DEVELOPMENT OF A MULTILAYERED AGGREGATE SWITCH ARCHITECTURE FOR DCN USING SOFTWARE DEFINED NETWORKING

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INTRODUCTION

A Data Center has to be optimized to balance the workload and provide efficient results to the network. Data center network performance can characteristically be illustrated using well-accredited metrics such as bandwidth, reliability, throughput, power consumption, latency and cost. With the introduction of software-defined networks, the control plane and data plane are separated from each other, with the centralization of state and network intelligence, and abstraction of the underlying network infrastructure from the applications. SDN gives us a more programmable and customize freedom to the network. The most deployed SDN protocol is OpenFlow, which allows setting into OF-compliant switches forwarding rules established by centralized SDN controller. We have designed the topologies for Fat tree and Multi-tier DCN with layering of aggregate switches. Layering of the aggregate switches has been done horizontally and vertically for both the fat-tree and multi-tier topology to understand and effectively compare the DCN topologies for communication between the hosts in same rack and communication between the hosts in different racks.

TOOLS USED

- **Mininet – Network emulation tool**

Created Python scripts for deploying all the three layers of switches and servers.

- **Open V Switch**

It has the ability to forward the packets based on the instructions from controller

- **Spanning tree protocol**

It avoids any possible looped networks

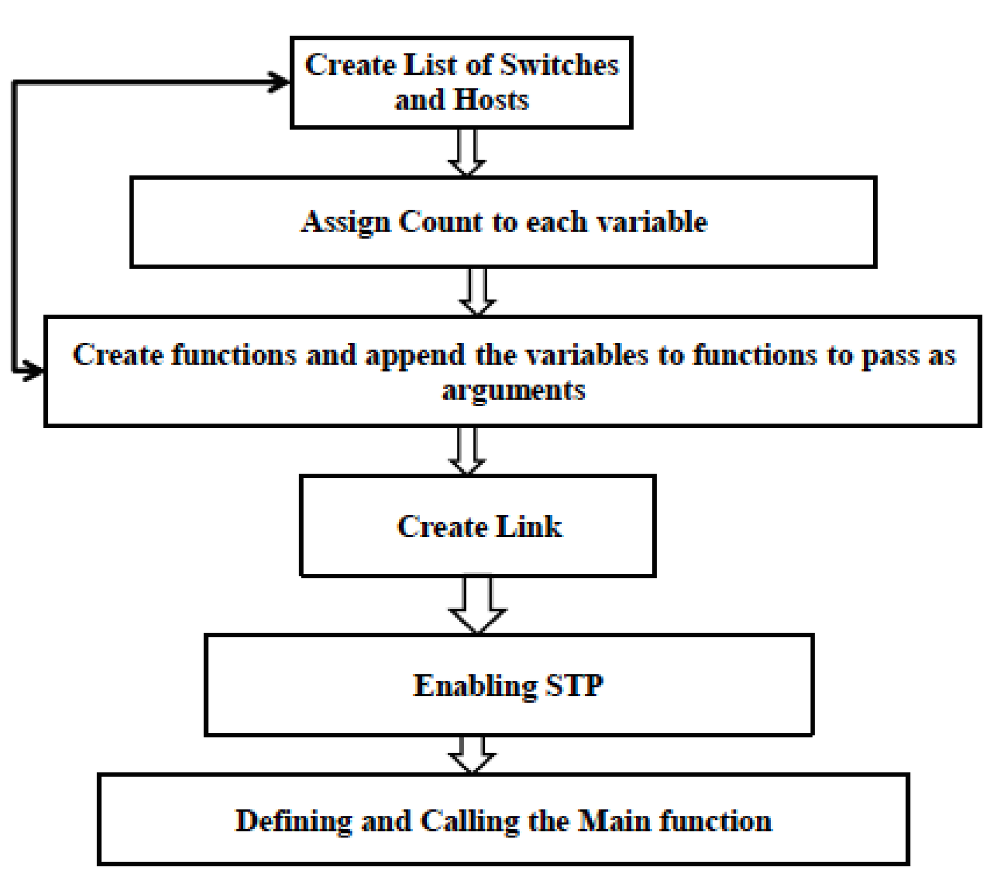
- **Default Controller**

ovs-controller and test controllers.

- Wireshark network analysis tool
- Iperf traffic generation tool

CODE FLOW

Below is a Flow Chart describing how Code works to create Mininet topology for Multi-tier and Fat-tree layered and non-layered DCN.



METHODOLOGY

In this project, Data Center Architectures are scaled vertically by increasing the aggregate layer and horizontally by increasing the number of Edge layer switches.

