An Enhanced Handover Algorithm for Increasing the Number of Users in WLAN Using SDN

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Abstract— **Wireless networks help users communicate anywhere and anytime. The user can move around from one position to another without interruption. The process of maintaining continuous communication among various coverage areas is called handoff, which maintains connection continuity while the station moves from one access point to another. Many researchers have presented solutions to network handoff problems, but these approaches resulted in skipping some users to access the network. This paper presents an enhanced handover algorithm, which leads to increasing the number of connected stations with a network. The proposed algorithm is implemented using software defined networking simulation tools. Many experiments are designed and implemented to validate the proposed algorithm. The experimental results show that the enhanced handover algorithm is efficiently increasing the number of clients connected to the network.**

Keywords—***Handover, WLAN and SDN.***

I. Introduction

Recently, there are more demands of wireless networks, as a result of the growing of mobile devices that support wireless networks.

Nowadays, wireless networks have become very important in life and needed all the time. Therefore, Continuation of an active station is one of the most important Quality of Service (QoS) in the wireless networks.

Wireless networks offer communication services to clients, anywhere with an Access Point (AP) coverage area. Mobility is the most important feature of the wireless networks. Continuous mobility service of a client with no interruption from a coverage area to another is controlled by a network system and it is a so-called handoff (or handover) [1].

Many Handoff methodologies has been developed and improved in performance, but further enhancement is needed to increase the QoS of Wireless Local Area network (WLAN).

WLAN Network is one of the most important wireless network types, this network covers area whose radius up to hundred meters, mainly in home and office environments. In WLAN, communication to/from a mobile station is always carried over the APs [9].

The aim of this paper is to increase the number of connected stations with WLAN, so more users will be provided a communication service. This work presents an improved algorithm of handoff process. It utilizes SDN technology, which is built by using a new WLAN architecture for centralized control introducing more flexibility and better performance [7].

The rest of this paper is organized as follows. Section II discusses the background and the related work. Section III presents an overall description of the proposed method. Section IV presents experimental results and discussion. Finally, Section V presents a conclusion of this paper.

II. Background & Related Work

Handover techniques are based on a set of factors; these factors affect the wireless network throughput of a client, and the entire network performance. The most important factors are:

- Received signal strength (RSS), which is based on distance between the mobile node (station) and the access point, in which the stations at long distances, the signal gets weaker and the wireless data rates get slower, leading to a lower whole throughput.

- Unbalanced loading of the access points leads to a poor performance of the wireless networks. This affects the throughput of stations and the entire network.

Next a brief review of the recent articles that appeared in the literature is presented.

The IEEE 802.11 standards use the Received Signal Strength Indicator (RSSI) as the access point (AP) association scheme. Unfortunately, this scheme may make some APs be overloaded, while leaving other adjacent APs under-loaded [4]. This load unbalancing leads to negative effects of station's performance and the entire network throughput.

Suresh et al. have proposed a programmable enterprise WLAN with Odin, where some MAC functionalities are transferred to a controller. The controller creates Light Virtual AP (LVAPs) with BSSID. The LVAP stores the basic information that is unique BSSID, given to the mobile device and the mobile device address. It also provides a mechanism for seamless handover by removing the LVAP from an old AP to new AP [3].

Rangisetti el al. has proposed a “Load-aware handover algorithm” that supports handover without station side modification, all the Open-Flow APs (OFAPs) use same SSID and BSSID. The station perceives there is only one AP in the wide network, while the coverage area of WLAN is covered by multiple physical APs. This work shows that both static and mobile clients in the overlapped region of APs can associate with under-loaded AP automatically [6].

Nahida et al. proposed a system model, in which each AP is responsible for sending the information about its local load, and connected stations to the controller. In this moment, the controller can distribute the traffic evenly among all access points in overlapped WLAN coverage areas. The proposed handover algorithm increases throughput with lower jitters between stations based on AP load [2].

Chen et al. has proposed a TPR (Throughput, Packet loss drop and RSSI) scheme, that for the IEEE 802.11 networks, that has the ability of increasing the throughput of multi-AP networks, and reducing the number of handoffs between APs This work is based on (Throughput, Packet loss drop and RSSI) to select AP [5].

Shafi et al. presented an algorithm for best AP selection in the environment, where a device is in overlapped area. This algorithm also defines load-balancing criteria for loaded AP. The performance of WLAN can be enhanced if handoff decision is not based only on RSSI, but it is also based on achieved throughput and AP load [8].

