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Predictive Analysis Of Telecom System Quality Parameters with SDN(Software Define Networking) Controlled Environment

Khawaja Tahir Mehmood (Department of Telecommunication Systems, B.Z.U, Multan, Department of Electrical Engineering, KFUEIT, Rahim Yar Khan), **ktahir@bzu.edu.pk.**
Dr.Shahid Atiq (Department of Electrical Engineering, KFUEIT, Rahim Yar Khan), **shahid.atiq@kfueit.edu.pk**
Muhammad Waqas Hashmi (Department of Telecommunication Systems, B.Z.U, Multan, Department of Electrical Engineering, KFUEIT, Rahim Yar Khan), **Waqas.hashmi@bzu.edu.pk.**

ABSTRACT: In this research article we have analyzed several Telecom System quality parameters (i.e. throughput,end to end delay,packet loss,latency and bandwidth etc) enhacement schemes based on SDN environment for extracting the best possible method to obtain the fruitful results.We have done implementation on the define Telecom Network in three portions.In the first portion the complex flow based mesh network in SDN controlled(POX controller) environment is installed on Mininet and the system quality parameters are analyzed and ploted in I-perf and J-perf utilities by applying two different quality based algorithms namely AM-QOS(active measurement based QOS),SQAR(stimulated annealing based QOS), and draw their comparision with lagecy network (without SDN controller).The results shows that AM-QOS is better in term of system quality parameters as compared to SAQR and lagecy network. In the second portion the Hybrid approach even though with less QOS based results, shows that practically it is not fessible due to higher cost to completely change system switches status from lagecy switches to open flow based SDN switches but with hybrid network approach creating virtual foudation between lagacy switch and open flow switch can help the ordinary network with legacy switches to be centralizedly controlled and even give better QOS based results as comapred to ordinary network. In the third portion of the implementation the active sensing measurement is compared to polling method(tradictionally used for network parameters calculations) with results it can be analyzed that obtained system quality parameters are quite near so active sensing method can be considered helpful in designing system quality based alogrithm to be used in SDN controlled environment.

KEY WORDS: SDN, QOS, Legacy switch, AM-QOS, SAQR, Active sensing measurement, polling.

I. INTRODUCTION:

In the modern-era of emerging technologies, due to intense development in the field of Telecommunication Networks, IoTs, Big Data applications, Cloud Computing and ever increasing demand of higher data rates, the traditional networks and current prevailing techniques cannot fulfil modern day system and user requirements. Today all the technologies in the field of Telecom Networks require software oriented and controlled network architectures. One such software based technique is SDN (Software Defined Networking) which consist of three main operating layers based control system. In the first layer there is a program application, second layer contain network controller and system status measurement schemes as provided by the application layer program and the third layer contain the data forwarding/routing schemes as guided by the second layer. In the SDN the abstract view of whole network is obtained with the help of second layer (centralized controller) [9] for better management of the network. The quality constrains calculations in SDN is fast and managed in easier manner. A case study in research article [10] shows that SDN out-performed a traditional/legacy network by the 47% in the presences of
higher congestion environment with 256 severs. While case study in [11] reflects that SDN over through the entire fragile traditional networks when used for Hadoop application even in the case of normal forwarding modes. One of the biggest hurdles in the successful communication (i.e. wired or wireless) in current era is the system quality parameters. They are measured through end results of any communication cycle on the basis of maximum throughput, end to end delay, latency, jitter etc. On the obtaining smooth results of above mentioned quantities the one can say that applied technique have performed better.
The SDN provides the result far better with separate data and control layer as compared to other network architecture techniques [1]. This article is further subdivided in five more section as following .In **section II** the basic SDN architecture is presented .In **section III** the literature review of different technique based on differential analysis of different research articles to further obtain better system quality constrains. In **section IV** the experimented setup is created and above mentioned algorithm are applied to study system quality constrains .In **section V** results are discussed along with conclusion.

II. SOFWARE DEFINED NETWORKING (SDN):

Software Defined Networking (SDN) is the software application based network architecture approach that allows the dynamic configurations of network along with flexible programmability along with centralized control as compared to decentralized and complex traditional network approach. Today the networking World including internet applications are using protocols namely (IP, BGP, MPLS, Ethernet, Virtualization based on VMware) for user data transformation.

The SDN contains all the features and these protocols can easily be employed in SDN environment, with this flexibility the SDN is becoming major force in virtualization of the network for better control and enhancement of system quality parameters [7-8]. This all is accomplished with different control and data layer [5]. The control layer of SDN where all intelligence is incorporated can have two or more controllers to obtain better system quality constrains. The SDN basic framework is shown in figure(I) includes five important features for better understanding of its architecture the (1)SDN Application , (2)SDN controller ,(3)SDN Data-Plane,(4)Control to data path interface(CDPI),(5) Northbound Interface (NBI)[2-3&6].

