OpenFlow-Based Load Balancing in WLAN: Throughput Analysis

Syed Mushhad M. Gilani, Heng Meng Heang, Tang Hong, Guofeng Zhao and Chuan Xu

Abstract Software-Defined Wireless Network (SDWN) aims to build a flexible wireless network infrastructure that can support future Internet services. In this paper, we present WLAN architecture to take advantage of OpenFlow that provides the global view of the entire network including wireless network configuration, resource allocation, and flow control policies to make the load balanced network environment. We build simulation environment through Mininet-WiFi to analysis throughput and jitter values of associated stations. The results demonstrate that proposed architecture can divide the load between APs that increase the average throughput of associated stations.

Keywords OpenFlow · WLAN · Load balancing · Software-defined network

1 Introduction

IEEE802.11-based wireless network considers to provide high-speed Internet with robust throughput for extensive sort of devices. The capacity of WLAN users rapidly increased although the performance is reducing. The wireless network infrastructure is becoming gradually more complex, dispute and deficient with predefined existing standards, rules, and technologies. The most dominating issues of enterprise WLAN includes load-imbalance [1] between APs that produce transmission delay, minimized throughput, lack of resources, and low responsiveness.

Load balancing in IEEE802.11 wireless network initiated when different access points coverage area is overlapped. In this kind of scenario, at least, two access points available for association with the user. Thus, to make a fair selection of access point apply the load balancing technique that calculates the network load and distributes the load equally using predefined rules or algorithms.

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Software-Defined Wireless Network (SDWN) [2] technology has been obtaining a significant interest for separation of control plane and data plane. It has been applied to various domains of a wireless network with tremendous flexibility, dynamic scheduling, fine-grained packet control and global view of the entire network.

We propose a system model for WLAN within load balancing environment, based on SDN paradigm. The main objective of this research work is to construct OpenFlow-based simulation topology for testing and analysis of TCP throughput and UDP throughput in WLAN. We focus on improving the performance of the wireless network regarding transmission throughput which affected due to load-imbalance between APs.

2 Related Work

As mentioned earlier, SDWN spreads into depth level of the wireless networks such as on-demand resource allocation with resource optimization, simultaneous support for heterogeneous wireless networks, and execution of open APIs. Moreover, SDWN is helpful for multiple entities of a wireless network including ISP providers, network operators, and consumers [2]. However, SDWN is not bounded in only wireless network dimensions. The other dimension of SDWN is mobile network covering radio technology that targets the base station [3]. The multidimensional nature of SDWN makes it more complex then SDN-wired networking approach. OpenRoads [4] is the pilot project about SDWN that enables user mobility between WiFi and WiMax. NOX [5] controller deploy to control network devices, and FlowVisor [6] makes virtualization with the isolation of traffic paths. However, OpenRoads limited to mobility in WLAN environment without awareness of load balancing.

Recently, researchers have been introduced some load balancing schemes in the wired SDN environment. Such as [7], in which authors proposed an architecture for mobility management with an extensive feature of load balancing between switches to reduce the packet delay. Another [8] load balancing technique introduced for OpenFlow-enabled switches which installed in data center networks. In comparison to schemes mentioned above our proposed scheme specifically, targets the load balancing between APs.

3 System Model

The proposed load balancing system model consists of a centralized controller installed with load balancing applications, OpenFlow-enabled switches, and APs. OpenFlow-based controller POX [9] is to provide a global view of entire wireless access network regarding packet control, traffic flow management, end-terminal association, and load balancing. OpenFlow/SDN enables rapid development and deployment of innovative applications. We deploy three applications on the top of the controller as mentioned in Fig. 1.

Wired Ethernet switches configured with OpenFlow table to keep records of packet flow statistics includes packet forwarding rules and flow entries with switch port numbers. OpenFlow-enabled AP (OFAP) received instructions from controller regarding packet forwarding, packet discarding, packet re-transmitting, and packet broadcasting policies. The proposed system consists OFAP with Load calculation agent (LCA) as depicted in Fig. 2. The centralized controller forwards the station probe request to LCA that creates load calculation virtual AP (LCVAP) to provide a dedicated virtual connection for an individual station.