Both, the throughput and balance of load on access points are affected by the number of clients connected with the network. Therefore, many solutions have been developed to enhance the handoff process.

It can be observed from the above reviewed articles, that all above works do not focus on the maximization of the number of clients associated with the WLAN network. Their solutions have a drawback, which is reducing the number of clients (stations) connected with the network.

To overcome the above mentioned drawback, this research will present an enhanced algorithm to maximize the number connected stations with WLAN.

III. Proposed Method

A. System Model

A system model is designed based on Software Design Network Technology (SDN), as shown in Fig.1 that consists of a controller, two Access Points and five Mobile Nodes (stations). The controller is a logical centralized controller that has a full control of all network topology and flows. The controller is connected to “OpenFlow enabled access points”. The controller is configured by application that runs on its top.

The model architecture has a Wireless Local Area Network with two Access Points (AP1 & AP2), such that their coverage areas are overlapped. There are five stations, sta1 is located in AP1 coverage area and connected with it. Sta4 is located in AP2 coverage area and connected with it. Sta2 is located in overlapped coverage area of APs, and therefore, sta2 can connect with AP1 or AP2. Sta3 and sta5 are located out of the coverage areas of the two APs, and they have the ability to move to the coverage areas of APs.

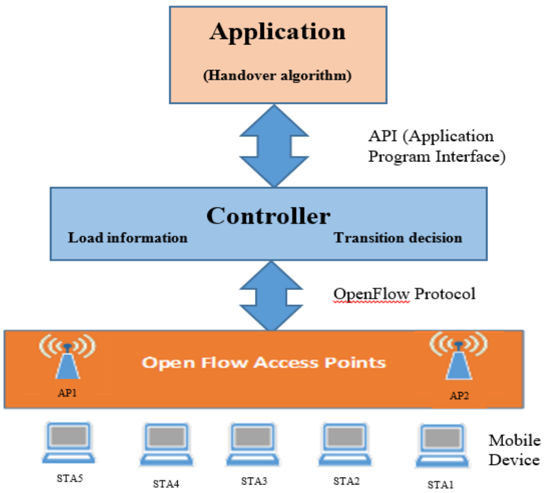

Fig. 1 System model

B. Proposed Topology Using Mini-Net Wi-Fi:

Mini-net Wi-Fi Emulator is the suitable tool to design software defined wireless networks. Mini-net Wi-Fi Emulator supports Wi-Fi technology by adding virtualized APs and stations (STAs) [2].

To implement the experiments, a topology has been proposed in mini-net Wi-Fi that consists of the following components:

- Five stations (sta1, sta2, sta3, sta4 and sta5), every station has static traffic equals to 2 Mbps.

- Two access points (AP1 & AP2), they have overload threshold of 5 Mbps; therefore, any access point cannot associate with more than 3 stations. The positions of access points are set in way their coverage area every one overlaps with the other.

In this system model, every access point is connected with one stationary station, (sta1 is linked with AP1, and sta4 is linked with AP2). There is one station (sta2) in overlapped area of access points, this station can associate with either AP1 or AP2. Initially sta2 is associated with AP1. There are two mobile stations (sta3 & sta5) out of the coverage areas of the APs and are not associated with any AP.

Every station communicates with the other stations and APs via its default interface wlan0.

The iperf TCP/UDP tests are conducted which generate the load for stations by TCP station/server tools. Initially, four experiments are performed to show that the proposed algorithm implements handover process in WLANs.

Then, an experiment is performed to show that the proposed algorithm supports more users of the network without affecting the throughput and delay in WLANs.

All access points and stations use the parameters shown in table1 and table2 as following:

TABLE 1 ACCESS POINT PARAMETERS

Access Point	**SSID**	**Channel**	**Mode**	**Position**	**Range**
AP1	ssid-ap1	Channal1	g	30.60.0	30
AP2	ssid-ap2	Channal2	g	70.60.0	30

TABLE 2 STATIONS PARAMETERS

Station	**IP**	**Range**	**Interface**
Sta1	10.0.0.2	Range=30	Wlan0
Sta2	10.0.0.3	Range=30	Wlan0
Sta3	10.0.0.4	Range=30	Wlan0
Sta4	10.0.0.5	Range=30	Wlan0
Sta5	10.0.0.6	Range=30	Wlan0

Scenario:

This scenario is illustrated by flowchart in Fig.2, which shows that when a station enters the coverage area of any AP, it receives signals from this access points and broadcasts the probe request frame, during the active scanning process. The access point will reply by probe response frames, and then stores the MAC address of the station that sent the probe request frame, and then exchanging this information with the controller.