Fat-Tree architecture was built for a total of 16, 35, 64 and 98 hosts in network. The vertical scaled architectures have at least 2 aggregate layers. As the topologies are scaled architectures, the connections between layered switches are designed to be one-to-many. Fat-tree follows an algorithm to build its network. Where k is the number of pods;

Number of servers per rack = $(k/2)^2$

Number of Access Layer/TOR switches per pod = k/2

Number of Aggregate Layer switches per pod = k/2

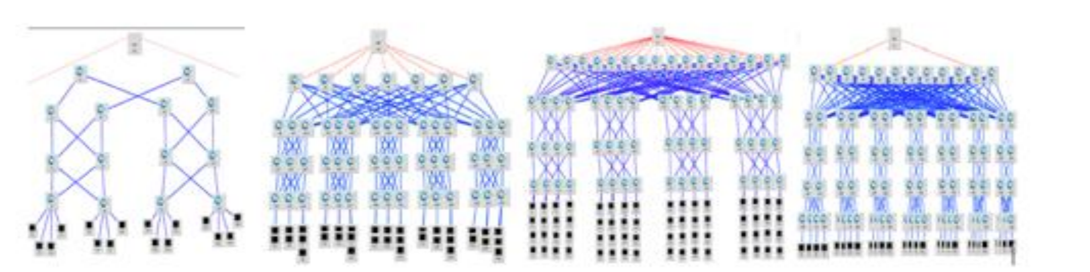
Total Number of Core Switches in the topology = $(k/2)^2$

Multi-Tier architecture was built for a total of 16, 32, 64 and 96 hosts in the network with an over-subscription ratio of 1:1. In the scaled architectures, aggregate layer is increased to 3 layers, having links interconnecting every switch. Multi-Tiered architecture has a flexible algorithmic structure. Where k is number of Hosts in a rack;

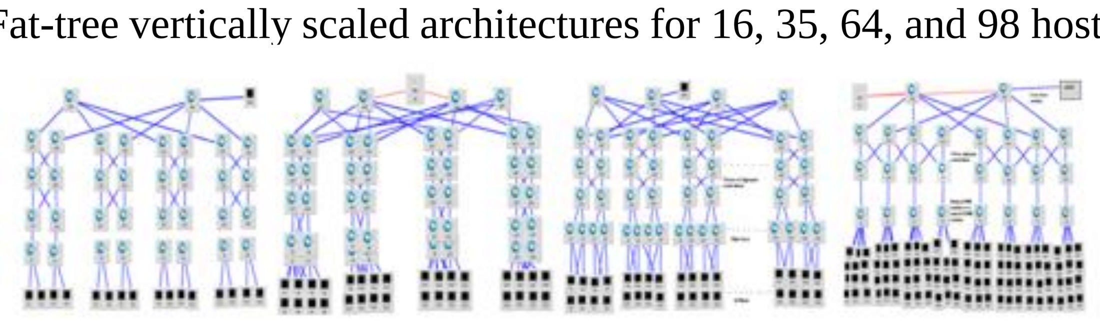
Number of Access Layer/ToR Switches per rack = k/2

Number of Aggregate Switches per rack = k/4

Number of Core switches = k/8

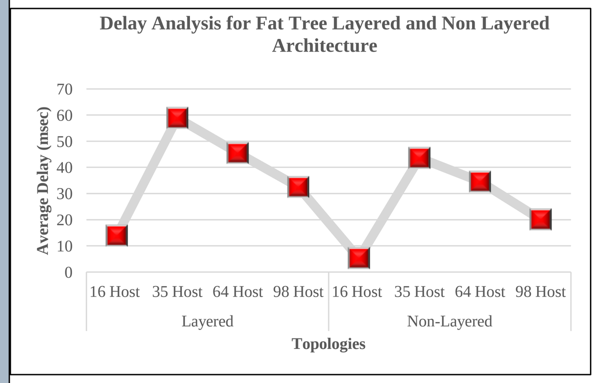


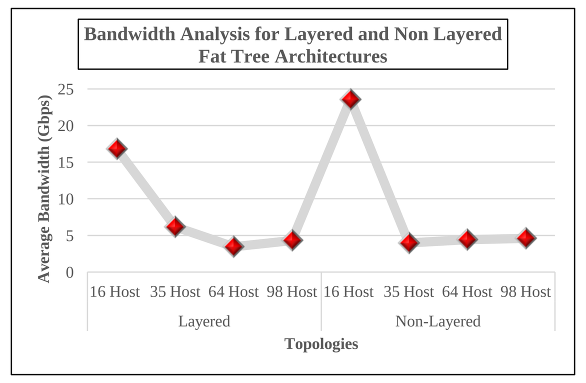
Fat-tree vertically scaled architectures for 16, 35, 64, and 98 hosts



