# Experimentation of Traditional Load Balancing Algorithms in Software Defined Network

**C. Fancy, M. Pushpalatha, Pushpa**

***Abstract--- In the real world, the number of network devices is increasing everyday, managing the network traffic is becoming very difficult. Hence load balancing plays a major role in maximizing the network throughput and minimizing the response time. In order to provide a balanced load in anynetwork, a complete knowledge of the current network status is needed. The process of collecting network status in a traditional network needs additional processing which increases complexity, whereas,in a Software Defined Network(SDN), the controller keeps track of the nodes, links between them in the network. Hence it is decided to analyze the working of various load balancing algorithms in SDN.***

***Keywords--- Software Defined Network, OpenFlow, Load BalancingAlgorithms, Throughput, Round Robin, LoadBalancer Metrics.***

## I. INTRODUCTION

In a real-world network scenario, the concentration towards delay sensitive applications andnetwork trafficneeds congestion free spectrum utilization. The fruitful maintenance of QoS parameters is the only possible way to achieve maximum throughput. Few of the delay sensitive applications includes VOIP and on-demand video streaming. Load balancing is one the key factors in improvising the throughput [14]. It is defined as the process of dividing the jobs among various servers in a Datacenter.

In traditional methods, load balancing is achieved by a dedicated hardware. The common drawback of vendor-specific devices is its features cannot match for other networks all the time. But in case of Software Defined Network(SDN), the load balancer is a software, which can be programmable at any time. Hence SDN is not more sophisticated than thetraditional networks. That is why in this paper a detailed study on experimenting the various load balancing algorithms inSDN environment.

The load balancing can be categorized in many ways. One approach is to divide the flow requests among the various nodes. Another approach is distributing the flow request processing among multiple controllers[9,10,11]. Also, in order to balance the load for the current network, its updated status must be available for the load balancer[12]. In Traditional networks, every node shares its information to the neighbor nodes. Thus the all the nodes get the updated network status. But in SDN, the topology discovery, Flow statistics collection, etc are managed by the controller itself. Hence the nodes report to the controller.

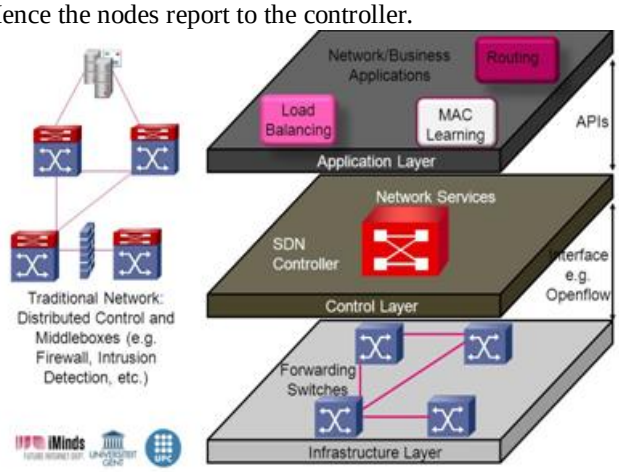


**Fig.1: Traditional vs Software Defined Network**

Based on the functionality, the Flow statistics collection process can be categorized under proactive and reactive[4]methods.Some of the conventional load balancing algorithms include Least connections, Round Robin,and Random algorithms. Upon research, it is identified that the above-mentioned algorithms are not applicable to the heterogeneous networks[6].Load balancing can be achieved by focusing on the server's response time as well[6,13]. Thus the implementation of load balancing algorithms as an application module in the SDN controller is now a very important research topic. Because it improves throughput, minimize response time and also supports scalability[15]. This research paper is explained as follows: Section II explains the journal papers relevant to load balancing concept. Section III gives the detailed explanation of the three algorithms. Section IV explains the simulation works and analysis. Section V defines the conclusion of the works done and Section VI gives the referred papers.