Assuming that the station (sat5) has entered AP1 coverage area, and AP1 has sent its loads to the controller as shown in Fig. 3. Now AP1 is overloaded, then when a new station enters the AP1 coverage area, AP1 sends notification to the controller about incoming a new station. The controller will check the previous record of the stations in the overlapped area of APs, and decide whether any station (located in the overlapped area of APs) can be handover-ed to AP2. If the result is true, then the controller sends an acknowledgment to AP1 to disconnect this station "let's STA2", and a notification to AP2 to connect it. After the connection is done, the controller will send a notification to AP1 to add the new station. Then the AP1 sends probe response to the new station, the new station will be connected as shown in Fig.4. After the connection is done, the station will start transmitting data, without affecting handover delays.

As mentioned earlier, in the literature most of the previous works focus on the load balance on Access Points, and do not concentrate on the number of WLAN users. More specifically, The Nahida's algorithm rejects the new station that enters the range of any overloaded access point at all, without considering other solutions to accept this station.

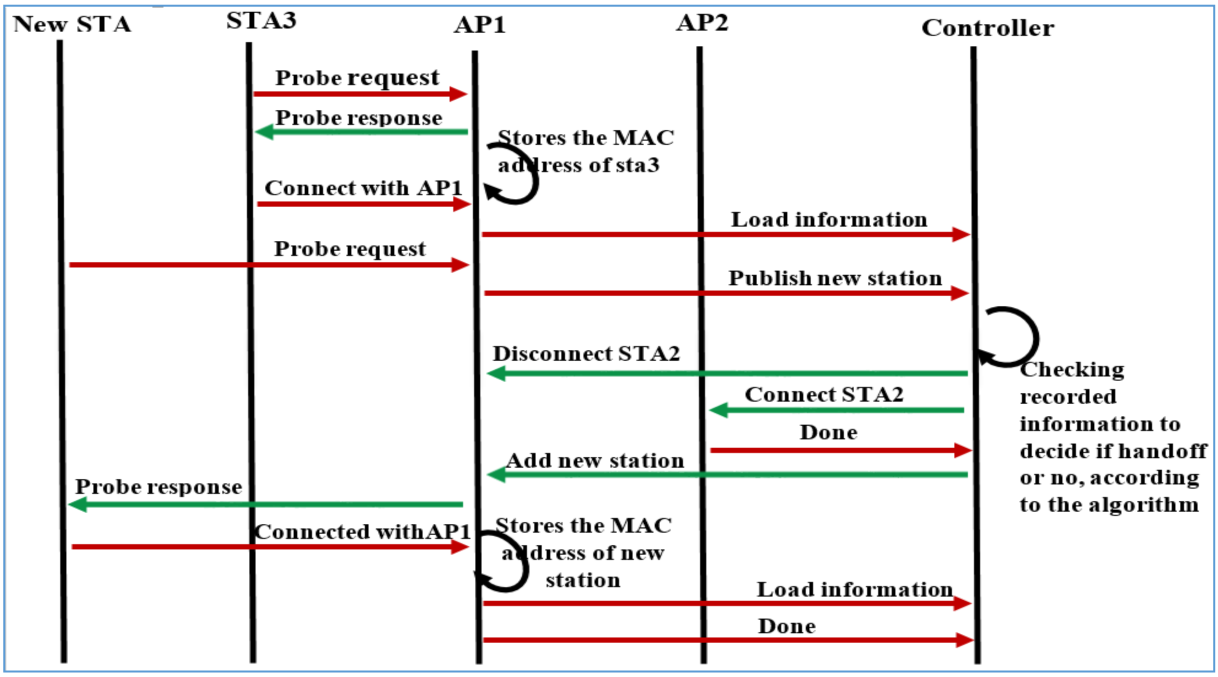

Fig. 2 Flowchart of The proposed algorithm

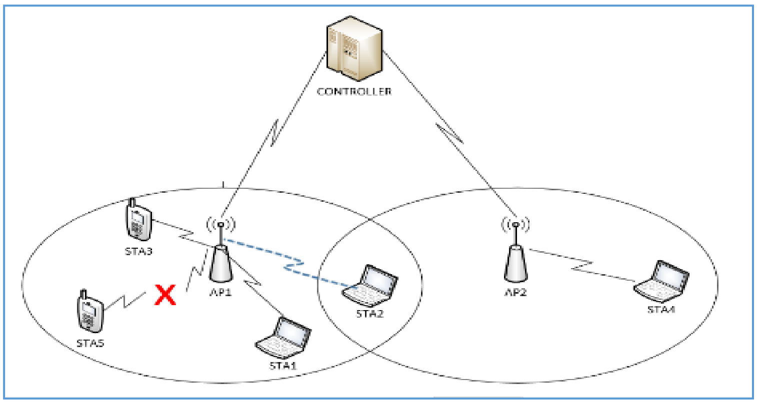

Fig. 2 Number of connected stations before the transition

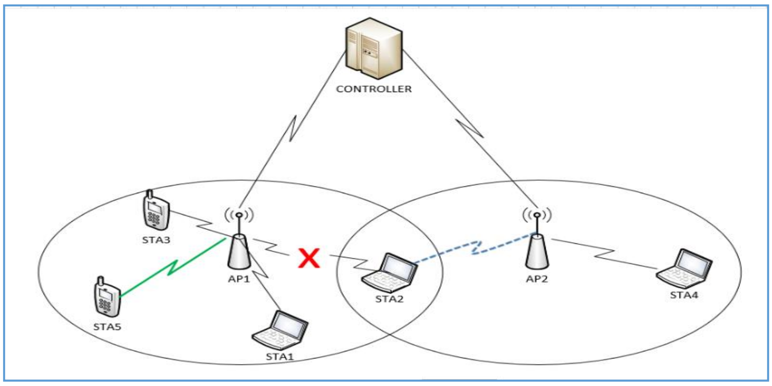

Fig. 3 Number of connected stations after the transition

So, the proposed algorithm focuses on the number of WLAN users, and takes into account the load balance on the access points. The proposed algorithm is stated in Fig.5.

Proposed algorithm to enhance the handover process
1: Controller gets load information from APs in WLAN systems
2: Controller compares the load of each AP with a threshold value
3: Loop
4: if APload ≤ Threshold then
5: AP under-loaded
6: Accept new station