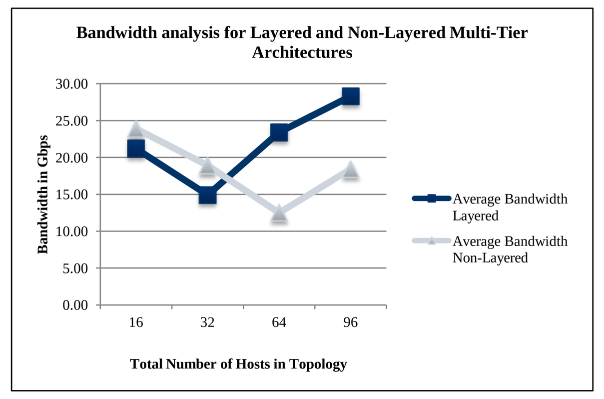
Multi-tier vertically scaled architectures for 16, 32, 64, and 98 hosts

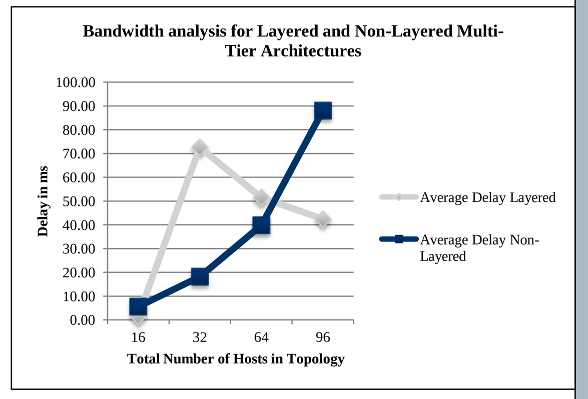
Below graphs represent the Overall Delay-Bandwidth Analysis of Fat-Tree and Multi-Tier architectures





Total Delay-Bandwidth Analysis of Layered and Non-Layered Fat -Tree Architectures





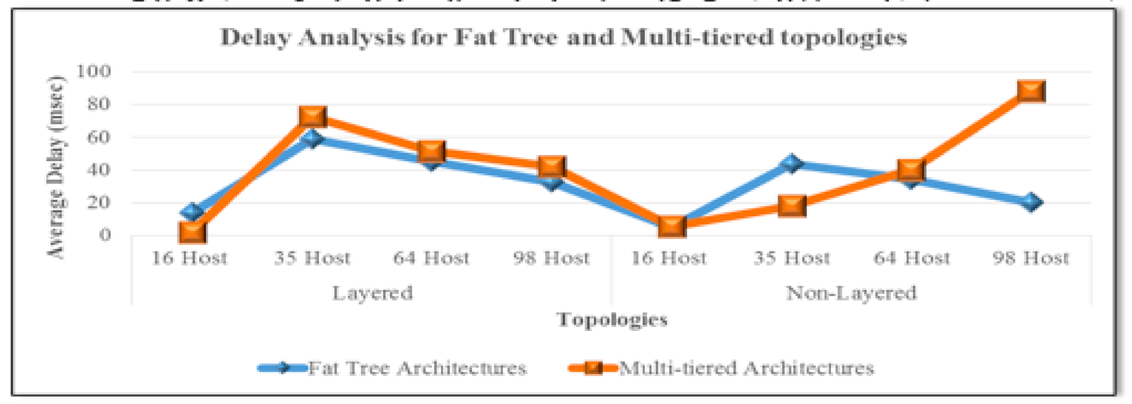
Total Delay-Bandwidth Analysis of Layered and Non-Layered Multi-Tiered Architectures

RESULTS

We calculated and compared the overall average bandwidth and delay for all custom topologies of Multi-Tiered and Fat-Tree architectures. The data was analyzed based on the total number of hosts in the network and the architecture styles; Layered and Non-Layered.

