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ORIGINAL ARTICLE

Load Balancing of SDN-enabled Wireless Network: Challenges, Technique and Evaluation

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ABSTRACT

Today's era is demanding constant wireless connectivity with sustainable bandwidth due to massive number of mobile applications in every domain of life. The uneven distribution of network load in wireless network may results in minimum throughput and unsatisfactory Quality of Experience (QoE). In order to resolve such issues, the traffic is equally distributed among all available access points (APs), which is termed as load balancing. Software Defined Network (SDN) based load balancing scheme in Wi-Fi network has been introduced to monitors the whole network status information. In this paper, we presented the load balancing techniques and their findings in SD-WLAN environment. We proposed an algorithm for load balancing which calculates the End to End Delay (EED) and Received Signal Strength Indicator (RSSI) values, and on the basis of calculated values less loaded AP can selected. The future challenges and their potential solutions are also being focused in this paper. Regarding performance evaluation, simulation is performed in MATLAB. Moreover, comparison with existing technique, the proposed solution improves the network performance in term of throughput and delay.

Keywords: Load Balancing, QoE, Access Points, Software-Defined Network, WiFi.

Author`s Contribution	Address of Correspondence	Article info.
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INTRODUCTION

The demand for wireless connectivity has been tremendously increasing with the emergence of smart device [1,2].The need for reliable wireless communication has been widely increased in different areas like in business, public areas and even in home [3]. Users demand to be connected to the network while moving within area in order to get the best quality of services. A Wi-Fi network considers to provide wider Internet connection to meet the high demand of mobile users. It is a requirement of time to provide the high speed network in order to ensure the availability of required services. While utilizing network services, it is found that unequal load reduces the network performance, and as a consequence the user experience suffers [4]. To solve this issue the load is distributed equally by implementation of different load balancing techniques. Logically, load balancing is such a successful technique in which network load is equally distributed among all Access Points (APs). Consequently balanced load in network helps to optimize the utilization of resources by maximizing the throughput and minimizing the End to End Delay (EED).

In the traditional Wi-Fi system, users connect themselves with the AP that has the strongest Received Signal Strength Indicator (RSSI) value without considering the load condition as illustrated in Figure 1. Therefore, in Wi-Fi the load on AP's is mostly distributed unevenly, which obstructs the network to providing the maximum throughput and quality of services to its users. It is very hard to give the optimized solution of load balancing without knowing future traffic demand on each AP [5].

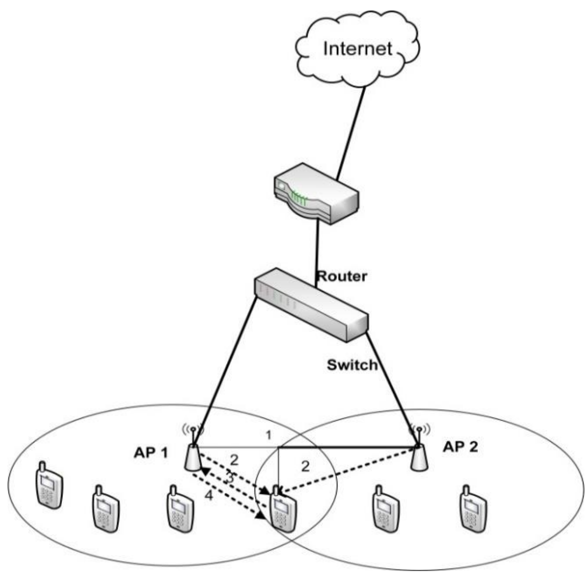


Figure 1. Uneven Load Distribution among Aps

There are two main issues that need to be addressed in this regard. The first is to determine the load of Wi-Fi and the second is to equally allocate the current load to all available APs. To resolve the first issue, the simple metric for measuring the AP load is considered that is the number of user connected with AP, but if not all the connected users active then it will be difficult to achieve an accurate result. In order to resolve the second issue, the user will be switched from overload AP to the light load AP, in case of uneven load distribution among available AP's. However, how the target AP will be chosen and which user should be switched is still an existing problem because when client select the AP on the basis of high signal strength then the AP could be more overloaded as compared to the AP have low signal strength which will result in imbalance load among APs.

In given Figure 1 the AP1 is already overloaded as compared to AP2 because of more clients are connected with it. When a new client scans or searches the AP it also gets connected with AP1 because of its strong RSSI. In such a case, another metric that is AP load status along with RSSI could be used to ensure the load balance.

Software Defined Network (SDN) controller has a global view of the entire network to centrally monitor the traffic load [6]. The SDN evolutions have now been extended for WLANs as it is known that WLANs function in a dynamic environment. A general precise solution is therefore required for addressing AP selection and load balance. Classical solutions to solve the issues SDN is presented in WLAN.