7: else if APload > Threshold then
8: Compare all APs' load, if one is under-load, then
9: Specify any one station that is located in the overlapped region of APs
10: Send disconnection message to the old-AP to disconnect this station
11:Send connection message to the under-loaded AP to connect with this station
12:Add the new station to the old AP.
13: else AP overloaded
14: No handover
15: Deny the new stations
16: end if
17: end loop

Fig.3 The Proposed Algorithm

IV. EXPERIMENTAL RESULTS

A. Experiments and results:

Based on Mini-net Wi-Fi Topology as shown in previous section, set of the experiments are implemented to show the enhancement of the handover process that occurred by the increase in the number of network users.

Experiment 1:

The aim of this experiment is to show that sta3 will not be connected with any access point. In this experiment, sta3 is located out of the APs coverage area (at position A) as shown in Fig.6, and therefore, it is expected that sta3 will not be linked to any access point.

The results:

As a result of running the simulation of this topology in Mini-net Wi-Fi, "sta3 iwconfig" command is used to display links of sta3. The results in Fig.7, shows that sta3 is not connected to any access point through the two phrases: "sta3-wlan0 IEEE 802.11 ESSID: off/any".

Experiment 2:

The aim of this experiment is proving that sta3 will be connected with the AP1. In this experiment, when sta3 enters in the coverage area of AP1 (at position B) as shown in Fig.8. It is expected that sta3 will be connected with this access point.

The results:

In this experiment, the same previous command is used to display links in the topology which is running in Mini-net Wi-Fi. The results show that sta3 is connected with the AP1 via ssid-ap1 by sta3-wlan0 interface as shown in Fig.9, by the phrase: "sta3-wlan0 IEEE 802.11 ESSID:ssid-ap1".

To show the throughput of sta3, the iperf TCP tool are used, as shown Fig.10, which shows the throughput between sta3 and sta1 via AP1.