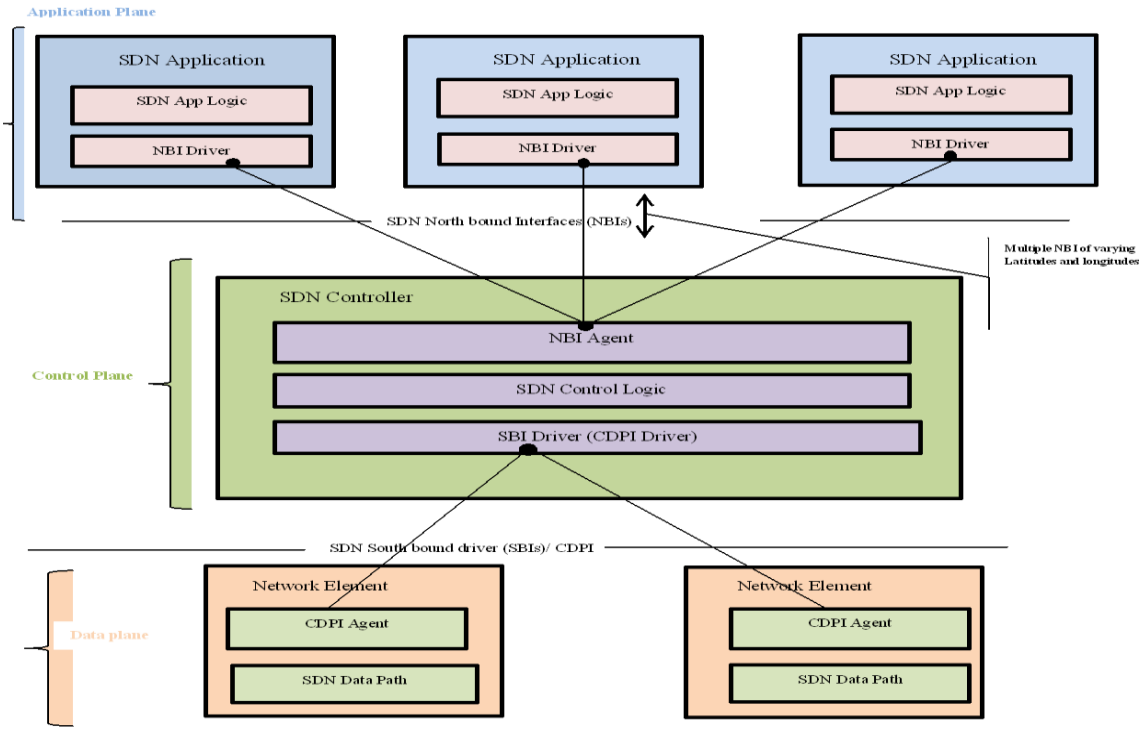

Figure I: Architecture of SDN (Software Defined Networking).

SDN applications are the user required network behaviour that in simple meaning are the instructions that is to be conveyed in the form of some programming language to SDN controller in the control plane with the help of North bound interface .The application program layer may have the image of abstract view of the network to be controlled in SDN environment. It can also be proved helpful for further amendment in system behaviour with the control results obtained in the abstract view of the network image. SDN control plane normally consist of north bound agents for accessing the requirement obtained from the application layer and the controller to route and flow control the data plane with help of south bound (or CDPI).In the data plane the south bound agents exist and allow different data routing devices to work according to the instruction given by the controller and after every successful flow the controller guide the application program with north bound for further updates after accessing the system quality(throughput, bandwidth, latency, etc.) based results.

III. LITERATURE REVIEW:

This section includes different techniques along with their practical constrains and fruitful effects to obtain better system quality (i.e. throughput,end to end delay,packet loss,latency and bandwidth etc) results. In

order to access the correct quality parameters the load on the SDN environment is divided into two parts (1) data load (being shared among different data travelling devices (routers, switches, etc.).(2) Control data (instructions from controller to data layer).The basic framework of load in SDN is divided into two categories: Network load measurement and Network load management [4]. The network load framework with two subsystems is shown in figure (II).

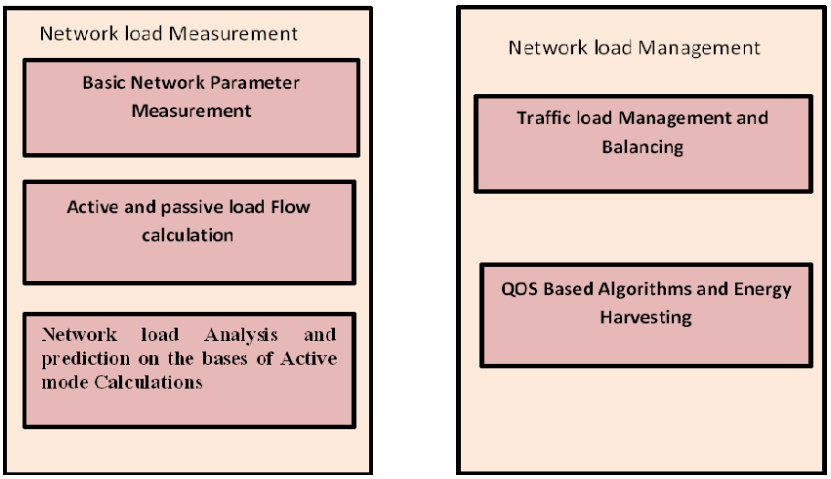

Figure II: Framework for System Quality Constrains management in SDN based Network.

