International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-2, December, 2019

Multipath Routing of Elephant Flows in Data Centers Based on Software Defined Networking

R. Thamilselvan, K. Tamil Selvi, R. R. Rajalaxmi, E. Gothai,

Abstract: ***The data center networks encompass various cloud services. Network congestion and network load imbalance may occur in data center networks due to elephant flows. In order to improve the throughput and overall utilization of the network, a dynamic load balancing mechanism has to be in place. Software Defined Networking (SDN) is used to perform the balancing of the network load. SDN can obtain the global view of the network and hence contain the status and topology of the entire data center network. The elephant flows can be split and send to multiple paths based on the current state of the network. The described idea is implemented in the OpenFlow environment and tested for improvement. The result shows the enhancement in throughput and network utilization.***

Keywords – Data center, SDN, Elephant flows, Multipath

I. INTRODUCTION

Multipath capability of multi-rooted topologies of conventional routing using single path algorithm cannot be fully utilized. In multipath routing, the traffic is split across multiple paths to the destination. The traffic is distributed across unused multiple path and hence the congestion in the network is reduced. Hence load balancing and efficient utilization of network resources can be achieved. The main considerations in multipath routing are how to select multiple paths in the network, how many paths are needed and how to deal with failure handling mechanism in multiple paths. The traditional routing algorithms do not support multipath routing. Network performance is the crucial aspect of data center networks. High throughput and packet loss sensitive are the requirements of the network. Redundant links are needed in the data centers to avoid failure of the network. These redundant links are back up and provides less utilization. This can be avoided by fat tree topology. Fig.1 shows the fat tree topology. The multipath routing exploits the unused links and provides effective utilization. Many schemes like Equal Cost Multipath Routing (ECMP) [1] can be used to solve the problem. The paths that have same weight apply ECMP. When multiple paths are present, a method is needed to determine which path can be used to deliver the packet. The other methods like Random chose, Round Robin, Modulo-N Hash can be used to choose the path.

Revised Manuscript Received on December 30, 2019.
* Correspondence Author
Dr. R.Thamilselvan, Professor, Kongu Engineering College, Perundurai – 638060, Tamil Nadu, India
E-mail: rthamilselvan75@gmail.com.
K. Tamil Selvi, Assistant Professor, Kongu Engineering College, Perundurai – 638060, Tamil Nadu, India
ktamilselvikec@gmail.com
Dr. R.R. Rajalaxmi, Professor, Kongu Engineering College, Perundurai – 638060, Tamil Nadu, India
Dr.E.Gothai, Associate Professor, Kongu Engineering College, Perundurai – 638060, Tamil Nadu, India

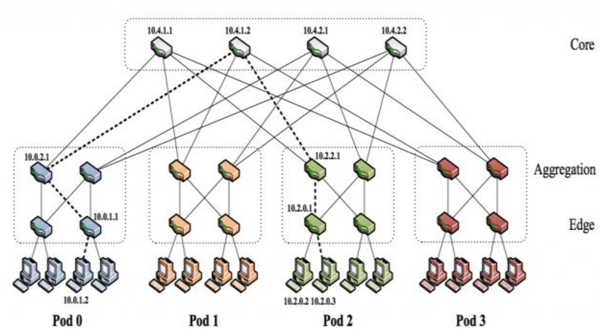

Figure 1. Fat-tree Topology

II. RELATED WORKS

The traffic in the data center network is classified as mice flows and elephant flows. Mice flows are short lived and elephant flows are throughput bounded. In data center traffic, elephant flows are only 10% but it contribute to 80% of entire traffic volume [2]. So there is need for traffic management of elephant flows in data center traffic. ECMP can provide routing for mice flows but not for elephant flows. An adaptive worst-fit multipath routing for data center networks based on software Defined Networking is proposed by [3]. When multiple paths are available, a path for new-incoming flow can be selected based on available network resources and bandwidth requirements. By this method, number of multiple path construction is reduced and thereby reduced the cost.