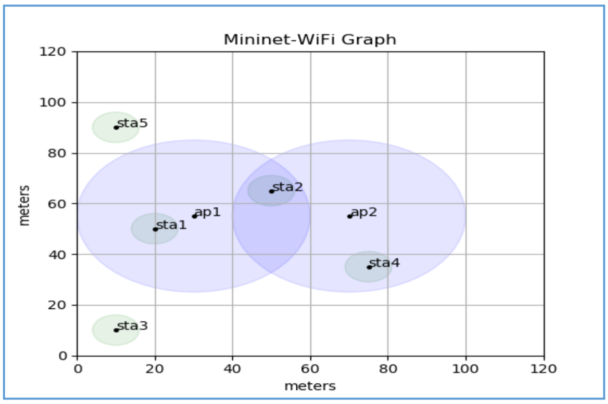

Fig. 4 Sat3 at position A

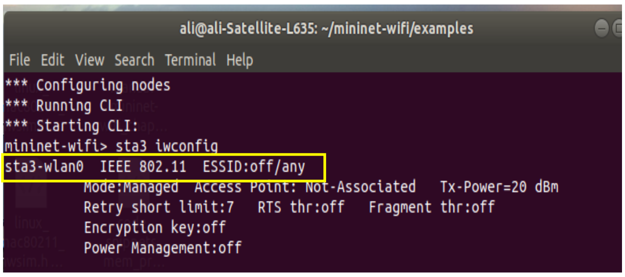

Fig.7 Links of sat3 at position A

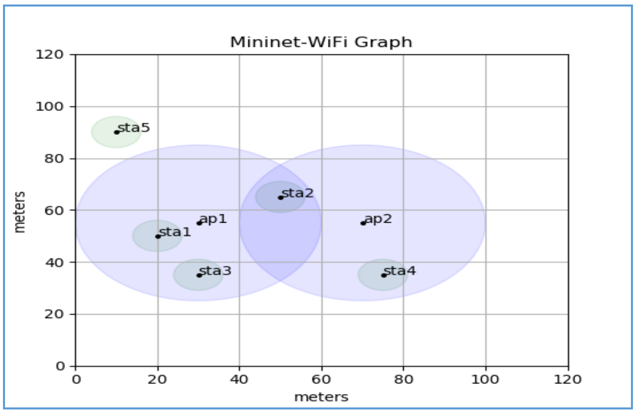

Fig.8 Sat3 at position B

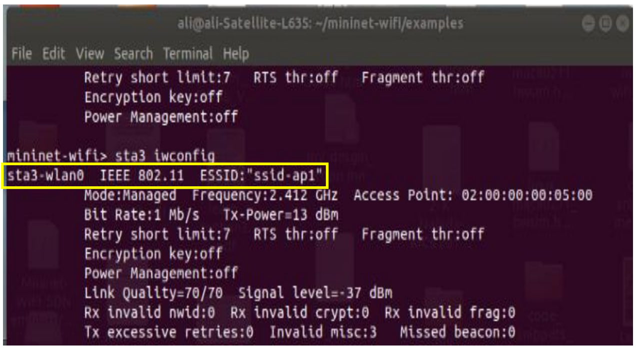

Fig.9 Links of sat3 at position B

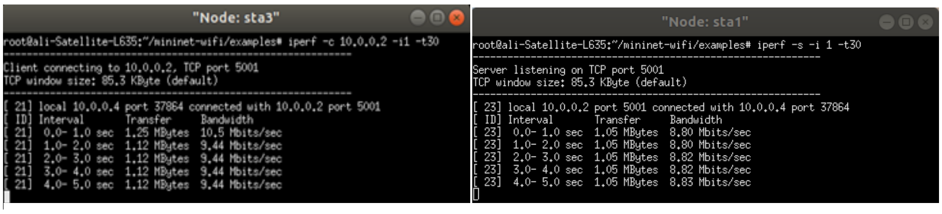

Fig.10 Throughput of sta3 at position B in Mini-net Wi-Fi

Experiment 3:

Since sta3 is located in the coverage area of AP1 and connected with it, as shown in Fig.8 and Fig.9, and based on Nahida's handover algorithm [2], when a new station (sta5) enters coverage area of AP1 as shown in Fig.11, then sta5 cannot connect with AP1, because AP1 is overloaded, as it is fully connected to three stations (sta1, sta2 and sta3).

But, based on the proposed handover algorithm, and since sta2 is located in the overlapped region of the access points as shown in Fig.11, then sta2 can be disconnected from AP1 and connected to AP2, allowing sta5 connect with AP1.

The results:

In accordance with the assumptions in the previous section, Fig 12 shows that sta2 is connected with AP1 via sta2-wlan0 interface as shown by the phrase: "sta2-wlan0 IEEE 802.11 ESSID:ssid-ap1". And it is shown that sta2 is disconnected from the AP1 using "sta2 iw dev sta2-wlan0 disconnect" command as shown in phrase: "sta2-wlan0 IEEE 802.11 ESSID: off/any". Fig.13 shows using "sta2 iw dev sta2-wlan0 connect ssid-ap2" command to connect sta2 with AP2 as shown in phrase: "sta2-wlan0 IEEE 802.11 ESSID:ssid-ap2".

