Sindh Univ. Res. Jour. (Sci. Ser.) Vol.49(1) 37-42 (2017)

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Analysis and Improvement of Throughput for Open Flow Networks

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Received 22nd June 2016 and Revised 9th November 2016

Abstract: Open flow is an open standard that enables researchers to run experimental protocols in the campus networks we use every day. Open flow is added as a feature to commercial Ethernet switches, routers and wireless access points and provides a standardized hook to allow researchers to run experiments, without requiring vendors to expose the internal workings of their network devices. We have conducted experimental software results of network parameters of Wireless Mesh Network and Open Flow Network and analyzed them. The routing protocols selected for this work are OLSR (proactive) and AODV (reactive). The comparison between the two networks is based on key parameters such as Packets Sent to Received Ratio and Throughput.

Keywords: Open Flow Network, Wireless Mesh Network, Proactive, Reactive, OLSR, AODV, Throughput.

1. INTRODUCTION

Open Flow, a technology based on Software Defined Networks (SDN) emerged to revolution switches for the wired networks make them intelligent and the flexibility as programmable. OpenFlow comprise of the forwarding intelligence in the control server, along with simplification of switches or routers. This technique permits the implementation of forwarding productive with virtualization (Hu, *et al*., 2014).

The Wireless Mesh Network (WMN) is becoming the predominant wireless network technology for next generation networks. It has many advantages as compared with traditional wireless networks (Vural, *et al*., 2012).

- Self-Organizing routing paths by each node itself
- Wide coverage
- Scalable size of network
- Network reliance for connection stability
- Cost effective

Herein we provide the experimental use as well as results obtained by comparative analysis of OpenFlow while having Wireless Mesh Networks (WMN) allowing the flexibility as well as the efficiency.

2. MATERIALS AND METHODS

This section briefly explains selected routing protocols and Open Flow Networks.

2.1 Optimized Link State Routing (OLSR) protocol:

The Optimized Link State Protocol (OLSR) is a proactive routing protocol, so routing is continuously accessible whenever it is been in need. As a result, topology changes cause topology information to flood to all hosts within network. MultiPoint Relay (MPR) is used to decrease broadcast by the help of reducing the broadcasts numbers. OLSR practices two types of control messages: Topology Control (or TC) and HELLO. The Hello message is cast-off to find information regarding the status of link and neighbors of the host. The TC message is used to broadcast information regarding its promoted neighbor that comprises at minimum a list of MPR selectors. When a link is removed or added from a TC message, in both cases the host must increment the sequence number as shown in **(Fig-1)**.

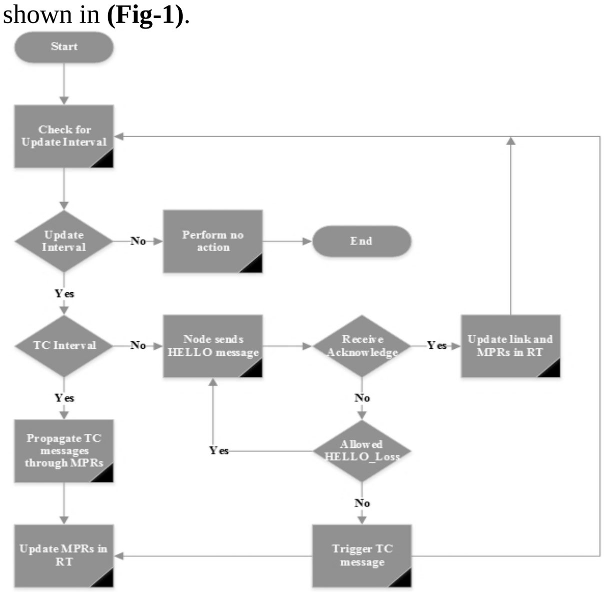

Fig. 1: Flow Chart of OLSR protocol

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The routing table are constructed by the help of hosts and its entries consists of following evidence: destination point address, next coming address, hop count towards destination point, and the local network address of interface. The shortest path algorithm is used to find the route of the routing table entry (Clausen and Jacquet, 2003).

