Performance Analysis of OSPF and Hybrid Networks

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***Abstract* — Software Defined Network (SDN) for large-scale IP provider network is an open issue and different solutions were proposed. However, the hybrid IP networks in which both distributed and centralized approach provide centralization of SDN and reliability of distributed networks. The common approach in which SDN controls the prioritized traffic and OSPF (Open Shortest Path First) guarantees the operation of traffic. In this research, we propose the SDN segregation, which maintain central management over dispersed routing control. A given topology is split in some fields with OpenFlow enabled switches as in between nodes. OSPF enabled router triggered updates to other routers in other field via SDN switches. The centralized controller defines how two OSPF routers observe each other. There will be a tradeoff between central control of SDN and fault tolerance capability of OSPF. As we increase SDN nodes control will increase and fault tolerance capacity of overall network decreases. The novelty of research work for balanced topology segregation also offers the models for network management. To show the enhancement provided by hybrid network over routing protocol deployment we have deployed separate test beds for routing protocol and proposed hybrid network.**

Keywords* — *SDN (Software Defined Network), OSPF (Open Shortest Path First), ABR (Area Border Router).

I. INTRODUCTION

Hybrid networks are pointing towards an important architecture domain, where the logically centralized control paradigm i.e. SDN and distributed routing algorithm like OSPF is implemented in same topology. Before step into hybrid networks we need to know about distributed and centralized approaches. [1–2]

A. Distributed:

Many organizations are running some algorithm for traffic forwarding in their internal network. Such networks are very robust, as they got structural cycle of implementation. If a forwarding device got a packet that has to reach on a given destination, then device will read that packet process it and decide based on implemented algorithm where to send this packet. Now days many algorithms are being used by vendors, some of them are standardized and some are proprietary. Like RIP V2, OSPF V2, EIGRP. In this research, we are going to use OSPF, as it is not proprietary, structural architecture, and almost every manufacturer supports it. We will only consider the network of an organization [3–5]. OSPF is a nonproprietary interior gateway protocol (IGP), which provides high availability, redundancy and classless routing for internal network, based on link-state technology. It uses Dijkstra algorithm, which is extension of Bellman-Ford vector based algorithms. OSPF also supports authentication of routing updates, and VLSM and route summarization [9]. OSPF uses flooding phenomena to maintain link-state database of routers. If a change occurs in network, then concerned router will trigger and flood message to all routers in area. Areas used to define boundary of flooding. Flooding and calculation of the Dijkstra algorithm on a router is limited to changes within an area. All routers in an area should have exactly same link-state database. Area border routers (ABRs) are the one that belong to multiple areas, and connect these areas to the backbone area. That is why ABRs should have information regarding concerned areas and backbone area. Area depends upon interface of router. A router whose interfaces are advertise in more than one area is called ABR as shown in Figure1 [3], [9].

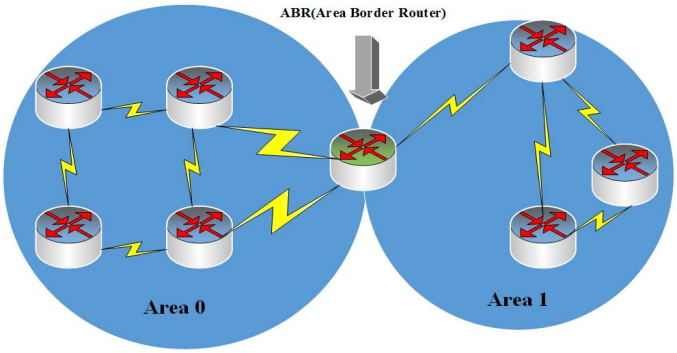

Fig. 1 OSPF Area Border Router

B. Centralized:

In last decade networks evolve rapidly as organizations, want vendor independent and cost-effective solution. In addition, cloud computing has presented many new challenges for service providers such as: big data, wider application and centralized management of geographically separated

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datacenters. Therefore, link capacity, network scalability and security have become key points that have to be more efficient than ever. At the same time, Open Networking Foundation (ONF) presents open flow protocol. In last 5 years, SDN has become very hot topic for researchers. As it promises to gasp all the market by 2020 [6].