In Network load measurement we deal with control, measure and access information of the network current status of working. The network current status of working means topology of the underlying network, ports status, throughput, bandwidth, latency, packet drop rate, end to end delay etc. By getting this information we can predict that where the network is performing well in the current circumstances .While in the Network load management we managed the system quality parameters by running different algorithm with the results obtain from the load parameters measurement. The detail of all the subsystems along with different techniques in differential view form is as under:

A-Basic Network Parameter Measurement:

The SDN basic network parameter measurement includes the measurement of network topology, network load parameters and network performance under north bound instructions. The SDN maintain the general topological information of the under lying network by using LLDP (Link Layer Discovery Protocol)[12] and STP (Spanning Tree) protocol.

In this protocol the controller send LLDP packets as Packet-out-message to all the switches in the network. When the switch receives the LLDP packet from the controller it sends to all other switches directly connected to it. When the switch receives the LLDP packet from other switch it sends the packet as Packet-in-message to controller for help to model the flow and by this packet-in-message the controller detects which switches are connected to each other and access global topology [13]. This is the simple network topology extraction in the case where all are SDN based switches, while in the practical arrangement of Hybrid network (combination of legacy switch and open flow based switch) where we cannot replace or change all the legacy switch with SDN switches due to higher cost we prefer to work in above mention network arrangement[5].This arrangement is shown in figure(III).The STP packet creates a virtual switch in the controller composed of two or three legacy switches with two ports .The first ports contain the MAC address detail and second port information about port id and bridge id .

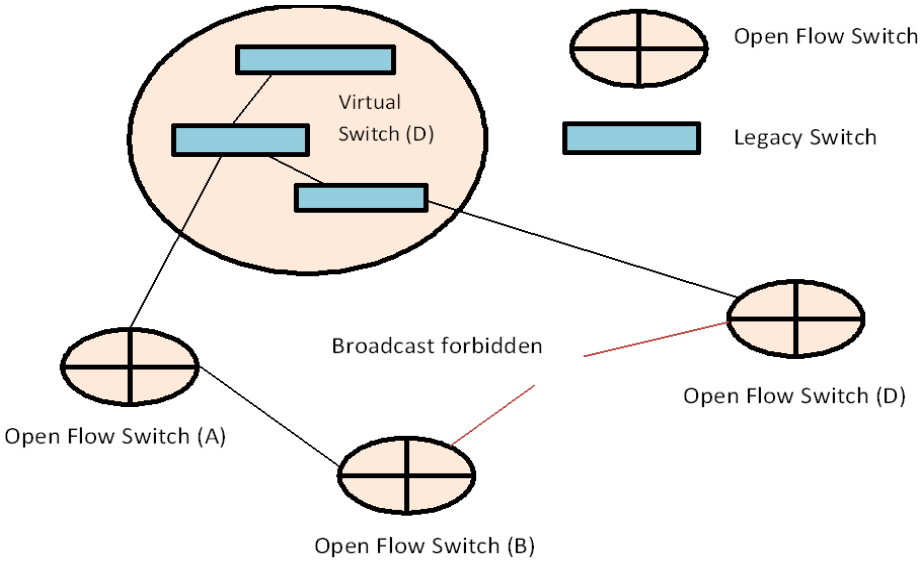

Figure III: Formation of Virtual switch in the controller and flow mechanism in Hybrid Network.

We can route a packet from switch (A) to switch(D) via virtual switch (D) by first sending the packet out information (false packet) to Virtual switch(D) from switch (D) that tell that packets contain destination address of switch(D) and should be send to switch (D).So this how the flow is managed.
The network load parameters include the amount of data successfully passed through the network devices. In research article [14] Prog-ME was developed which statistical flow data of each node which was not accurate while calculating exact quality constrains to judge network performance .In research article [15] Open-TM was discussed which was used to calculate the net flow of all the network nodes according to the routing instructions given by the controller and give approximate results. In research article [16] the I-STAMP method was used based on TCAM (Ternary Content Addressable Memory table) to calculated network load parameters by creating flow matrix, but have one major drawback that the packet passing through same network devices with same flow is considered one and no separate entry is allocated to them so at the end when all efficiency is calculated the system accuracy in term of maximum through put is not judged. In research article [17] the authors discussed the traffic measurements of data centres with ToR SDN switches only but difficult to implement in practical Telecom Network which prefer the hybrid network to save cost as mentioned above in [5].In research article [18] Open-Net method is discussed it monitors throughput (by accessing only the last switch in the path instead of whole flow), Packet loss (by accessing flow detail in first and last switch in the flow that how many packets entered in the first switch and got out in the last switch in the forward path flow loop) and Delay (it send the message from the control layer to date layer and see after how much type it appeared at the controller side?) . In article [19] the flow sense method was designed for the aid of controller to judge the performance of each switch after every flow and especially in the case of flow removed message.