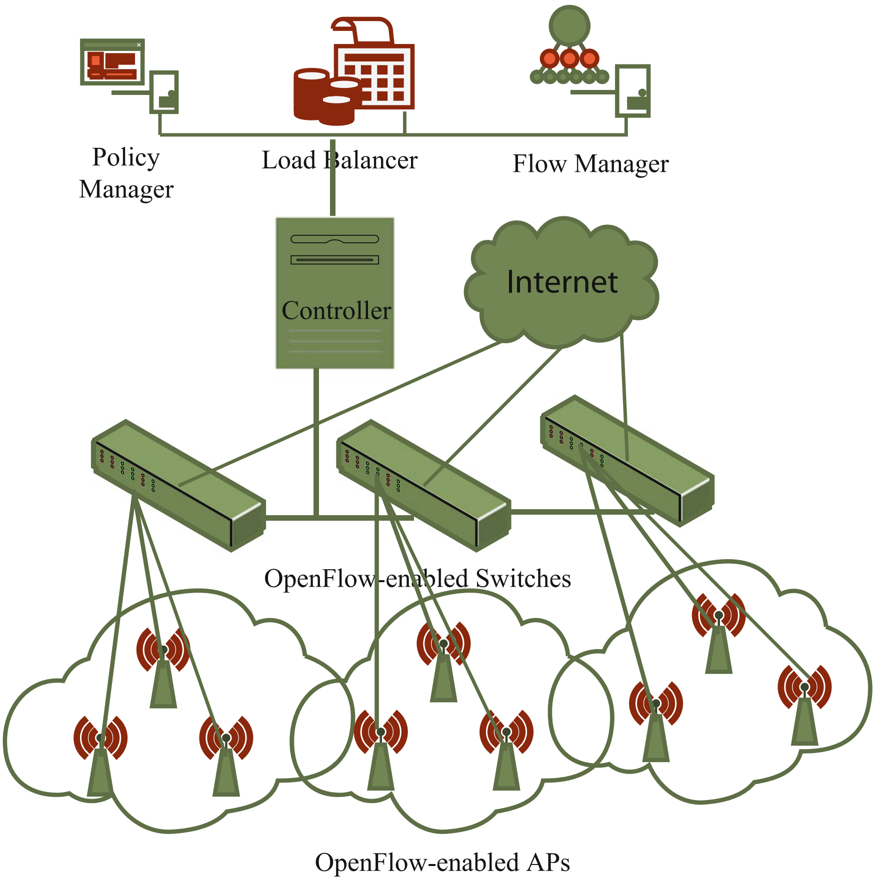

Fig. 1 Overall system model

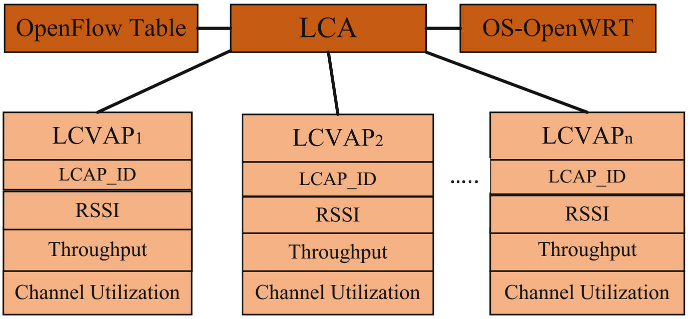

Fig. 2 OFAP structure

4 Simulation Test

We evaluate the SDN-based load balancing mechanism within WLAN through Mininet-WiFi [10] simulation environment as illustrated in Fig. 3. We consider ten stations which are associated with three different APs in this simulation topology. In this experiment, we deployed APs in overlapping area to analyze the traffic load.