2.2 Ad Hoc On-demand Distance Vector (AODV) routing protocol:

AODV, known to be a special reactive protocol, and technique for the developing and maintaining routing tables to create and maintain routes only when in need. Its routing table provisions the evidence of the sequence numbers. Routing discovery is cast-off by flooding RREQ messages towards neighbors. Every passing host is updated in its individual routing table for the requested host. When a message has an active acknowledgment option, in the response of RREP message, the RREP-ACK message must be sent. Whenever a link disconnection occurs, the host requisite invalidates the current route by sending a Routing Error (RERR) message to the corresponding neighbor, as shown in **(Fig-2)**.

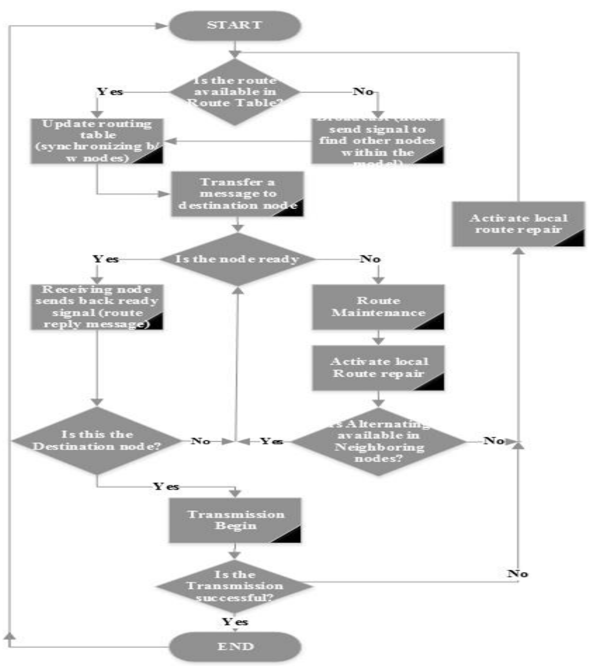

Fig. 2: Flow Chart of AODV protocol

The AODV periodically also uses Hello messages to get informed their neighbors about the host link status that it is alive. Hello message is broadcast where TTL is equal to 1, so that the message is not forwarded further. The AODV contains a routing table that contains fields as: destination point address, next hop, hop count, destination point sequence number, lifetime, and preamble list and route status (Bagwari, *et al*., 2012).

2.3 Open Flow Networks:

A typical router/switch contains firmly inter-linked elements that are used to handle packets (presented by data plane) forwarding along with respective forwarding tables (presented by control plane). These Switches are more complex and problematic to outspread with novel functions. OpenFlow technology discourses such matter by splitting control plane and data plane. Where Control plane does not reside on switches merely, but also executed partly in the server network that turns a network simulation wide (based on NOX most of all).

For flow processing, set of rules are used which are abstracted from flow tables directed within data plane which in terms provide security between both planes. Whenever packet arrived at the switch and for that packet no suitable flow entry in the flow table is found. For such packet, the Network Operating System is referred. Due to its property of awareness regarding packet and its flow, OpenFlow provides many interesting paying off network facilities that could be applied efficiently (Jarschel, *et al*., 2011).

Routing as well as forwarding in the WMNs is like in many ways to a wired traditional network. OpenFlow with WMN got some ideas which must be considered; since the link quality changes and the nodes join and leave the network and the network topology changes at the advanced speed as compared to the wired network. By means of WMN's self-configuration requirements, this requires independent topology discovery.

OpenFlow classically practices out of band network signaling having a distinct network from actual data network. Meanwhile IEEE 802.11 MAC layer doesn't provision VLANs, in that case 802.11 Service Set Identifier (SSID) could be castoff equally (Selmic, *et al*., 2016).

