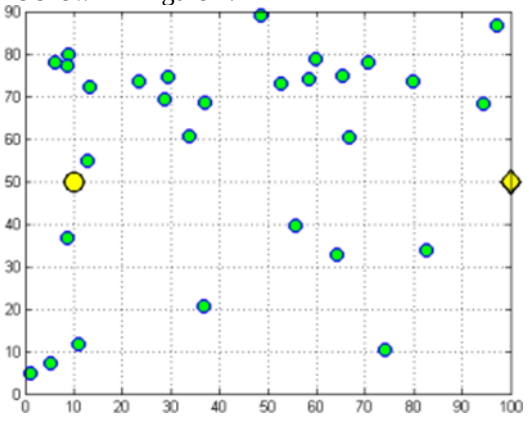

Fig. 1. Initial nodes before communication.

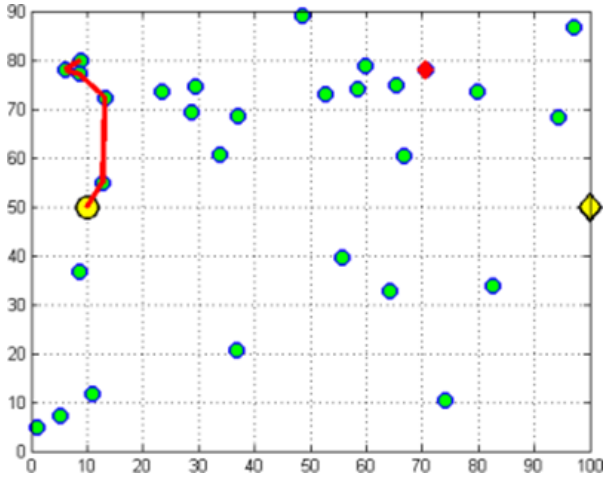

Fig. 2. Node Failure occur during transmission. (red node indicates failure).

Step 1 and 2 assign weight to the links using Eq (1). step 4 to step 5. The shortest path is selected with lowest weight. At step 7, if path does not get the required bandwidth Dijkstra algorithm used (that is when a node fails). Step 8 update the value with minimum weight. By this algorithm ISP provides the users their requested services also getting maximum benefit.

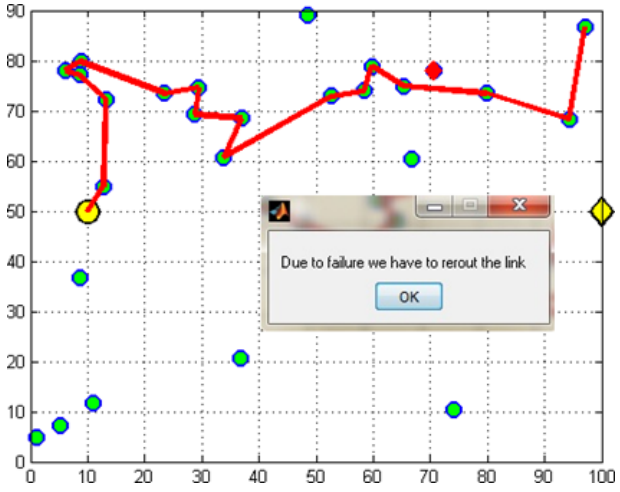

Fig. 3. Instead of making a re-connection path is rerouted.

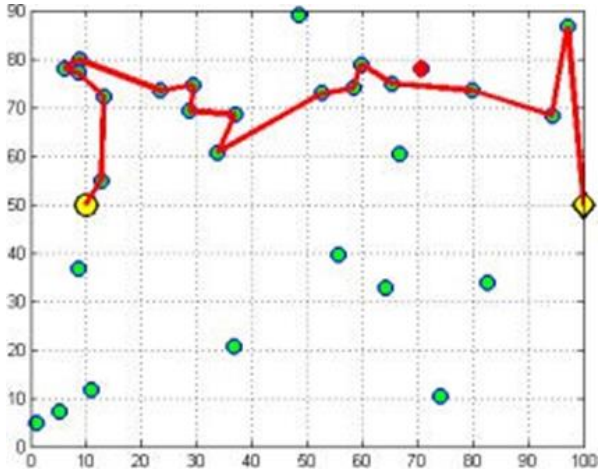

Fig. 4. Successful Communication.

The values of the QoS parameters achieved for the above simulation for 30 nodes are as follows:

Qos Parameters	*Value (nodes taken 30)*
Successful Allocation	3.7586
Saturated links	1.5273
Bandwidth used	13.2719
Energy Consumption	3.8224

In order to quantify the improvement, the results obtained with Fault Tolerant Algorithm are compared with Bandwidth Energy Efficient Algorithm asunder. For the comparison of the existing and proposed algorithm nodes from 10 to 100 are taken. The nodes are randomly chosen.