B-Active and Passive load Flow calculation:
The Network load measurement can be divided into two methods. (1) Passive mode (in this mode we only measure the flow of packets coming in and out of the network devices). (2) Active mode (in this mode we do some extra calculation in addition to the actual flow happening so that its value could be used for future load prediction in the SDN network).In SDN we normally preferred the Active mode based flow measurements. In research article [20] the NET-Flow method designed by the CISCO is discussed and gives approximate graph of the network instead of giving the new flow information (flow not managed in the routing table of the router by the controller) of each node so that by getting active information about that node can aid the controller to managed the flow in that node properly. In research article [21-22] the S-Flow and J-Flow is discussed that give the message about each flow (already managed in routing table of router and new flow not managed) to controller making it loaded in the case of large topology based network. In research article [23] a low cost method namely the (pay-Less) method based on polling to detect the flow was discussed, which in this paper we have compared with active sensing method and obtained the satisfactory results to overthrow this method. In research article [24] Open-Sketch method is discussed which involve different types of hash algorithms (process involving conversion of data into string with secure Hash algorithm) depending upon data types and application layer SLA. This method involves large

amount of hardware infrastructure and doesn't seems to the ideal choice in the case of large networks. In research article [25] the authors discussed a management of hardware network project DREAM, which consist of have the three level one for user to input the command (which are the requirement to be fulfil) and second level includes the algorithm running on SDN to full fill the command or guide the network devices accordingly and important layer that is to guide the controller on giving his status to take new task or not.

C-Network load Analysis and prediction on the bases of Active mode Calculations:

The network load prediction is very important to have better control of the system in term of throughput, bandwidth enhancement, latency, end to end delay. In this session few load predictions method are discussed and as following: In research article [26] ATD (Anomalous traffic detection) with SDN was discussed but it was limited to specific scenario and cannot be applied to real time controlled environment. In research article[27] the Open TAD method is discussed this is light weight online load traffic detection method it only work for small network but its effective and easy to design. In research article [28] Nice system was discussed is used to error in open flow applications. The router that that running open flow applications but are not accessed by controller can be resolved by above mentioned method. In research article [29] Veri-flow was discussed it is deployed between SDN control layer and data layer and used to check the flow managed (assign the class to each network device having same or different flow and check forwarding picture of each flow) by the controller and update / modify the flow by accessing system status in term of packet loss ratio and after upgradation inform the controller about new modified flow rules.

D-Traffic load Management and Balancing:

With the help of result obtained in sub-section (A, B, C) one of the major goal remains is to manage the load to better efficiency of SDN controlled network. In research paper [30] one of major flow of ECMP (equivalence multi path routing) is discussed. The main problem is formation of elephant flows (if the path to route the data is shortest and we always prefer shortest path for data routing is loaded then all the packets will follow the command in algorithm and keep on moving in that load shortest path keeping rest of path even though not shortest unload/un used this is elephant flow) which create the waste of bandwidth and efficiency and the scenario is shown in figure (IV).

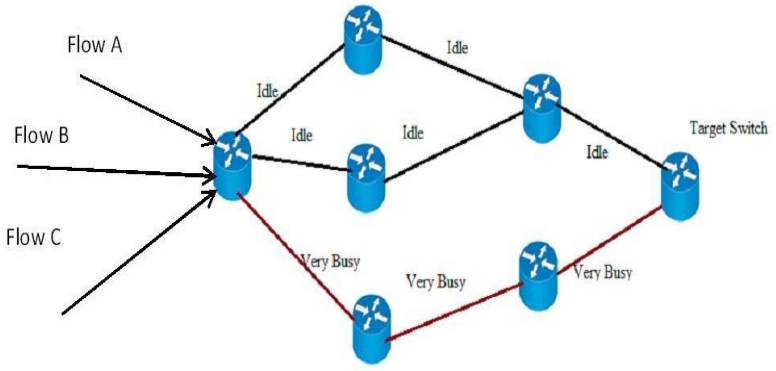

Figure IV: Formation of Elephant Flows in ECMP

In research article [31-34] several method were discussed to find the elephant flows in ECMP method but were complex and required large complex iteration in the algorithms. In research article [35] the packet is send by using ECMP method with specific timing (t<=Tc). If the packet is in que for the time (t>Tc) then it labelled it as elephant flow and dropped that packet and ask to resend after some wait in random time. In research article [36] the ECMP method is used but this time with priority mechanism. The data packets with low priority are sent by ECMP and if elephant flow occur that matter is dealt with same as mentioned in (35).But for high priority data link state optimization is done. In research article [37] the packet are forwarded with only link state optimization algorithm. While in the case of Devo-Flow[38] and DIF-ane[39] method controller modified the routing table of each switch if by following that command the elephant flow occur the switch are ask to manage the flow itself and message the controller to be better controlled for next flows.