## II. LOAD BALANCING AMONG CONTROLLERS

An efficient way of controlling network devices is given in [1]. The network is partitioned into various sub-domains. Each sub-domain has an SDN enabled border router that helps in routing to other domains. Here the network management is adaptive. Because, if the domain size is large, inter-domain management functions were very less compared to a smaller domain size. With this scenario, effectiveness is achieved in scalability of bandwidth allocation, route determination based on current load, and

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recovery from failures.The challenges of Wireless Network Virtualization[2] are highly varying traffic,multidimensional heterogeneity. Besides these drawbacks, efficiency can be achieved in QoS provisioning, resource sharing, verification of new techniques before it can be widely deployed. The resource allocation in the inter-virtual network must be dynamic. This is due to the changes in service requirement and a new request for the virtual network.There are a lot of issues in creating a load balanced aggregation tree for a Wireless Sensor Network[3]. The author analyzedthree related problems. The important parameter discussed in their model is the transmission success ratio for every link in the network.

| Author | Approach | Load Balancing Metrics Used | | | | | | Advantage |
|---|---|---|---|---|---|---|---|---|
| | | Response Time | Load Threshold | Current Throughput of switch | Bandwidth Utilization/ Capacity | Link/ Transmission Cost | Flow Rate | |
| Wei, Chin, Hsin, Han[17] | Greedy based Service Orientation | | | | √ | √ | | Reduces Data Transmission time. |
| Guodong, Peng, Yanxiao, Jun, Min [21] | OpenFlow based Inbound Load Balancing | | | | √ | √ | | Avoids Unnecessary Flow scheduling. |
| Li, Jing [27] | Domain division algorithm | | √ | | | | | Network performance, Network reliability is improved. |
| Sohaib, Xiaojun, Wenqing [28] | Dynamic two-tier load balancing. | | √ | | | | √ | Improves Throughput, Reduces delay. |
| Syed, Donghan, Yongdeuk, Kangwoo, Hyunseung [29] | Dynamic load balancing. | | √ | | | | | Improvement in uplink and downlink traffic disruption periods |

## III. LOAD BALANCING AMONGSWITCHES

The status of a network can be acquired in two ways active and passive[4].

If the flow rule is not available in a switch, at that time a request is sent to the controller. Then the controller maintains a local flow rule table for the switches. This is the passive way of network state management. This method cannot be applicable to applications that need updated information all the time.

Hence the active network management concept is introduced.

In this method, the controller sendscontrol commands periodically to gain the network status. Hence the network status will be an updated one all the time.

The load balancing algorithms used in SDN can be categorized into deterministic and non-deterministic[5].Deterministic methods produce constant output for a particular input.

Non-deterministic methods give different output every time it is executed for the same input.

The efficiency of the algorithms is determined by parameters such as throughput, response time, overhead, energy consumption, latency, availability, packet loss and so on.

The efficiency of the load balancing can be improved by including techniques like Back Propagation Artificial Neural Network for balancing load[7].

The Flow statistics information also plays a major role in balancing the network load[8].Researchhas been done on the flow detection between the controller and switch[20]. It is observed that the flow statistics helps in providing the accurate flow table entries.

This, in turn, supports the controller to provide a better load balancing.

The flow traffic is categorized into the heavy flow, elephant flow,andbulk flow. With the help of Sample & Pick, Sample & Hold, and Sample & HH methods, heavy flow is detected.

The author Naga katta[30] introduced the usage of HULA switches instead of the leaf switches at data plane. It improves the flow completion time.

The difference between the leaf and the HULA switches is the former tracks congestion in all possible paths to reach the destination, whereas the latter finds congestion at the optimal path to the sink.

**Table 1: Summary of Load Balancing among Switches**

| Author | Approach | Load Balancing Metrics Used | | | | | | Advantage |
|---|---|---|---|---|---|---|---|---|
| | | Response Time | Load Threshold | Current Throughput of switch | Bandwidth Utilization/ Capacity | Link/ Transmission Cost | Flow Rate | |
| Mohamed, Ashraf[4]. | Network State Collection. | | √ | | | | | Defining flows will improve the application performance. |
| Hong, Yaming, andJie[6]. | Load Balancing by server response time. | √ | | | | | | Good scalability. Low-cost characteristic. |
| Nareg, Georgi, Zaher, Imad, Ayman and Ali[8]. | Flow-based load balancing. | | √ | √ | | | | Increase Throughput. Decrease Latency. |
| Faais, Shavan[16]. | Dynamic load balancing by re-routing | | | | √ | | | Improves Throughput. |
| L. Boero, M. Cello, C. Garibotto , M. Marchese, M. Mongelli [19] | BeaQoS. | | √ | | √ | | | Efficient Queue Balancing. |
| Shuo,Jiao,Tao, Tian, Jiang,Yunjie [22] | Greedy Round Robin Algorithm | | | | | √ | √ | Reduces Flow completion time, Provides higher Scalability. |
| Anil, Thomas, Bheemarjuna [23] | QoS aware Load Balancing. | | √ | | | | √ | Decreases total network overload. |
| Chung, Ka[24] | Distributed Flow by Flow Fair Routing Algorithm | | √ | | √ | | √ | Efficient for Data Center Networks with random traffic patterns. |
| Krisztián,Attil, Gábor [25] | Virtual Resource Allocation | | | | √ | √ | √ | Incrementally deployable. Fully compatible with practically all existing protocols and data planes. |
| Nikolaos, Dimitrios, Spyros, Symeon [26] | Hierarchical control framework | √ | √ | | | √ | √ | Achieves high-level performance in highly varying workload. |