In this experiment, traffic is generated by iperf TCP/UDP tests, between sta2 (client) and sta1 (server), for measuring the throughput of sta2 before transition of this station from AP1 to AP2, during time interval of 10 seconds. During this interval, the throughput average of sta2 is 8.98 Mbps. Also, Fig.14 shows the throughput graph of sta2 before the transition from AP1 to AP2, during 10 seconds.

Same test is applied between sta2 (client) and sta4 (server), for measuring the throughput of sta2 after the transition of sta2 from AP1 to AP2, during time interval of 10 seconds, so, the throughput average of sta2 is 8.93 Mbps. Fig.15 shows the throughput graph of sta2 after the transition from AP1 to AP2, during 10 second.

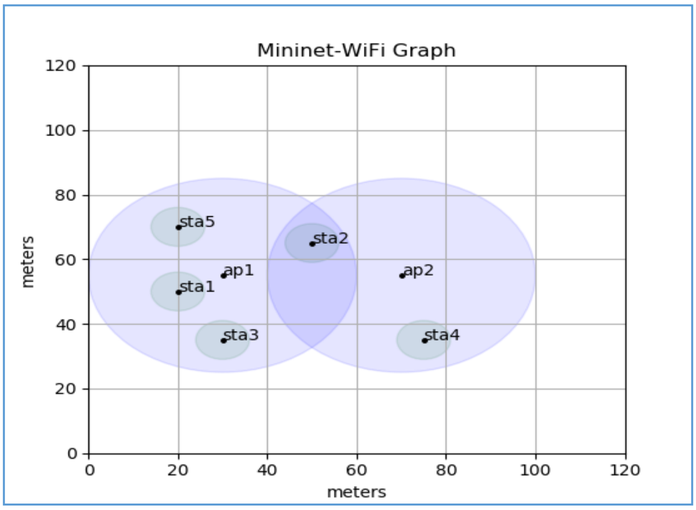

Fig.11 Position of sta5

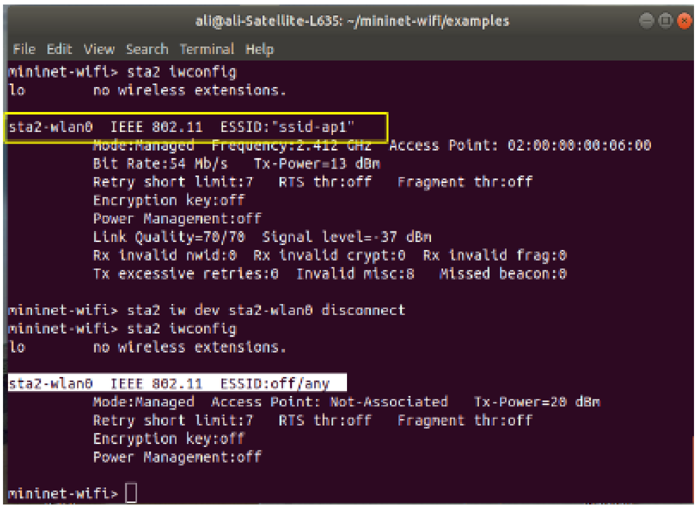

Fig.12 Shows sta2 disassociation from AP1.

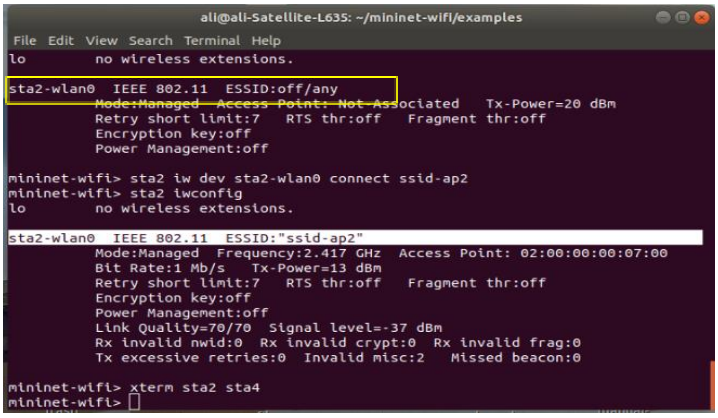

Fig. 13 Shows sta2 association to AP2.