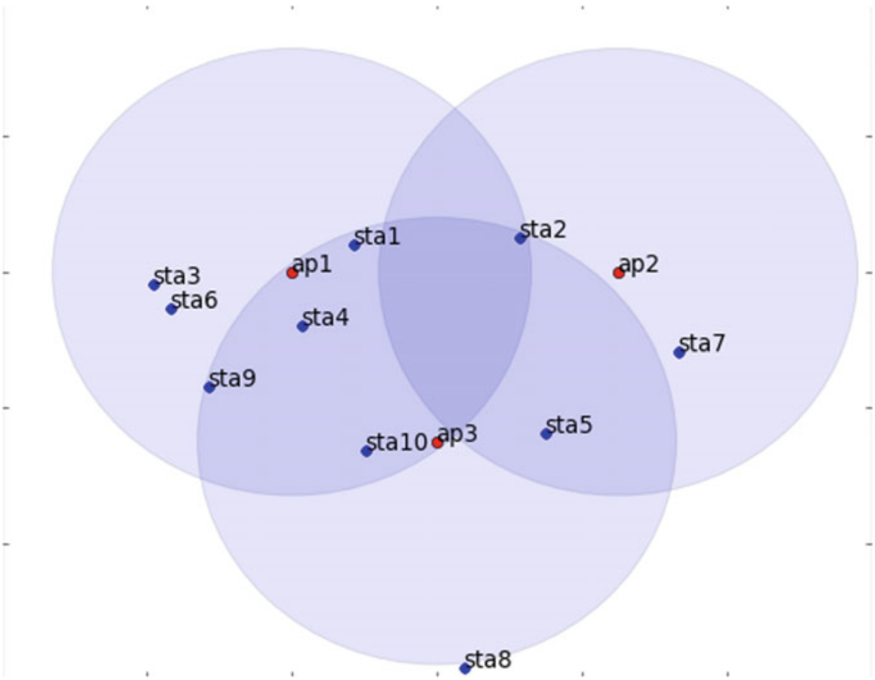

Fig. 3 Simulation environment to analyze transmission throughput

Table 1 Simulation configuration parameters

Controller	Wireless standard	Channel	Data rate	Data range	Tx-power	Transmission type
POX	802.11 g	Channel 6 (20 MHz)	54.0 Mbit/s	100 m	20 dBm	TCP and UDP

After creating a custom topology, two stations are taken as HTTP server and the remaining stations are performing as HTTP client. According to the traffic load, the server schedules the clients. The centralized controller which configures with load balancer defined the policy and rewrites the destination address of incoming packets for forwarding towards less loaded APs. Ipref uses to measure the throughput between stations and server. Moreover, it also permits to perform various tests that enabled insight view of the current network performance with packet loss ratio, delay, and jitter (Table 1).

In our simulation topology, we collected the distance value of each station with associated AP and related-received signal strength indicator (RSSI).

4.1 TCP Throughput

Initially, TCP Server configured on Sta2 with port 5566 at default TCP window size 58.3 Kbyte. TCP Clients on Sta1, Sta3, Sta4… Sta10, associated with sta2 for sending TCP traffic at different transfer rate through various APs. The association interval time is set to 15 s with various transfer rates as mentioned in Table 3. The first test performed using the traditional approach in which each station association is based only on RSSI that creating an imbalance between APs and effect the bandwidth. Figure 4a represents two stations sta1 and sta3 that associated with

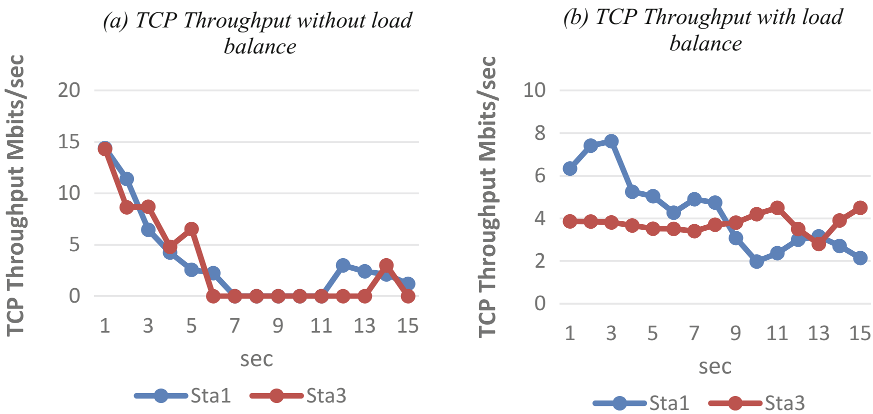

Fig. 4 TCP throughput analysis between sta1 and sta3

Table 2 Comparison of TCP throughput during access to server sta2

		Traditional approach		OF-based approach	
Station	Time interval (s)	Transfer (Mb)	Bandwidth (Mb/s)	Transfer (Mb)	Bandwidth (Mb/s)
Sta1 => Sta2	0–15	2.38	1.23	8.00	4.32
Sta3 => Sta2	0–15	2.10	1.11	8.25	4.51
Sta4 => Sta2	0–15	1.82	0.8	8.30	4.6
Sta5 => Sta2	0–15	1.09	0.7	8.00	4.33
Sta6 => Sta2	0–15	3.02	1.85	7.92	4.1
Sta7 => Sta2	0–15	2.08	1.02	8.25	4.51
Sta8 => Sta2	0–15	3.00	2.01	9.00	5.2
Sta9 => Sta2	0–15	0.79	0.52	8.30	4.6
Sta10 =>Sta2	0–15	0.98	0.56	7.92	4.1

overloaded AP and in results throughput degradation started and reached to 0 Mbits/s.

The same test performed with OF-based approach in which stations association based on the load of individual OFAP. After adopting the proposed approach the throughput of sta1 and sta3 enhanced as illustrated in Fig. 4b. Meanwhile, others associated stations transfer rate and bandwidth also improved. Table 2 provides comparison results between the traditional approach and OF-based approach.