ECMP utilizes modified Dijkstra's algorithm to search for the available shortest path and uses mod-N hashing in the selection of path for the delivery of the packet [4]. The fat-tree topology uses SDN for collection of the global network view through the SDN controller. Multipath topologies can be adapted in the modern data center networks. This provides greater bisection bandwidth and better fault tolerance. A stochastic load balanced multipath routing algorithm based on log normal distribution of traffic model [5]. With this method, the probability of each link facing congestion is reduced since the traffic demand in the data center network shows stochastic pattern.

Scheduling flows through a capacitated network simultaneously is features as Multi-Commodity Flow (MCF). To improve network utilization in data centers, load balancing algorithm will evenly assign flows among different paths [6]. The scheduling can be done on a single flow, flowcell with fixed length and flowlet. The load balancing in data centers can be centralized or distributed. SDN controller can collect congestion information and assign flows to the paths based on the global view of the controller.

The classification of flows into mice and elephant flows are based on static threshold assignment. But static threshold assignment will not be suitable for dynamically changing data center networks. Hence adaptive threshold assignment to keep in pace with varying workloads [7]. Many proposed flow management algorithms considers elephant flows for increased throughput with little consideration of mice flows. There is a need to setup different path for mice flows and elephant flows based on network loads. The proactive weighted routing algorithm [8] can be used for mice flows and blocking island based path setup algorithm for elephant flows can be used. Based on current link utilization ratio, flows have to reschedule dynamically.
SDN provides auto-configuration [9] of the network elements through centralized controller, provides a way for managing traffic flows. The controller based framework monitors the network traffic and calculates the load deviation parameters to find the heavily congested links. An adaptive route modification can be applied to distribute the loads among different links to balance their loads.
To mitigate the network congestion and load imbalance caused by elephant flows in the data center networks, SDN based traffic engineering approach to handle elephant flows is proposed. Through the global network view provided by the SDN controller, topology and status of the entire network can be obtained. Then multipath routing of elephant flows is performed based on the ratios of dynamically computed network link features.

III. MULTIPATH ROUTING OF ELEPHANT FLOWS

The proposed mechanism provides the load balancing through multipath routing. It can be achieved through three sequences of processes. First process is elephant flow detection at the end-host. Next, splitting of elephant flows takes place. Then employ weighted routing algorithm. The process flow is depicted in the Fig.2.

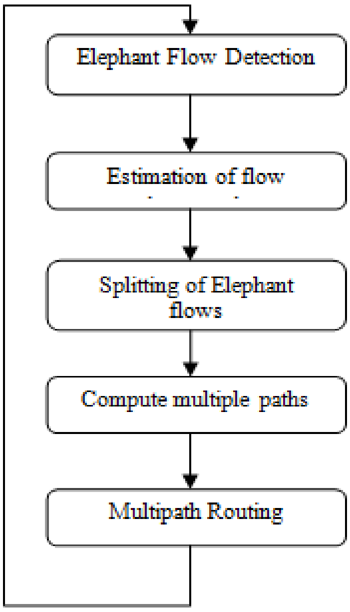

Figure 2. Process flow of Multipath routing of Elephant Flows

A. Detection Elephant Flow

The elephant flow detection is based on three evaluation indicators [10] namely accuracy, timeliness and network overhead. The detection process is classified into two categories namely detection in switch and detection in end-host. Fig.3 shows the available mechanism for elephant flow detection. The flow statistic based method compares the flow size with the pre-defined threshold. If the flow size exceeds the threshold, then the flow is identified as an elephant flow. The flow characteristic based technique detects the elephant flow by marking identification or flow classification based on the markings or features extracted through the destination flow.
The advantages of end host based elephant flow detection compared to switch based mechanism are

- End host has more programmability options
- It has rich computing power
- It perceives elephant flow earlier than the network

The network traffic captured by end host is only minimal, the flow detection is based on flow statistic threshold. It incorporates Virtual machines for scalability issues. Hence the elephant flows are detected in end host by monitoring TCP socket buffer based on threshold.