E-QOS Based Algorithms and Energy Harvesting:
In the SDN controlled environment to have better quality based result several algorithm techniques are discussed. In this article we will apply (AM-QOS[1] ,SAQR[5]) QOS based algorithms and discuss the quality constrains in them. One of the important matters of concern in modern day crises is energy shortage. According to study as mentioned in[40-41] telecommunication networks account for 5% for overall energy consumption in developed countries and going up to annual increase10%.In research article[42] IPGA(iterative parallel clustering algorithm) is discussed which help us find minimum number of switches required to flow data in SDN control network by switching off additional switches hence saving energy 30%.In [43,44] some other energy harvesting techniques were discussed to limit the elephant flows by finding exact shortest path or the path with less number of relay nodes and switching off additional network devices.

IV. EXPERIMENT SETUP:

This section is further sub divided into three sections which is as following:

Section-I

Deployment of complex mesh topology on Mini-Net with AM-QOS,SAQR QOS-based algorithms and Lagecy network.

The above mentioned algorithms is applied to six switch based Mesh topology with each having 10 hosts except switch s6 as shown in figure (V) and loaded on Mini-net with pox controller and the above algorithms python based script are loaded on SDN controller to performed the system quality constrains calculations to determine which algorithm is the better and feasible to use for complex networks .All the switches in the network have equal number of interface and with bandwidth of 20Mb/s .The packet lost ratio is 0.75% with delay of 3ms each.

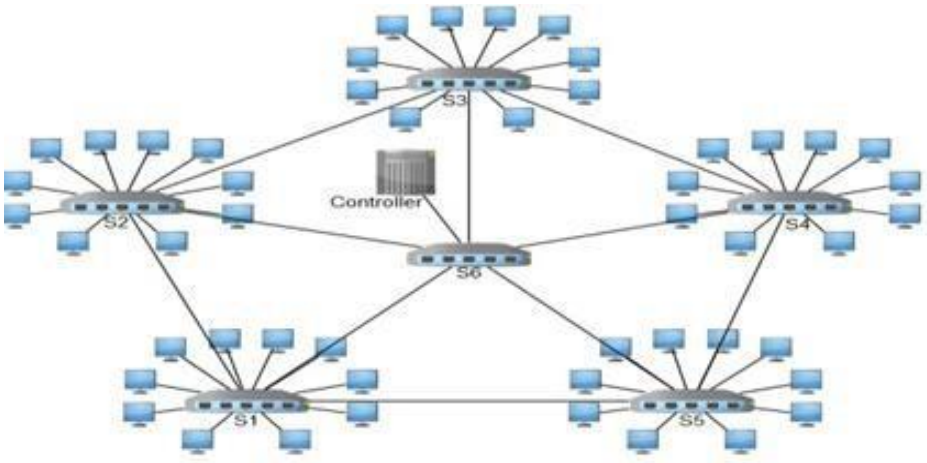

Figure V: General Mesh topology used to compute results.

The algorithm steps of AM-QOS are as following:
Step 1: Initialization of simulation parameters (minimum threshold value β1& β2, time out in matched flow case and time out switch is idol.
Step 2: If packet received by the switch matched the flow table modelled by the controller with switch buffer time in this scenario is 9ms if this time is exceeded (packet is in que and not forwarded) then even this flow is discarded.
Step 3: If the flow obtain doesn't matches the flow table managed by the controller with switch buffer time of 35ms and if this time limits is exceeded and no flow mode is obtained from the controller(request made by the switch in the form Packet-In and controller should respond in the form of Flow In) the packet is discarded.
Step 4: After the successful procedure done in either two or step three the controller demand status request if the results obtained (in the form of ϒ1) is greater than minimum threshold value β1 then flow table of the

switch is not changed .If the value obtained (in the form of ϒ2) is less than β2 then the flow table is changed after sending switch throughput status information to application layer through north bound.
The working Flow chart of above mentioned steps is shown in figure (VI) along with some basic assumptions are made (1) The time-out for flow measurement in the idle switch is 35ms.(2)If the flow obtain doesn't matches the flow table managed by the controller with switch buffer time of 35ms and if this time limits is exceeded and no flow mode is obtained from the controller the packet is discarded.(3) If the flow obtained is matched with table modelled by the controller with switch buffer time in this scenario is 9ms if this time is exceeded then even this flow is discarded.