Core network **(Fig. 3)** includes a Monitoring and control server (or MCS) and a NOX (a controller). This MCS interrogations information from grid switches/routers and clients and establishes the topology with association (Tootoonchian and Ganjali, 2010).

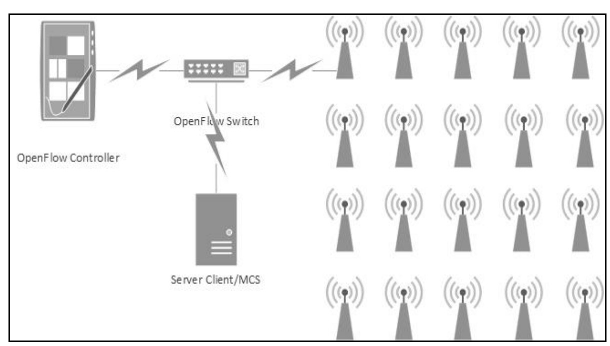

Fig. 3: Open Flow Configuration with WMN

The chief purpose of the controller NOX is to achieve routing associated jobs managing network point addresses and handling node mobility. In case of supporting these tasks, this controller (i.e., NOX) can utilize all the databases that are preserved by the MCS (Lara, *et al*., 2014). Furthermore, **(Fig- 4)** states the flow chart of OpenFlow configuration relating the actions and flow of packets for negotiating with controller.

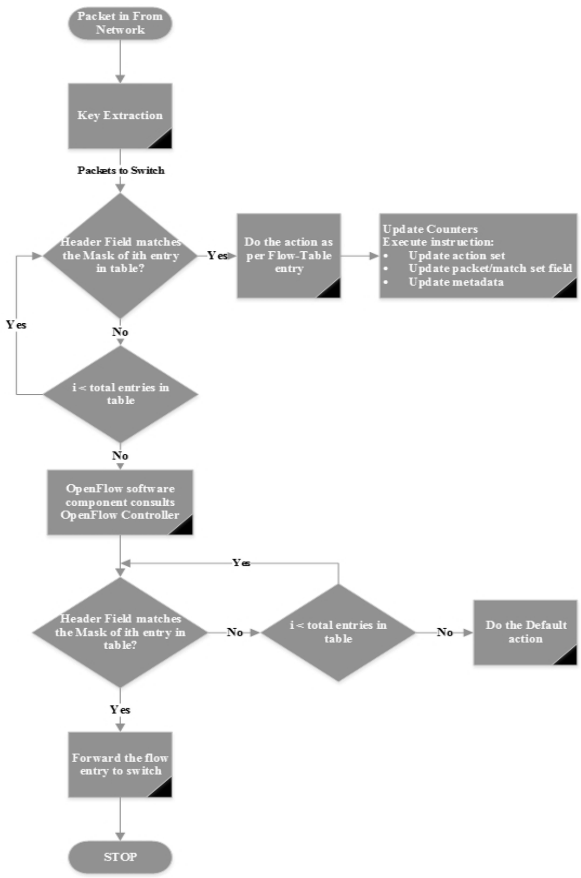

Fig. 4: Flow Chart of Open Flow Configuration

3. IMPLEMENTATION

In our research work, we implemented the basic SDN architecture in the NS3 software using C++ language which is connected to wireless routers called as nodes in our implemented WMN. NS3 software is used to implement two routing protocols proactive and reactive protocols as OLSR and AODV respectively. These routing protocols are implemented over WMN and OpenFlow network separately. The experiment implementation forwarded in such a way that OpenFlow controller is connected to a client and the OpenFlow Switch/router. The mesh network is then connected to the same OpenFlow switch/router to communicate with each other.