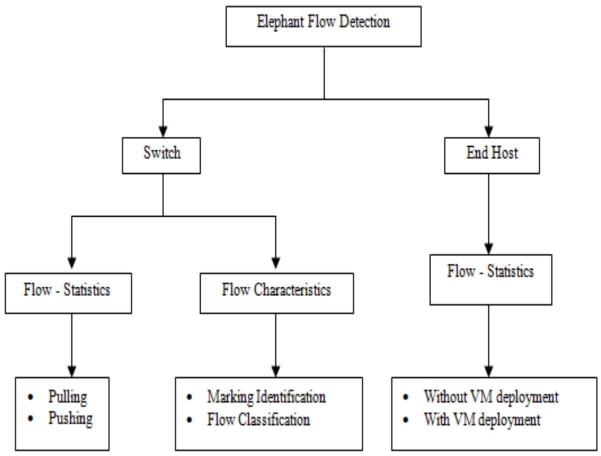

Figure 3. Elephant Flow Detection Techniques

B. Elephant Flow Splitting

The multipath routing in Open flow protocol version 1.1 is supported through the use of flow tables and group tables. The flow points to instructions to a group in multipath routing. Each group consist of list of action buckets and each action bucket contains set of actions applied to the matching flow. A weight field is associated with each bucket which indicates the share of traffic processed by the group in the bucket. The detected elephant flow is pointed to a group. The group table consists of list of action buckets with the action buckets contains path for the flow to the destination.

Retrieval Number: B3258129219/2019©BEIESP
DOI: 10.35940/ijeat.B3258.129219
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

C. Elephant Path Computation

The bisection bandwidth available in data center network can be used for path computation. The weighted multipath routing algorithm is used for routing of elephant flow.
It calculates the load ratio of the candidate paths between any pair of end host based statistics collected. Then assign the elephant flows across multiple paths based on the computed load ration. Thus the load in data center network is balanced dynamically.

D. Weighted Multipath Routing Algorithm

Link utilization is given by ratio of link capacity to link load. At each node of the elephant flow path, the weight of the path is computed. When the weight of the path is higher, the path is less loaded. A path with weight one is excluded from the candidate path. After computing the path weight, the weight field will be updated in the action bucket of the group.

Algorithm 1: Weighted Multipath Routing Algorithm

Step 1: Compute the Link Utilization of each link of the selected path

$$Link\ \ Utilization = \frac{Link\ \ load}{Link\ \ capacity}$$

Step 2: Compute the Path Utilization of each candidate path to the destination

$$Path\ \ Utilization = \frac{\sum Subpath\ \ utilization}{Number\ \ of\ \ links\ \ in\ \ the\ \ subpath}$$

Step 3: Compute the path weight of each candidate path

$$Path\ \ weight = \left(1 - \left(\frac{Path\ \ utilization}{Total\ \ Node\ \ Load}\right)\right) * 10$$

Step 4: Exclude the overloaded path with weight <1

IV. EXPERIMENTAL SETUP AND PERFORMANCE EVALUATION

Mininet is used for OpenFlow environment simulation. The SDN controller used is NOX [11]. OF V.1.3 is used as southbound protocol. ECMP is also tested in SDN environment for single path routing. The traffic pattern is generated which is a mix of both mice and elephant flows. The features of flow used are Source IP, Destination IP, Source Port, Destination Port, and Protocol Type. The flow is distributed in Poisson distribution.
The performance of the proposed system can be experienced based on throughput, latency and link utilization. When elephant flows are high, latency is high in single path routing system. But in multipath routing, the latency is reduced by 5% as shown in Fig.4. There is an increase in latency when load increases which is shown in Table 1. But multipath routing manages to stabilize the network with minimum delay. The reduction in latency is influenced by load balancing of elephant flows among multiple paths.