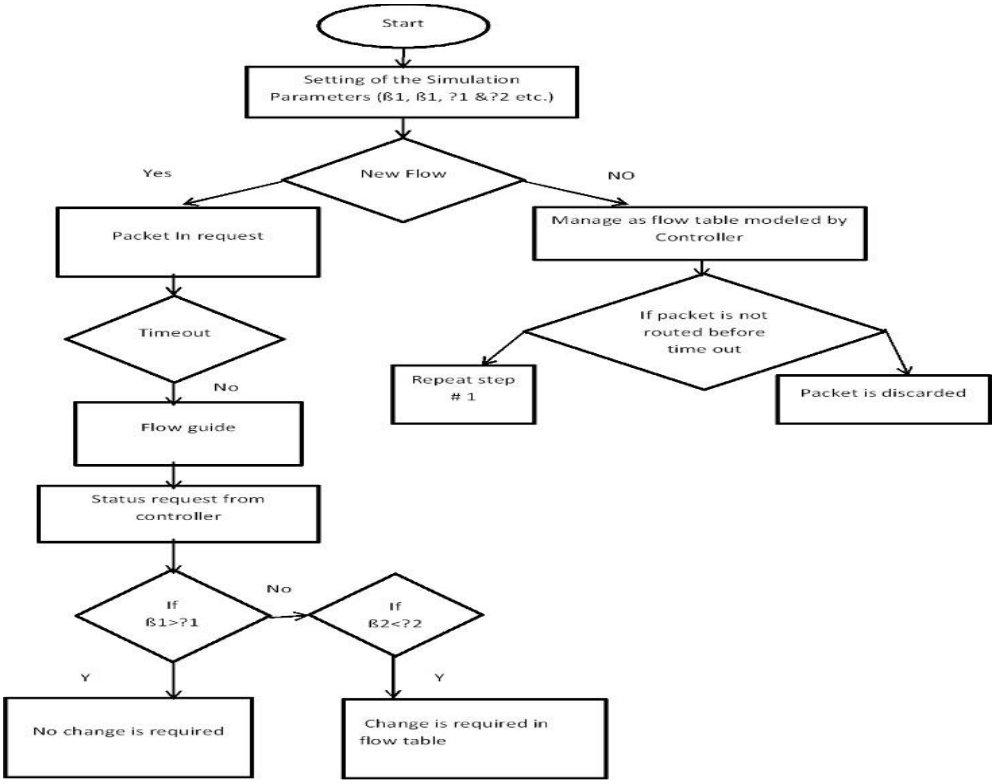

Figure VI: Working Flow chart of above mentioned steps

The Simulation parameters for AM-QOS is shown in Table-I.

Table 1
Parameters used in simulation of AM-based QOS Algorithm

Parameters	Assumed Value
Bandwidth of each Switch	20Mb/s
Packet loss ratio	0.65%
Delay	3ms
time out in the case of idle switch	35ms
time out in the case of Matched flow	9ms
Sampling Period	1s
Upper limit of time	150s
Flow Into	S2
Flow out	S5
β1	0.03

B2	0.23
Y1	1.9
Y2	1.325

The algorithm steps for SQAR Algorithm are as following along with some basic equations to calculate out the cost of best route:

Step1: Select the path with less number of relay nodes between sender and receiver.
Step2: If the path with less number of relay nodes is loaded then select another path by calculating cost Cp.

$$Cp = Wd\frac{(Pd - Rd)}{Rd} + Wl\frac{(Pl - Rl)}{Rl} + Wb\frac{(Rb - Pb)}{Rb} \quad (1)$$

$$Wx = \frac{MRx}{MRd + MRl + MRb} \quad (2)$$

$$MRx = \frac{No\ of\ flow\ doesnot\ meet\ the\ minimum\ requirement\ x}{history\ of\ flow} \quad (3)$$

$$P(Cp, Cn, t) = \begin{cases} 1, & Cn < Cp \\ e^{\frac{|Cn-Cp|}{t}}, & Cn > Cp \end{cases} \quad (4)$$

Cp= Cost of selected path
Wd= Weight of delay
Wl=Weight of loss
Wb=Bandwidth
Pd=Delay of selected path
Pb= Bandwidth of selected path
Pl= Packet loss of selected path
Wx=Weight of path x
MRd=Miss rate of delay
MRl=Miss rate of loss
MRb=Miss rate of bandwidth

Step 3: If the calculated path Cp is less than Neighbouring path Cn cost Cp then replace that path to avoid Elephant Flows.
Step 4: Repeat step 1

Figure VII: Working Flow chart of above mentioned steps

V. RESULTS AND DISCUSSIONS:

Section-A (Deployment of complex mesh topology on Mini-Net with AM-QOS,SAQRand MINA QOS-based algorithms)

Results:

(**Green Curve** represents AM-Based-Qos, **Blue Curve** represents SAQR and **Red Curve** represents Legacy Network):