Following parametric units are set to perform implementation analysis:

- Number of Nodes: 25 (change as per analysis: 5x5)
- Simulation Time: 120 seconds (change as per analysis)
- Mobility Model: RandomWalk2d
- Size of packets: 1024 bytes
- Controller: DropController (NS3)
- Data Rate of Point to Point links: 1000Mbps
- Data Rate of CSMA connection: 1000Mbps
- Data Rate of Wireless Mesh connection: 1000Mbps
- Data Rate of CSMA connection from controller to switch: 1000Mbps
- Distance between each node: 100 meters (change as per analysis)

The routers are configured to mesh routing in the WMN and implementation of OpenFlow situation for both data and control path. NOX (controller) is used as an Operating System. The OpenFlow technology implements XML for link between the NOX and the IEEE 802.11 to activate a handoff at station.

4. EVALUATION

We evaluate and analyze the principal parameters of OpenFlow in Wireless Mesh Networks concentrating on the general ability performance of architecture likewise Packet Sent/Received Ratio and throughput separately for OLSR and AODV. All results are obtained after iteration and represented in the average form.

4.1 Number of Packets Sent/Received (OLSR):

In this experiment we evaluate the reception of number of packets according to the number of packets that were sent. A node is selected as a source node which qualifies to send the packets to destination node. This destination node is also set by coding language.

It is an important factor to analyze the ability of network that how many packets are sent or dropped. For this reason, we encountered the 10 packets over such network to watch and analyze the behavior of Wireless mesh network and OpenFlow network while using OLSR routing protocol as a messenger in the network. **Fig-5(a)** shows the comparative analysis of the Number of Packets Sent and received respectively. In our implementation, we considered the number of nodes/access points/WMRs in a range of 9 to 64. These number of nodes are selected in such a manner that the mesh should exist in an nxn format. The behavior of OLSR with OpenFlow architecture shows the combinational effect by receiving all sent packets. Our results shows that packets were dropped completely when the number of nodes increased above 36 due to the limitation of OLSR protocol respective to distance between source and destination node but the OpenFlow network still responds with 100 percent efficiency by receiving all the sent packets.

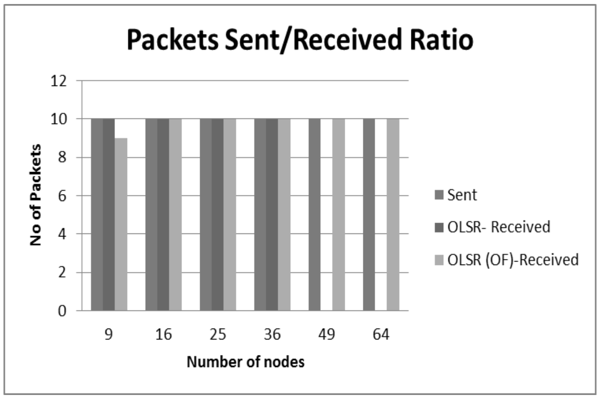

Fig. 5(a): Number of Packets sent/Received Ratio

While in **Fig-5(b)**, the comparative analysis of Number of packets sent vs received in both networks with change in Simulation Time in seconds has been taken. NS-3 simulation software appears to send the specific 10 number of packets over the network by selecting a specific simulation time (seconds). Let suppose if we take 30 seconds of simulation time, it means that after the start of simulation when simulator reach to 30 seconds of simulation time, the source node tends to send 10 numbers of packets over that specific seconds of simulation time. Herby Figure shows quite impressive and significant results for OpenFlow network as compared to the simple wireless mesh network by increasing the simulation time. The results clarifies that the OpenFlow network requires short interval to complete its Simulation in software scenario under scaling method.

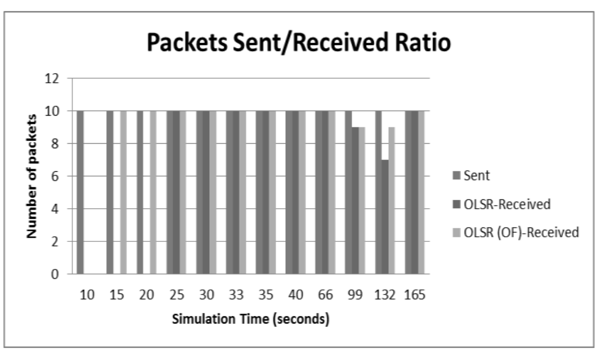

Fig. 5(b): Number of Packets sent/Received Ratio

4.2 Throughput (OLSR):

Throughput has been a measure of the comparative effectiveness of large commercial computers that run many programs at the same time. Our analysis concluded the result for throughput w.r.t change in Number of Nodes, Simulation time (seconds) and Distance between nodes (meters).