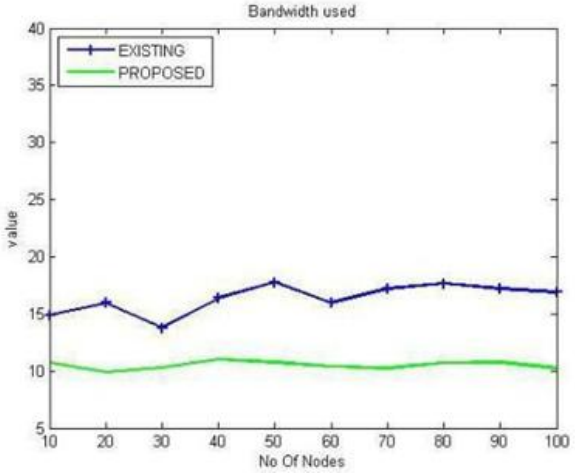

Fig. 5. Comparison of 'bandwidth usage' between FTSP and Bandwidth Energy Efficient Algorithm

Bandwidth usage is the amount of bandwidth used by the link once the request is allocated. FTSP algorithm use 25% less bandwidth than the BEE algorithm.

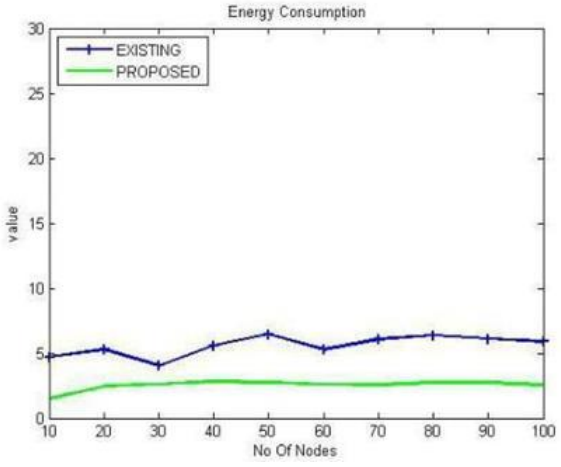

Fig. 6. Comparison of 'energy consumption' between FTSP and Bandwidth Energy Efficient Algorithm.

Energy Consumption is the amount of per quantum energy used in the network infrastructure. FTSP use 14 % of less energy than BEE algorithm.

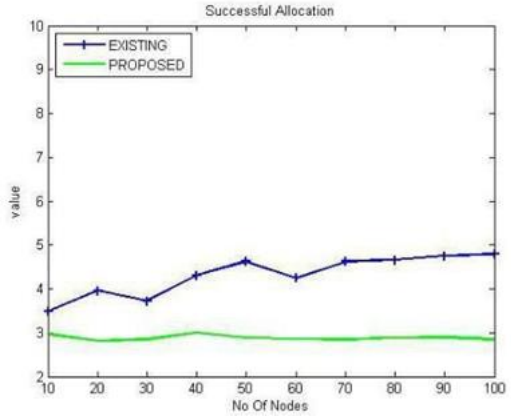

Fig. 7. Comparison of 'successful allocation' between FTSP and Bandwidth Energy Efficient Algorithm.

Successful Allocation is from the incoming requests in network how many are successfully solved. 32.88% more requests are successfully allocated than the existing.

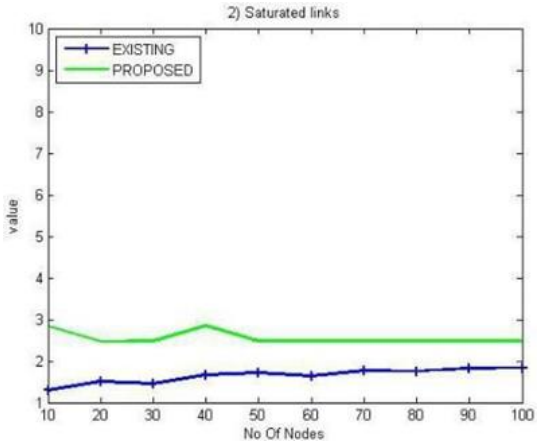

Fig. 8. Comparison of 'bandwidth usage' between FTSP and Bandwidth Energy Efficient Algorithm.

Saturated Link is the maximum load a link can handle. FTSP algo provides 55% increased traffic tolerance.

The QoS parameters are improved by the proposed algorithm. These QoS parameters include successful allocation, energy consumption and the bandwidth usage. The results are shown 35.8% increase in performance of the proposed algorithm with respect to existing algorithm.

VII. CONCLUSION

The usage of internet is growing day by day. Major part of human life now day relies on the internet. To get the internet service users make SLA with the ISP. To get more SLA's for profit ISP degrade the performance which lead to poor services to users.Any delay or loss of internet connection makes the users irritated. To overcome with this problem VSDN is a good solution. The fault tolerant algorithm with VSDN proposed in this paper deals with the node failures. Whenever a node fails, instead of starting the communication from the beginning, re-routing from the failed node is done using Dijkistra Algorithm. It is unprofitable to ISP's Which gives the shortest path to having higher bandwidth availibity and also work on energy efficiency.

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