SDN: Software Defined Networking (SDN) has emerged in recent years. This architecture separates the control plane and forwarding plane. It consists of three layers and interactions between these layers as shown in Figure. 2. [24]. The structure decouples the network functionalities, means control is located on different device than forwarding device, which enables the programmability of our network control. So, the forwarding physical devices functionality is abstracted and programmed as per application and network requirement. OpenFlow is an essential protocol for SDN architecture. The SDN is directly programmable as per our application requirement, adaptive as network services change, centrally managed as SDN controller gives access to hardware resources of physical infrastructure and vendor-neutral as we can use hardware switches from any manufacturer. As SDN is based on open standard protocols and no need a vendor proprietary protocol or hardware, so implementation and operation of network is quite simple [7-8].

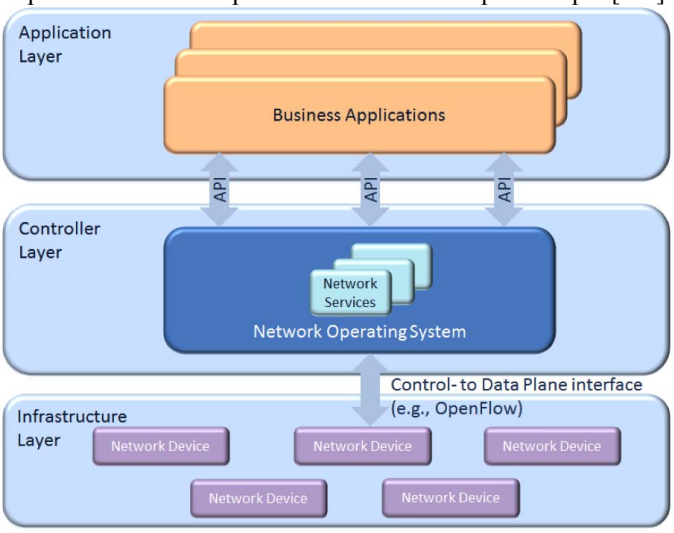

Fig 2. SDN Layered Architecture [24]

C. *Hybrid Networks:*

There are multiple reasons to implement hybrid network in corporate environment rather than implement complete SDN or Distributed, as migration from legacy network to SDN is extremely expensive because customer has to replace entire infrastructure at once. Legacy networks are fully robust for fault tolerance as compare to SDN. Moreover, distributed protocols are scalable by design and SDN is scalable by ad-hoc communication. A number of approaches are introducing in last 3 years to implement hybrid SDN. [12-14]. In typical distributed network control, one forwarding device is keen how others are configured. This will create abnormalities like routing loops and black holes, which eat all the bandwidth. To mitigate these issues multiple mechanisms, have to be implemented like split horizon, route poisoning etc. However, centralized network devices are only concerned to their flowable, and controller implement any algorithm to communicate between any two devices.

II. Related Work

Hybrid SDN has been explained in [8], [16-18]. In [19] "policy based routing on steroids" capability of SDN controller to alter the table has discussed in [16]. It presents an efficient way to migrate gradually from legacy to SDN network. Sequence of changing routers is legacy network has very diverse effect on network performance. Google's B4 [20] is a practical implementation of hybrid control plane. Inter area communication of OSPF is defined in [3], where areas are defined for simplified administration of large scale networks. An approach about zoning the OSPF network using SDN controller has explained in [21]. A zone is a network part which is governed by same paradigm (Central or Distributed). Another hybrid SDN network approach is explained in [12–13] fibbing. But in this approach SDN switch alter the network behavior by introducing little lies to legacy routers. Moreover, the operational difference is as follows: fibbing broadcast, false external link state advertisements (LSAs) (i.e., Type 5) towards the network, so extending the network size of OSPF with calculated virtual nodes. By design, Fibbing uses OSPF LSA-5 which is exotic feature of OSPF as defined in Cisco [22] and Juniper [21] articles. Fibbing also depends upon external traffic measurement tool. On the other hand, distance vector routing protocol (DVRP) cannot be used for hybrid SDN, because DVRP does not used flooding topology information.

III. Proposed Design Implementation Methoodlogy

In our proposed model, we are going to replace some routers with SDN open flow supported switches. Selection of network node to be replaced depends upon traffic flows. Those devices which are critical in whole autonomous system should be replaced. Therefore, we not only get a new architecture but also an optimistic approach for SDN migration. To achieve this, we have implemented a topology as shown by Figure 3, in which multiple areas are defined with four ABRs that are replaced with open flow switches in Figure 4 for second test bed. All the interfaces of routers in Figure 4 are defined in area0.