(**Fig-6(a))** is the result of Throughput obtained by iterations w.r.t change in Number of Nodes, collected by seeding/iterations for numerous throughput outputs while changing the Number of Nodes in numbers. The figure clearly shows the throughput increased up to 14 Mbps by using OpenFlow network. This is the significant result showing that while increase in Number of nodes occurs, OpenFlow networks maintains the better output while other network dies down.

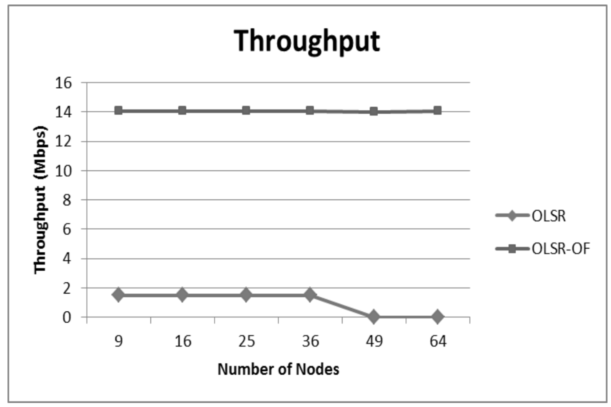

Fig. 6(a): Throughput

Second experiments i.e. **(Fig-6(b))** clearly shows that the OpenFlow network received all sent packets within a short interval of simulation time as compared with the simple WMN. An average of 23 Mbps throughput is obtained for OpenFlow network in a specific interval of simulation time. Such significant results clarifies that the OpenFlow network is faster than the other one. While using simple WMN, the throughput under overall simulation time remains 1.5 Mbps in average.

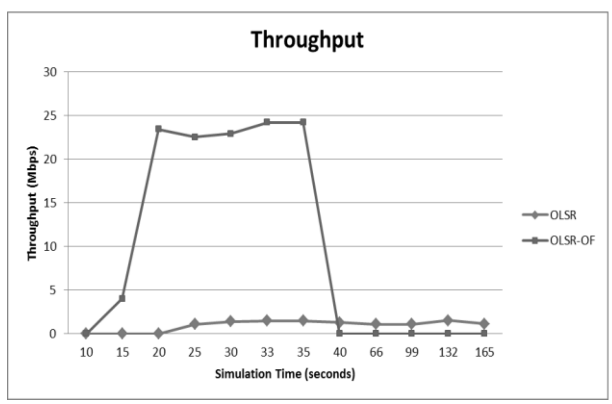

Fig. 6(b): Throughput

Our third experiment describes the effect when change in distance occurs. **(Fig-6(c))** shows the results of measuring Throughput w.r.t change in Distance between each node (measured in meters). An average of 14 Mbps throughput was observed over certain range of 700 meters distance between each node, while the other network gives 1.5 Mbps in average.