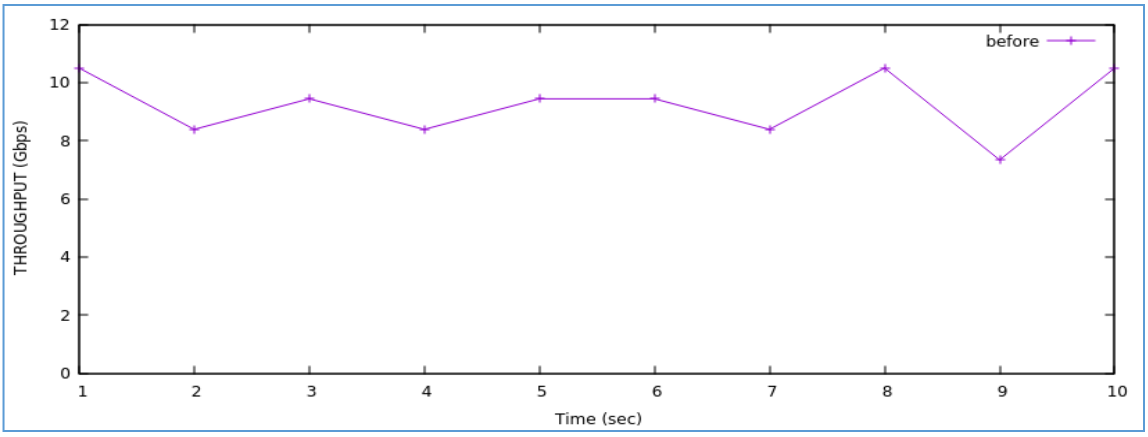

Fig. 14 Throughput of sta2 before transition from AP1 to AP2 in Mini-net

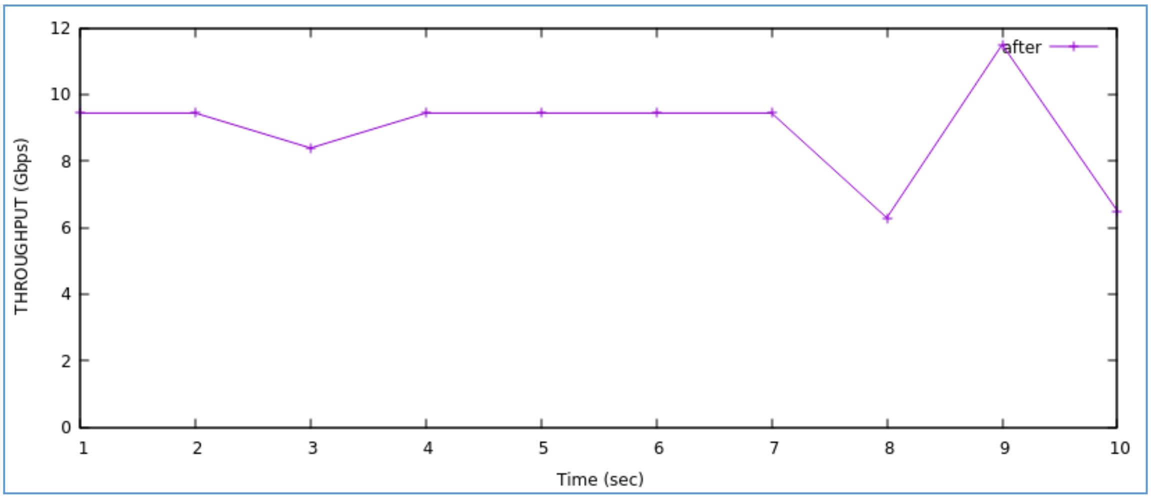

Fig. 15 Throughput of sta2 after transition from AP1 to AP2 in Mini-net

B. Discussion:

In the experiment1, when sta3 is located out of the coverage area of access points as shown in Fig.6, sta3 will not be connected with any access points. The experiment shows, that no communication between a station and an access point when this station is out of the access point coverage area as shown in Fig. 7.

In the experiment2, when sta3 moves from (Position A) to the coverage area of access points (Position B), sta3 is connected with AP1, because it is located inside the coverage area of this access point, and therefore, sta3 starts sending the data via AP1 to the server (sta1) using iperf-TCP/UDP.

This experiment shows that a connection is established between the station and the access point, when this station entered the coverage area of this access point.