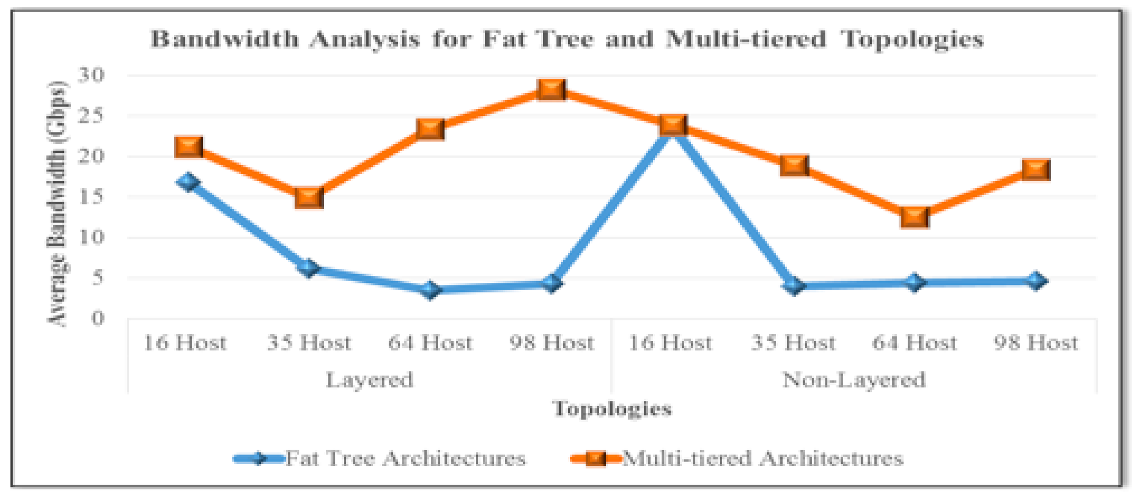
From the Delay-Bandwidth analysis, we observed that

- Multi-tiered architecture provides better bandwidth to data paths than fat tree architecture in case of both layered and non-layered architectures.
- Scaling the architecture, increases the number of switches in each architecture. Multi-Tier being a flexible architecture does not increase the number of switches exceptionally.
- Whereas in Fat-Tree due to the algorithm, increased the number of switches in network with increased number of hosts result in Bandwidth variations.
- However, in the Fat-Tree architecture, the delay has been consistently less than the delay in Multi-Tier. Though there is a slight variation in the delay values of both the architectures when they are Layered, it is observed that the delay has linearly increased in case of a Non-Layered Multi-Tier architecture. This is due to the reduced number of switches for many hosts in network.
- The graphical representation of Delay-Bandwidth analysis between Multi-Tier and Fat-Tree architectures is shown below. The comparison is differentiated between Layered and Non-Layered architectures.



Average Delay	Layered				Non-Layered			
	16 Host	35 Host	64 Host	98 Host	16 Host	35 Host	64 Host	98 Host
Fat Tree Architectures	13.88	58.91	45.5	32.48	5.22	43.6	34.54	20.09
Multi-tiered Architectures	1.6	72.6	51.5	42.4	5.6	18.2	39.8	88.1

Average delay analysis for fat-tree and multi-tiered, layered and non-layered architectures.



Average Bandwidth	Layered				Non-Layered			
	16 Host	35 Host	64 Host	98 Host	16 Host	35 Host	64 Host	98 Host
Fat Tree Architectures	16.8	6.17	3.44	4.3	23.56	3.96	4.4	4.6
Multi-tiered Architectures	21.2	14.9	23.4	28.3	23.9	18.9	12.5	18.4

Average bandwidth analysis for fat-tree and multi-tiered, layered and non-layered architectures.

SUMMARY

In this project, we designed and implemented Multi-Tier and Fat-Tree Data Center Architectures making use of the forward learning switches for centralized controlling, to compare and analyze the performances of two different Data Center Networks. We created a combination of architectures with 16, 32, 68 and 96 hosts for end-to-end testing. For the better performance of the network, we have scaled the networks vertically by increasing the number of aggregate layers and horizontally by increasing the number of Edge Layer switches and compared the Delay-Bandwidth values of the scaled and non-scaled networks. From the Delay-Bandwidth analysis, we conclude that, Multi-Tier architecture is well-suited for vertical scaling it increased the efficiency of network by increasing the bandwidth and decreasing the delay. However, horizontal scaling, in spite of offering a better bandwidth, it has increased the delay and cost of the network which is not suited for a real-time application. The performance of all Non-layered architectures has been consistent throughout our test and there has been no significant rise or fall of values. We also observed that the performance of network has improved when the network is scaled. When compared to Fat-Tree architecture, from the analysis we have performed, we concluded that Multi-tier is the better suited architecture for scaling as the algorithm allows to alter the number of switches to balance load on the network unlike Fat-Tree which has to bind to the algorithm which rapidly increases the number of switches in architecture and thus increasing network complexity and cost.

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