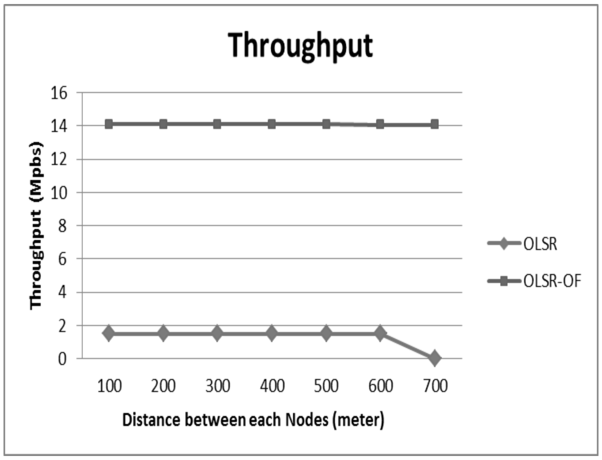

Fig. 6(c): Throughput

4.3 Number of Packets Sent/Received (AODV):

Just like our above mentioned experiment and its analysis while replacing OLSR protocol by AODV protocol, we concluded following results in the form of bar charts and line diagrams described as below:

Fig-7(a) shows the comparative analysis of the Number of Packets Sent and received respectively. The range of 9 to 64 number of nodes been selected to demonstrate the experiment results. These nodes form nxn format. The behavior of AODV with OpenFlow architecture shows the combinational effect by receiving all sent packets. OpenFlow network responds with almost 100 percent efficiency by receiving all the sent packets.

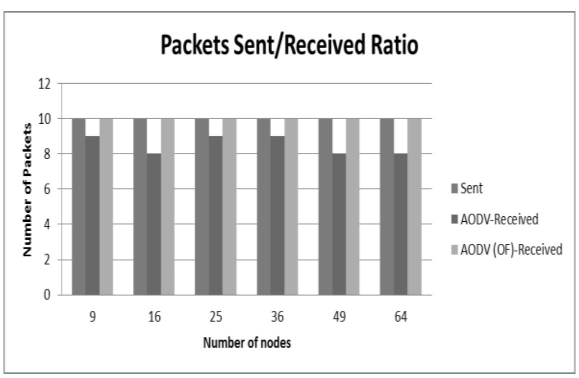

Fig. 7(a): Number of Packets sent/Received Ratio

Fig-7(b) describes the packets Sent/Received Ratio with respect to change in simulation time. Suppose if we take 30 seconds of simulation time, it means that after the start of simulation when simulator reach to 30 seconds of simulation time, the source node tends to send 10 number of packets over that specific seconds of simulation time. NS-3 simulation software appears to send the specific 10 number of packets over the network by selecting a specific simulation time (seconds). Herby figure shows that mesh network receives the packets at 20 seconds of simulation time and onwards. In comparative to OpenFlow network, almost all sent packets were received by the total simulation time. While in simple WMN, there is an irregularity in the Packets Sent/Received Ratio. Hence, packets are dropped which are due to many reasons. Among several, the mismanagement in the packet routing is the major one.

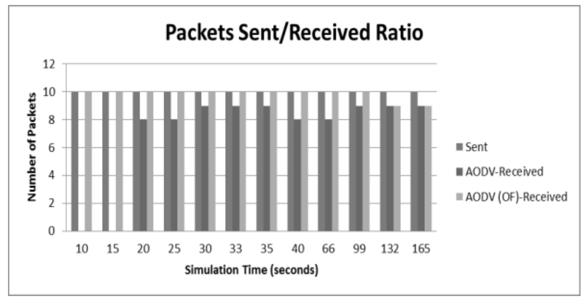

Fig. 7(b): Number of Packets sent/Received Ratio

4.4 Throughput (AODV):

Just like in the case of OLSR, AODV also showed significant results of throughput. **Fig-8(a), 8(b) and 8(c)** gives the brief description of throughput w.r.t change in Number of Nodes, Simulation Time and Distance between each node respectively.

As far as the effect of change in Number of Nodes over throughput is concerned, **(Fig-8(a))** described the obtained results of throughput while changing the Number of Nodes in numbers. Whenever the Number of Nodes increases, the distance for mesh grid also increases which directly influence the rate of bandwidth usage over the network. The figure clearly shows the throughput increased exponentially up to 180 Mbps by using OpenFlow network with full wireless mesh network while increase in number of nodes occurs (distance between source and destination node increases). This is the significant result showing that while allocating high bandwidth, OpenFlow networks improves the output by increase in throughput.