## IV. EXPERIMENTATION & RESULTS

The three load balancing algorithms taken into account for analysis purpose are least connections, Round RobinandWeighted Round Robinalgorithms.Section III explains the above-mentioned load balancing algorithms in details.

*a. Least Loaded Path Algorithm[Statistics method]*

This method finds the possible paths of equal hops to reach the destination.

The server with the least connections is chosen for the packet flow. The server having least number of active transactions is given a chance to process the data. Thus this algorithm is one of the simplest ways of load balancing. It can be used for multimedia based applications. This algorithm is termed to be a dynamic one because it has to count the number of connections at each node every time when it has to perform load balancing.

*b. Round Robin Algorithm*

This is the inbuilt load balancing algorithm available in the Floodlight controller.

It aims at allotting the flow requests equally among the available servers. Suppose, consider the set of Servers in a Datacenter $\{S_1,S_2 ..., S_n\}$. The flow requests from client nodes at the current time is queued and they are given to servers one by one in a round robin fashion. Time can also be an added parameter for shifting from one server to another for processing.

*c. Weighted Round Robin Algorithm- With Unequal Weights*

It can be said as an extended Round Robin Algorithm. Consider, six flow requests are ready to be transmitted at a time period t and there are two servers ready for processing. The servers are slightly varying in their characteristics. Assume, server1 has 5 times better capability than server2. Hence the first 5 flows can be processed by server1 and meanwhile the server2 processes only 1 flow request. In such situations, we shall utilize the weighted round robin algorithm. Consider an SDN based datacenter having many clients.

The set of Servers are denoted as $\{S_1, S_2...,S_n\}$. 'i' refers to the server that has got load last time. $W(S_i)$ refers the weight of the Server which is processing load currently. 'CW' refers to the current weight for load balancing.

*Analysis*

The experiments are done with the fat-tree topology depicted in Fig.5. The topology is implemented in the Mininet emulator.

Mininet is the widely used platform for creating Software Defined Networks. The network activities are managed by the Floodlight controller.

Experiments are done to analyze the working of the traditional load balancing algorithms such as Least connection(Statistics), Round Robin, and Weighted Round Robin, The metrics taken for analysis are Latency and Throughput.

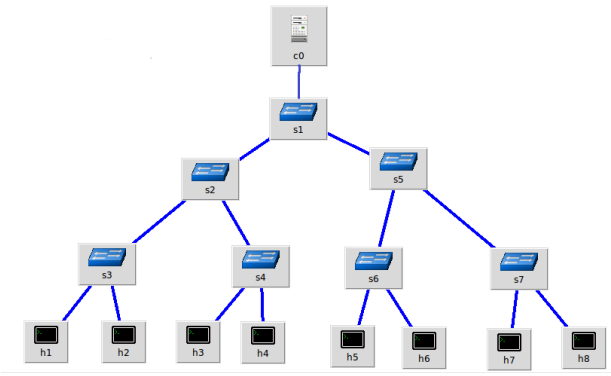


**Fig.2: Sample Topology**

*a. Latency*

The topology given in fig.3 is experimented repeatedlyby generating variable number of packets such as 100, 200, 300, 400, and 500. The average latency is find out with the help of ping command.The below chart is depicting the comparison of the three load balancing algorithms in terms of average response time.