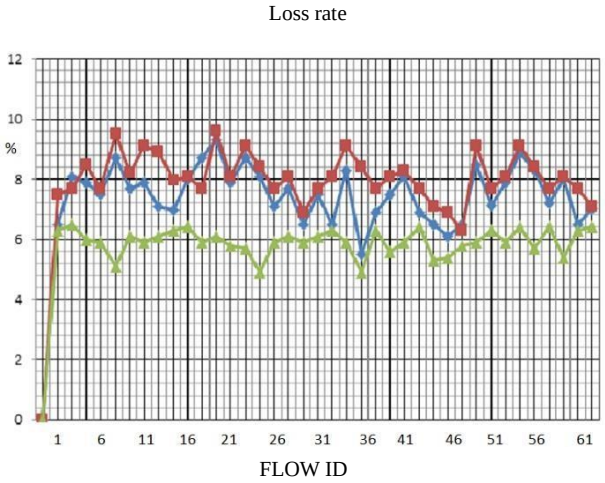

Figure VIII: Loss rate representation of AM-QOS (green), SAQR (blue) and legacy Network (red)

It is clear from above simulation diagram that as the flow id (no of users) increases the load on the switches of the network increases and results in a delay and packet lost. But with AM-QOS algorithm the load and the flow is balanced among switches as compared to SAQR-algorithm and legacy network.

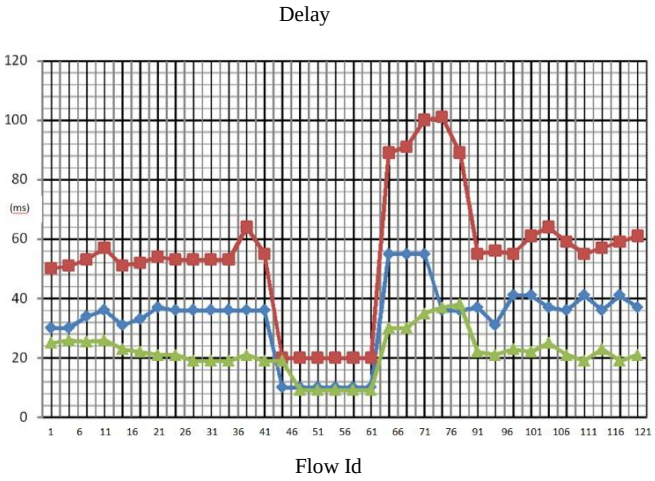

Figure IX: Delay in (ms) of AM-QOS (green), SAQR (blue) and legacy Network (red)

It is clear from above simulation diagram that as the flow id (no of users) increases the load on the switches of the network increases and results in a delay and packet lost. But with AM-QOS algorithm the load and the flow is balanced among switches and end to end delay is minimum as compared to SAQR-algorithm and legacy network.

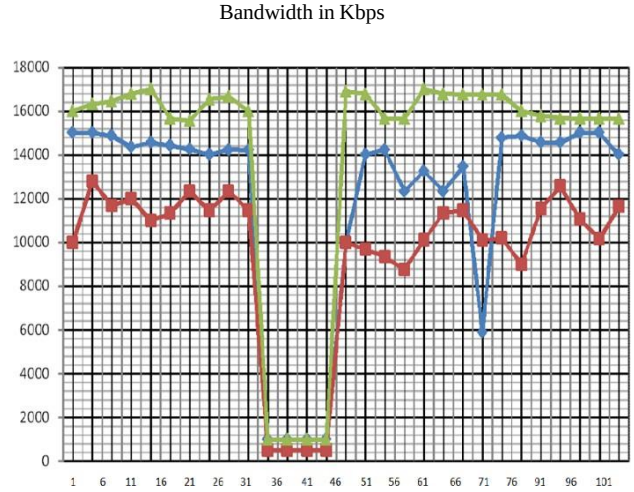

Figure X: Bandwidth in (Kbps) of AM-QOS (green), SAQR (blue) and Legacy network.

It is clear from above simulation diagram that with AM-QOS algorithm the flow of data among network switches is managed so there is less delay, less packet lost ratio which will eventually results in greater throughput enhancement in available bandwidth according to Shannon capacity formula.

Concluding remarks from results of section-A:
From the figure (VIII, IX, X) it can be clearly seen that AM-QOS performed slightly better but the SQAR [4] is more effective any easy to implement for best route in term of cost due avoid any elephant flows

Section-B (Deployment of complex mesh topology on Mini-Net with AM-QOS but with hybrid network) Results:
(**Red Curve** represents AM-Based-Qos with all Open flow based switches, **Blue Curve** represents hybrid Network and **Green Curve** represents Legacy Network):

The above mentioned algorithms is applied to six switch based Mesh topology with each having 10 hosts except switch s6 as shown in figure (XI) acting as legacy switch and create virtual switch in controller as represented in the figure(III).