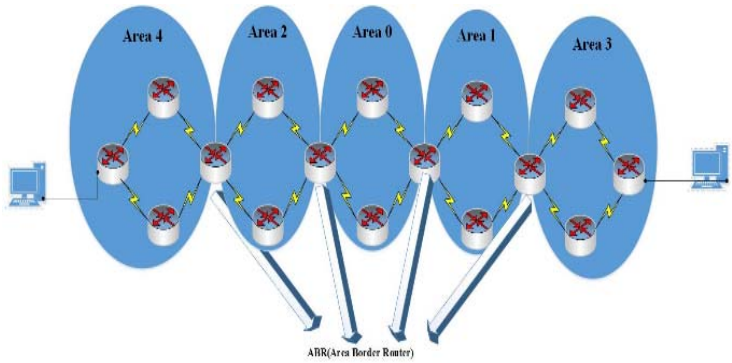

Fig 3. Typical OSPF Network

To accomplish this scenario, we use GNS3 a power full network simulator which can import router IOS and virtual box devices. We have implemented topology of cisco routers

and create HP commware virtual open flow switch in virtual box and import in GNS3. Furthermore, we have used two Linux systems at end of topology to plot results. In 1st part we have implemented simple OSPF topology with 5 areas and 4 ABRs. Secondly, we replaced all ABRs with OpenFlow switches.

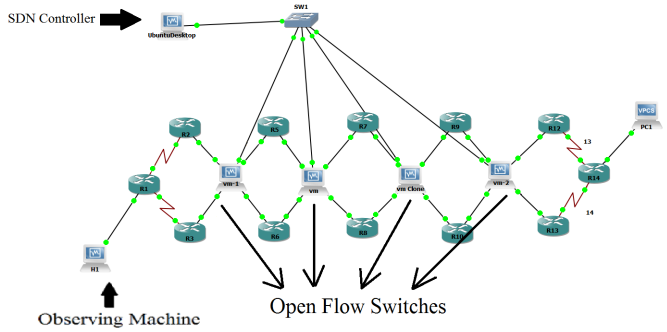

Fig. 4 Hybrid Network Design

IV. Simulation Results and Analysis

Node response time and network convergence time are key points when analyzing any type of network.

A. Node Response Time:

To obtain accurate values of node response time we have imported an external host to GNS3 with hrping utility which can measure response up to micro seconds. And capture the icmp packets with time. As OSPF needs to calculate SPF algorithm at each node so at each node processing delay for all incoming packet will increase. From Figure 5 it is clear that Node response time of our proposed model is much lesser than OSPF.

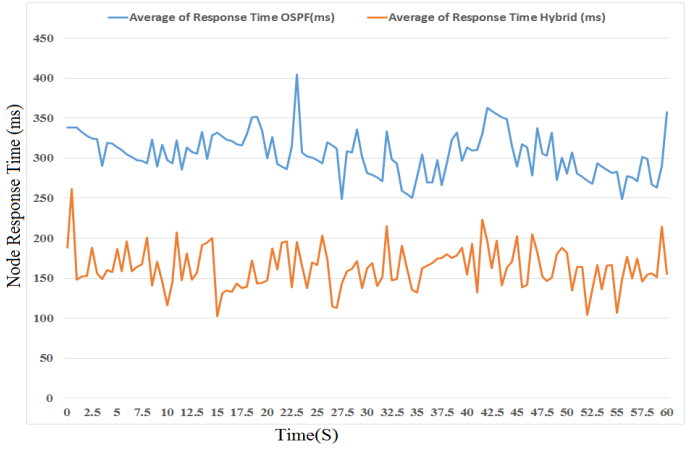

Fig. 5 Node Response Time Graph of OSPF and Hybrid Network

B. Convergence Time Analysis:

To measure the convergence time of each model we have applied an interrupt with link failure update in path of given scenario at specific node. A router is called fully converged in network when it has reachability to all the subnetworks of network. To measure the reachability time, we trigger a specific link update down or up and then measure the communication stop time to reinitialize time. This approach gives us true measurement of convergence time as the distance between two hosts is maximum and it covers convergence of all routers deployed in proposed topology. Figure 6 and Figure 7 represent the average convergence time of OSPF and hybrid network. Convergence time is the difference between two points, one is when response time drops to zero and second is when smooth communication starts. Figure 8 depicts about average convergence time for 15 tests.