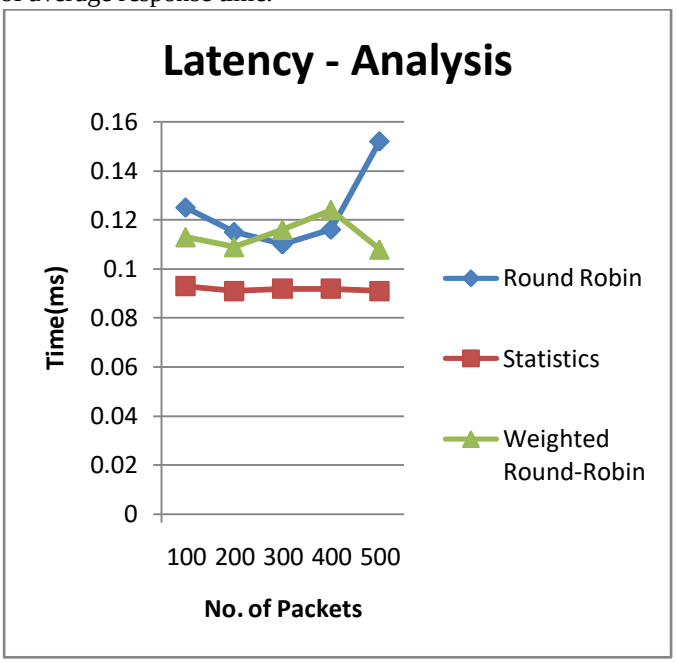


**Fig.3: Latency with respect to various load balancing algorithms**

The graph shows that the average response time is higher if the network uses round robin algorithm for distributing load. Also it is evident that the Least connections(Statistics)algorithm provides the response in lesser time, when compared to the Weighted Round Robin and Round Robin algorithms.

*b. Throughput*

The topology given in fig.3 is repeated for varying number of parallel requests from clients such as 100, 200, 300, 400 and 500. The below chart is depicting the performance of the three load balancing algorithms in terms of throughput per second for the varying number of requests.

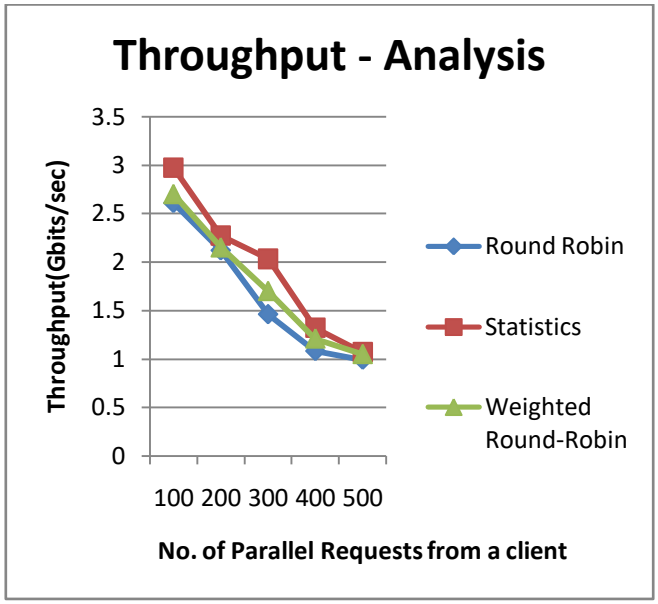


**Fig.4: Throughput per second with respect to the three algorithms**

The graph shows that the round robin algorithm could provide only least number of transactions. Also, it is evident that the Least connections(Statistics) algorithm provides highest throughput when compared to the Weighted Round Robin and Round Robin algorithms.

## V. CONCLUSION

Balancing the load in a network is an important part in obtaining network efficiency.Hence a theoretical analysis and an experimental work on the three basic load balancing algorithms are done. Based on the experimentation in the given topology which is controlled by Floodlight controller, the following inference arrives. The dynamic Least Connections(Statistics)algorithm produces higher throughput compared to the static Round Robin and Weighted Round Robinalgorithm. Also the latency of the Least Connections(Statistics) algorithm is considerably fair than the other two algorithm.Upon a study on the various load balancing algorithms, it is observed that the factors which are used for load balancing play a major role in maintaining the network efficiency. Few of the parameters include server's response time, the threshold in load, the throughput of the switch, bandwidth utilization of the link, link cost and so on.

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