4.2 UDP Throughput

The second experiment performed on UDP Server on Sta10 with port 5566 and monitored the results after every second. Start the UDP Clients on Sta1, Sta3… Sta10. We select two stations Sta7 and Sta9 to analyze their performance in a traditional environment and OF-based load-balancing environment. We measured the traffic using Ipref and collect samples of traffic throughput.

Figure 5a shows the results of sta7 and sta9 which are connected with server sta10 at 1.5 Mbits/s. Meanwhile, the associated AP received others stations association request due to strong RSSI and connected with them that make overloaded the AP. Due to an unbalanced network, the throughput of sta7 and sta9 gradually decreased and till reached to 0 Mbits/s.

The same experiment conducted in OF-based load-balancing approach that provides association on the basis of LCA that makes the overall balanced WLAN. Figure 5b shows the sta7 and sta9 performance which maintains better average throughput in comparison to traditionally based approach.

In this experiment, we also compare the traditional approach with OF based approach regarding congestion level of each station that reveals the OF-based WLAN is less congested. The results obtained from traditional and OF-based approach regarding jitter values are shown in Table 3.

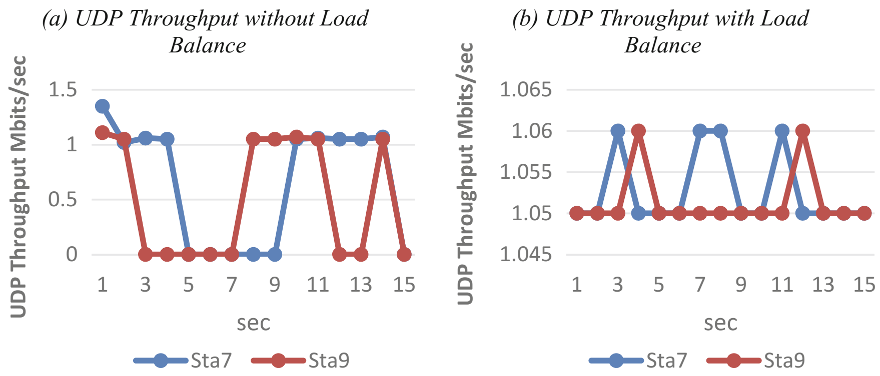

Fig. 5 UDP throughput analysis between sta1 and sta3

Table 3 Result of jitter values when all stations accessed to server Sta10

Station	Interval (s)	Jitter (Traditional) (ms)	Jitter (OF-based approach) (ms)
Sta1 => Sta10	0–15	1.196	0.230
Sta2 => Sta10	0–15	2.613	0.182
Sta3 => Sta10	0–15	2.087	0.375
Sta4 => Sta10	0–15	1.653	0.128
Sta5 => Sta10	0–15	1.879	0.448
Sta6 => Sta10	0–15	2.275	0.275
Sta7 => Sta10	0–15	3.012	0.248
Sta8 => Sta10	0–15	0.897	0.190
Sta9 => Sta10	0–15	1.673	0.162

We collect statistics of each station and make an overall comparison in traditionally based approach and OF-based approach. The results demonstrated in Fig. 6 exposes that OF-based load balancing approach enhanced the individual station throughput.

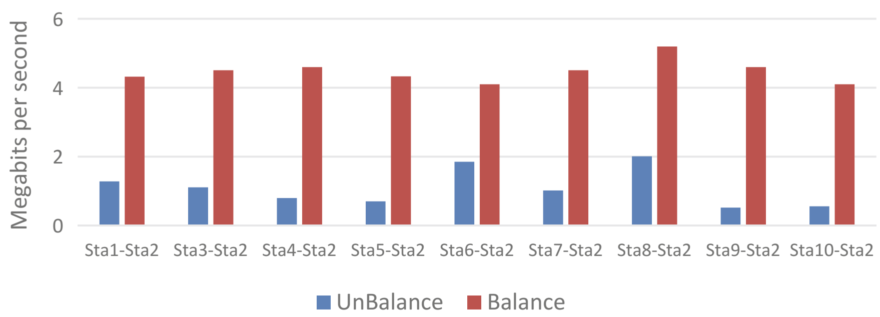

Fig. 6 Comparative bandwidth analysis of associated stations

5 Conclusion

The objective of this research paper is to evaluate the throughput of associated mobile stations and provide a comparison between traditional and proposed environment. We conducted experiments through Mininet-WiFi to the analysis of stations through in load balance and load-imbalance environment. In future work, we shall deploy the proposed architecture with different applications to evaluate the performance of OFAP.

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