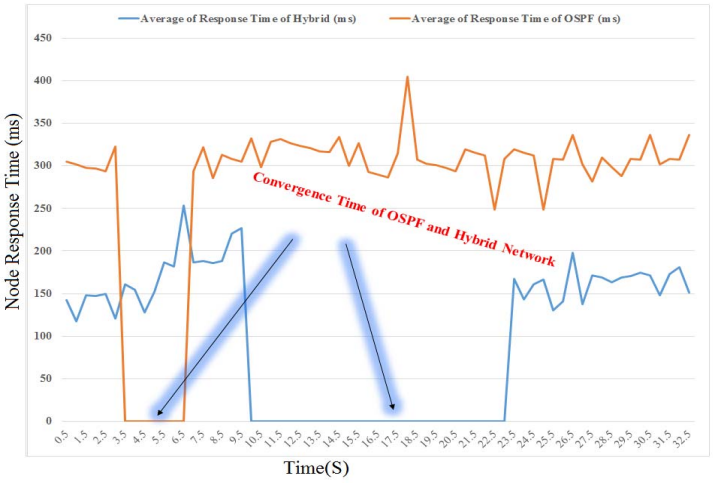

Fig 6. Test 1 for Convergence Time of OSPF and Hybrid

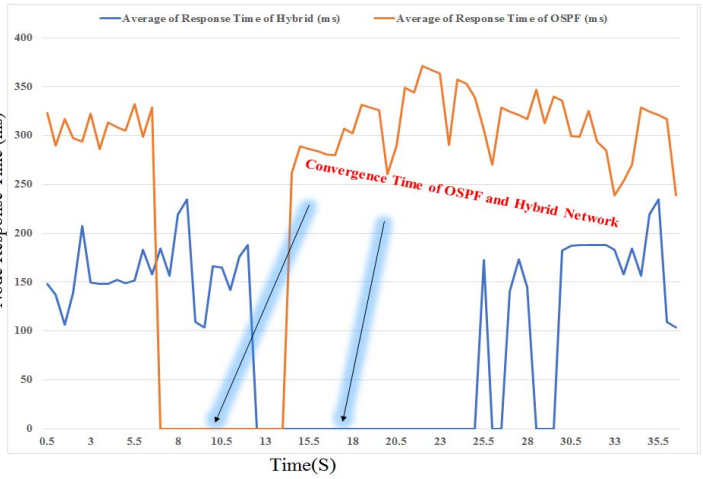

Figure 7 Test 2 for Convergence Time of OSPF and Hybrid

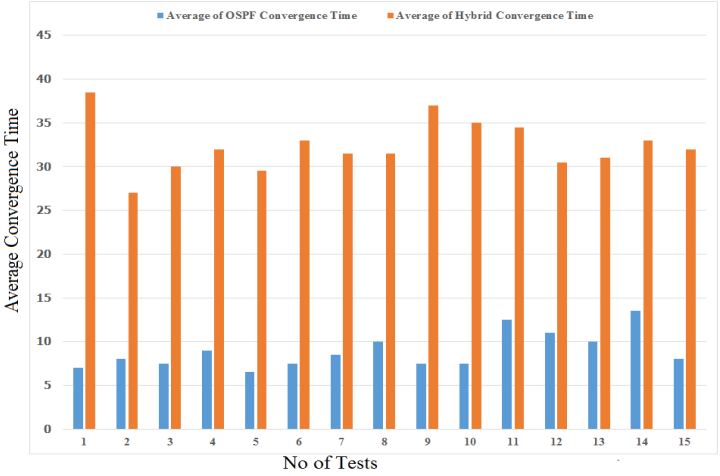

Fig. 8 Average Convergence Time for multiple tests

CONCLUSION

From above results it is concluded that we can use OpenFlow switches as intermediate node for legacy network communication. Using hybrid technique gives better response time for end to end communication when controller has written flow entries to switches it takes much lesser time to forward traffic to the respective port. When talk about convergence time due to link update during communication then OpenFlow nodes take more time to calculate path as they have to ask to controller to run algorithm for every switch in path and gives them flow entry. While every OSPF node runs its own SPF algorithm and when there is link update that specific routers reinitialize OSPF process and add routing entry to their own routing table so much lesser time is required compared to hybrid. Therefore, there is a tradeoff between node response time and convergence time when using hybrid technique.

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