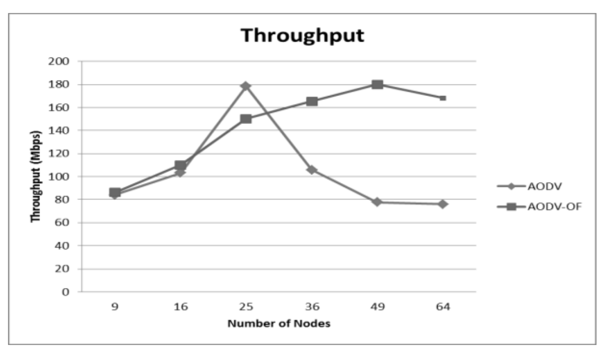

Fig. 8(a): Throughput

The Throughput is also calculated and observed by change in total simulation time. **(Fig-8(b))** clearly shows the high throughput of about an average of 175 Mbps in a specific interval of simulation time and graph drown down on 99 seconds of simulation time because controller shutdown the connection when all packets been received from the source node.

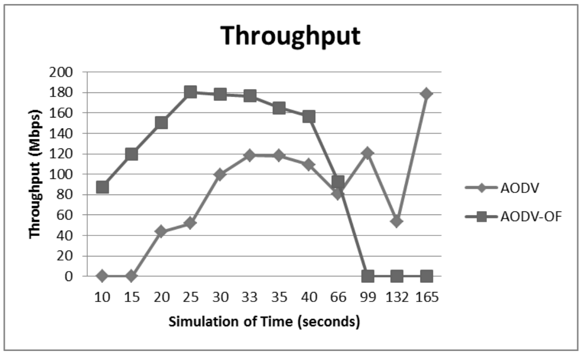

Fig.8(b): Throughput

Fig-8(c) represents the results of Throughput w.r.t change in distance between each node. Increase in distance of mesh matrix is directly proportional to the change in distance between each node. Following such idea by our implementation, OpenFlow gives an average of 160 Mbps high throughput w.r.t simple WMN using AODV protocol which dies down by 130 meters distance between each node.

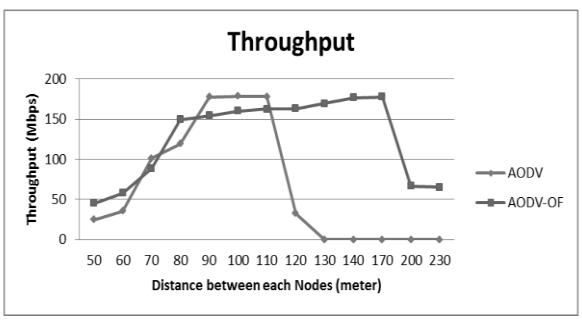

Fig. 8(c): Throughput

5. CONCLUSION

This paper presents the comparative analysis of throughput for two different networks i.e. simple wireless mesh network and OpenFlow structure with wireless mesh network over OLSR and AODV protocols separately. The important observation is the comparison of experimental results matches with the expected results based on the theoretical analysis. Two parameters were sorted out i.e. Packet Sent/Received Ratio and Throughput w.r.t Change in Number of Nodes, Simulation Time and Distance between each node. As expected, OpenFlow network outperforms WMN by considering ability for the maintenance of connection both in the case of OLSR and AODV by periodic exchange of information. The OpenFlow containing network (for both OLSR and AODV) found to be almost 100% efficient in receiving number of packets that were sent and gives wide range of throughput over a certain period of simulation while considering simple WMN, the packets Sent/Received Ratio shows the irregularity in receiving the packets and outputs lesser throughput over short intervals of simulation. Our analysis signifies that, the OpenFlow containing network works beneficial for dense and long distance networks.

As per future work been concerned, the same OpenFlow network should be considered with more than one controller connected to the WMN across both ends for improved and longer range communication and to move this technology to the next level.

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