Table 1. Load vs Latency

Load (Mbps)	300	400	500	600	700	800	900	1000
Latency (Multipath)	4	10	22	21	40	52	90	112
Latency (ECMP)	40	50	63	75	130	163	210	260

From Fig. 5, the proposed system provides enhancement in throughput by 3%.

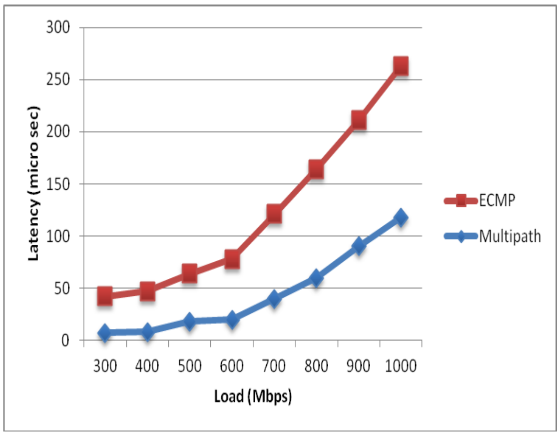

Figure 4. Load Vs Latency

This is due to weighted multipath routing capability implementation. The increase in throughput is due to less number of control messages which is shown in Table 2. The NOX controller will obtain the global network topology through which states of network and links can be obtained. The link utilization can be obtained through the use of HELLO and PACKET_OUT messages of OpenFlow protocol. When elephant flow increases by greater volume, a saturation point is attained and throughput remains constant. As the congestion in the network increases after the saturation point, throughput may decrease in multipath routing as well as ECMP.

Table 2. Load vs Throughput

Load (Mbps)	400	450	500	550	600	650	700	750	800	850
Throughput (Multipath)	400	450	500	570	600	670	700	720	760	750
Throughput (ECMP)	400	450	500	560	575	659	680	700	710	710

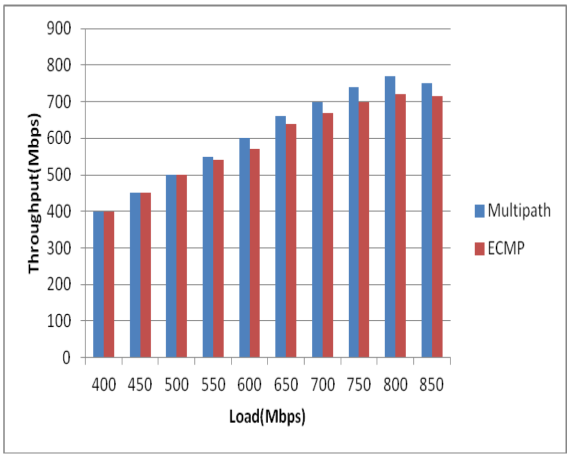

Figure 5. Load Vs Throughput

Retrieval Number: B3258129219/2019©BEIESP
DOI: 10.35940/ijeat.B3258.129219
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

V. CONCLUSION

This article proposed load balancing using multipath routing of elephant flows. The work is motivated by the fact that the elephant flows are less in frequency but more in volume than the mice flow. The utilization of data center resources is the driving force behind the efficiency of the network. The routing decisions are made dynamically based on the current state of the network which is provided by SDN controller. The effectiveness of the proposed system is shown by increase in throughput and decrease in latency. Further it can be enhanced with combination of mice and elephant flows multipath routing.