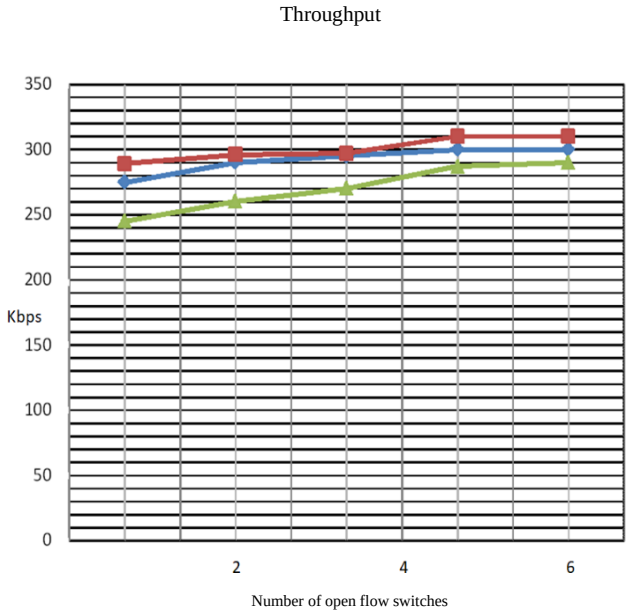

Figure XI: The throughput of analysis of hybrid network with full open flow based SDN network in term of open flow switches.

The result showed in figure (XI) proves that throughput of AM-QOS based hybrid network(blue colour curve) is very closed to network with all open flow switches(red colour and green colour line) so that hybrid approach can be used to save cost and can make the legacy switch to work efficiently in SDN environment.

Section-C
(Deployment of complex mesh topology on Mini-Net with comparison of Active flow method with traditional Polling Method)

(**Red Curve** represents calculated obtained from traditional polling method, Blue **Curve** represents the original (average results) and **Green Curve** represents results obtained by active sensing method :

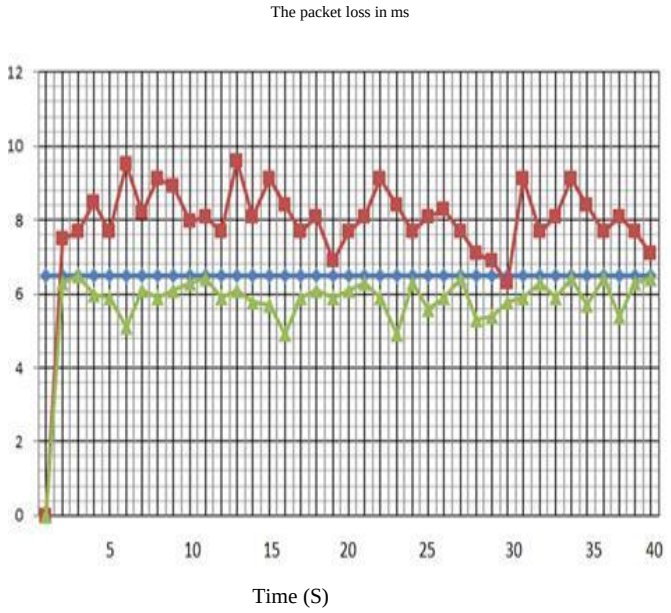

Figure XII: The Packet loss rate of polling (red) vs active (green) in term of real (blue)

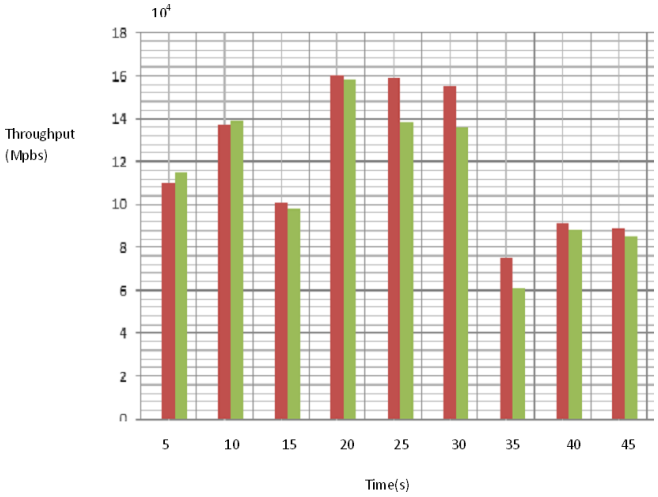

Figure XIII: The throughput calculation of polling (red colour) vs active method (green colour)

The results in figure (XII& XIII) shows that System quality constrain obtained from active method and the polling method are quite near .So the active method can seem to work more efficiently than ordinary polling method in modern SDN controlled environment.

VI. CONCLUSION:

In this research article we have shown that AM-based QOS performed better and have shown good system quality constrain values. The proposed Hybrid system fits well in accordance to full open flow based switched network. This method can be applied to save cost and at the same time can make us able to get centralized intelligence features of SDN in traditional network. The active sensing method works in accordance to traditional polling method so this active sensing method should be used in modern-era full controlled SDN environment.

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