In experiment 3, the main goal is proving that the proposed algorithm improves the handover process through an increase in the number of WLAN users. In this experiment, sta2 is located in the overlapped coverage area of both the access points, and therefore sta2 can connect with only one of the access points, and initially it is connected with AP1. In this case, the load of this access point exceeds the threshold value, that is limited in the previous hypothesis, and so, this access point is overloaded, because it is fully connected to three stations (sta1, sta2 and sta3). Therefore, when sta5 enters the coverage area of this access point, it rejects the connection with sta5. Unfortunately, this process minimizes the number of WLAN users.

In the proposed handover algorithm, sta5 is accepted by AP1 as well, taking into account the load balance on the access points as it is done in this experiment as follows:

In order to make AP1 accept connection with sta5, sta2 interface is disconnected from AP1, and then, connected to AP2. In this case, the AP1 load becomes less than the threshold value that is limited by the hypothesis, and hence, the AP1 becomes under-loaded and accepts connection with sta5. In experiment 3, two commands are implemented manually in Mini-net Wi-Fi, to prove the transition process of the station's interface from one access point to the other.

The proposed method is a novel feature enhances the handover process by increasing the number of clients. The throughput graphs created by iperf TCP tests show that transfer process of the station's interface is successfully done from one access point to the other, and the throughput is not affected by handover, so, it is about 8.9 Mbps before and after the transition, during time interval of 10 seconds.

C. Comparison between the previous and the new proposed work:

In this section, the proposed algorithm is compared with the algorithm in [2]. Table 3, gives the number of accepted stations for the cases. It shows that number of accepted stations of the proposed algorithm is greater than that of the one reported in [2], for different numbers of access points. This is presented in graph as shown in fig.16.

TABLE.3 COMPARISON BETWEEN PREVIOUS AND THE NEW PROPOSED WORK

Number of APs	total number of stations	Number of accepted station by using:	
		New proposed algorithm	Previous work
2	5	5	4
4	12	10	8
6	17	15	12
8	23	20	16

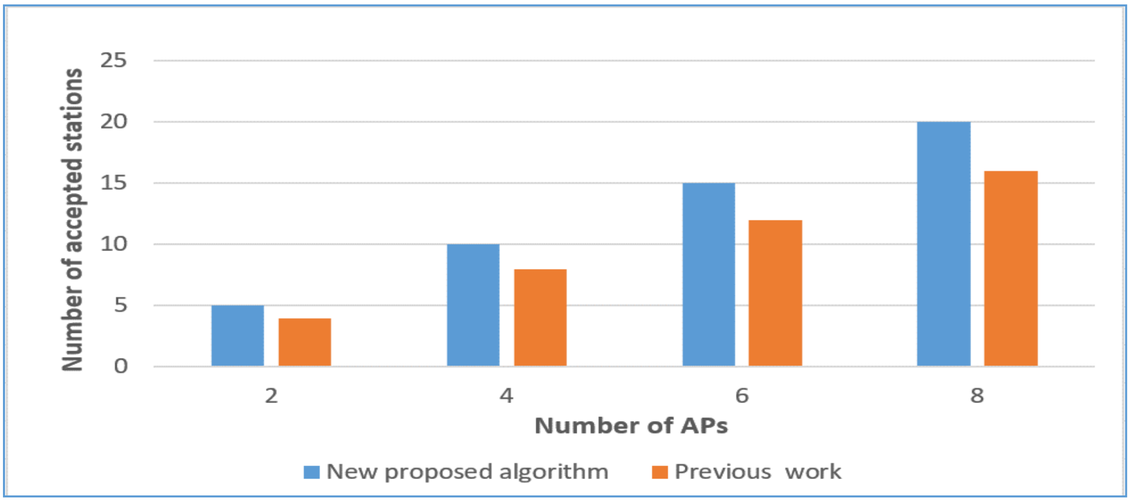

Fig.16 Comparison between previous and the new proposed work

V. CONCLUSION

Handover is an important feature in wireless networks. So, many researchers have presented improvements to enhance the handover, but their solutions have resulted in discarding number of connected users with the network. In this paper an enhanced algorithm is proposed to improve the performance of WLAN networks by maximizing the number of users accessing the network.

The experimental results shows that the connection of the station, located in overlapped coverage area of the access points, is transferred from the overloaded AP to the under-loaded AP, and this transition occurs only when a new station enters coverage area of the overloaded AP.

The proposed approach is efficient because it reduces the load of an overloaded AP, and makes this AP accept extra stations without affecting the throughputs, where that the throughput average before and after the transition is about 8.9 Mbps, when data is sent from client to server, during time interval of 10 seconds.

Also, the comparison between a previous and this proposed work shows that the number of stations accepted by the network using the proposed approach is more.

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