REFERENCES

1. Chiesa, M., G. Kindler, and M. Schapira, Traffic engineering with equal-cost-multipath: An algorithmic perspective. IEEE/ACM Transactions on Networking (TON), 2017. 25(2): p. 779-792.
2. Kandula, S., et al. The nature of data center traffic: measurements & analysis. in Proceedings of the 9th ACM SIGCOMM conference on Internet measurement. 2009. ACM.
3. Lei, Y.-C., K. Wang, and Y.-H. Hsu. Multipath Routing in SDN-based Data Center Networks. in 2015 European Conference on Networks and Communications (EuCNC). 2015. IEEE.
4. Rhamdani, F., N.A. Suwastika, and M.A. Nugroho. Equal-Cost Multipath Routing in Data Center Network Based on Software Defined Network. in 2018 6th International Conference on Information and Communication Technology (ICoICT). 2018. IEEE.
5. Fatmi, O. and D. Pan. Distributed multipath routing for data center networks based on stochastic traffic modeling. in Proceedings of the 11th IEEE International Conference on Networking, Sensing and Control. 2014. IEEE.
6. Zhang, J., et al., Load balancing in data center networks: A survey. IEEE Communications Surveys & Tutorials, 2018. 20(3): p. 2324-2352.
7. Wang, S., et al., Flow distribution-aware load balancing for the datacenter. Computer Communications, 2017. 106: p. 136-146.
8. Zhang, H., F. Tang, and L. Barolli, Efficient flow detection and scheduling for SDN-based big data centers. Journal of Ambient Intelligence and Humanized Computing, 2019. 10(5): p. 1915-1926.
9. Wang, Y.-C. and S.-Y. You, An efficient route management framework for load balance and overhead reduction in SDN-based data center networks. IEEE Transactions on Network and Service Management, 2018. 15(4): p. 1422-1434.
10. Wang, B. and J. Su. A survey of elephant flow detection in SDN. in 2018 6th International Symposium on Digital Forensic and Security (ISDFS). 2018. IEEE.
11. Gude, N., et al., NOX: towards an operating system for networks. ACM SIGCOMM Computer Communication Review, 2008. 38(3): p. 105-110.

AUTHORS PROFILE

R. Thamilselvan, is a Professor in the department of Information Technology, Kongu Engineering College, Perundurai, Tamilnadu, India. He has completed his M.E Computer Science and Engineering in 2005 and PhD in Computer Science and Engineering in 2013 under Anna University Chennai. He has completed 18 years of teaching service. He has published 14 papers in International Journal, 7 papers in International Conference and 15 papers in National Conference. He has completed one research project sponsored by AICTE, New Delhi under the scheme Research Promotion Scheme (RPS) and organised 2 national level seminar and 1 faculty development programme sponsored by AICTE, New Delhi. His area of interest includes Grid and Cloud Computing, Parallel Processing, Big Data Analytics and Distributed Computing.

K. Tamil Selvi, is an Assistant Professor in the Department of CSE, Kongu Engineering College, Perundurai, Tamil Nadu. She is pursuing Ph.D in the area of Traffic Engineering in Software Defined Networking (SDN). Her other areas of interest are Machine Learning, Deep Learning and Software Defined Networking. She has published more than 5 papers in the area of SDN.

Dr. R.R.Rajalaxmi completed M.E. Computer Science and Engineering under Bharathiar University in the year 2000. She completed her PhD in Information and Communication Engineering under Anna University in the year 2011. Currently she is working as the professor and Head of the Department, Department of Computer Science Engineering, Kongu Engineering College, Tamil Nadu. She is a life member of CSI and ISTE. Her area of interest is Data Mining, Data Analytics and Machine Learning. She organized 9 sponsored seminars/workshops/training prorammes. She published 11 research papers in the international journals and 6 papers in the international conferences. She also completed 3 research projects sponsored by various funding agencies.

Dr.E.Gothai completed Ph.D in the area of Big Data Analytics. . She has 19 years of teaching experience. She published 9 research papers in International journals and presented 16 papers in the conferences. She is working as an Associate Professor in the department of Department of Computer Science Engineering, Kongu Engineering College, Tamil Nadu. Her areas of interest include Data mining, Big Data Analytics and Deep Learning