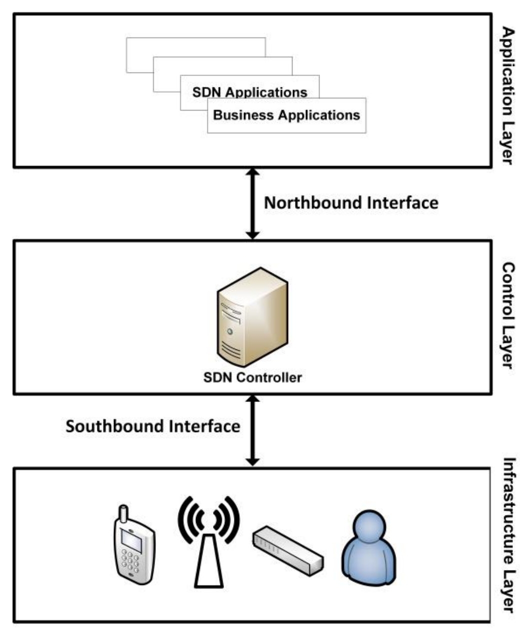


Figure 2. SDN Reference Architecture

SDN decouples the forwarding hardware from the control decisions as illustrated in Figure 2. SDN render networks more flexible and manageable. The aim of this paper is to solve the issue that exists traditional load balancing approaches by taking the advantage of SDN, along with EED, RSSI value and No of STAs as the focused parameters. SDN view the whole network and choose the less loaded AP after comparing the mentioned parameter value with the threshold value. In order to peruse our paper work, by using threshold of channel utilization we categorized APs as worst, average and best, so while load balancing, STAs will be moved from worst to average and then towards best mode. The related work algorithms have also been proposed. Mathematical equations to calculate the EED and Channel Load have also been added in paper.

The remainder of this paper is organized as follows. Section II discusses the previous research works related to field deals with the load balancing in SD-WLAN. Section III presents the challenges and opportunities of load balancing in SD-WLAN. Section IV familiarizes with the material and methods to solve the discussed problem. Section V provides the simulation results to show the performance of proposed work and Section VI effectively concludes the paper.

LITERATURE REVIEW

SDN is a newly introduced and implemented technology that mainly works on how to decouple the control plane and data plane. SDN provides high flexibility and rapid routing of traffic flow by handling the control decision to controller and allowing the data plane to forward the traffic according to decision taken by controller [7,8]. SDN comprises working on three layers. Firstly, the application layer consists of network applications used and handles by the user to get the services from control layer and infrastructure layer like business application, SDN applications, etc. These applications communicate with control layer using northbound interface. Secondly, the Control layer, on which controller work takes the forwarding decision, via connecting with infrastructure layer using southbound interface (OpenFlow) and the last one is infrastructure layer which is based on hardware resources.

OpenFlow controller communicates with OpenFlow switches through OpenFlow Channels according to the OpenFlow protocol specifications. It is the first standard interface used for communication between controllers and switches. SDN controller writes the processing rules in the flow tables of OpenFlow switch. A distinctive OpenFlow protocol is composed of three components. 1. Flow table, 2. Secure channel and 3. OpenFlow protocol. The Flow table maintains packet-dispatching information in order to guide the switches to process the flow. As shown in Figure 2, the forwarding plan and control plane are connected through northbound interfaces. Control plan takes the decision and forwards it to switches through OpenFlow protocol. There are three layers in SDN.

Load balancing technology encounters various problems in the WLAN system than in a wired system due to the mobility of stations and time variability of wireless channels in Extended Service Set (ESS). In WLAN, technology APs selection at each station is a critical problem in order to obtain satisfactory throughput [5] presented a user oriented load balancing scheme to increase the system throughput, and network availability. In the proposed paper load on APs could be achieved according to the user demand by coding at the application layer. More enhancement is needed as more applications are required to evaluate the designed platform and the effectiveness of hardware resources not defined on Virtual Access Control. In addition, the proposed approach is implanted in campus network to assess how its performance could be effected in a wide network.

Seamless handoff and Performance Anomaly Reduction (PER) schemes introduced by the authors [9] examined the OpenFlow AP (OFAP) system that use OpenFlow controller for seamless handoff and Performance Anomaly Reduction (PAR) scheme in order to improve and enhance the total throughput of the network. Therefore, client is only limited to passive scanning performance in OFAP system and all OFAP work on same channel so result could be possibly changed on different channels. This paper does not discuss the detailed working relationship between data rate RSSI.

A new OpenFlow based flow slice load balancing (OFS) algorithm [10] based on improvement of performance regarding load balancing and reduction in packet reordering describes the flow of network categorized as aggressive flow and normal flow. Open flow switches are utilized to work regarding processing of the traffic according to the flow rules defined on packet header. These rules are mainly base and utilized for load balancing.

The performance of OFS is partially dependent on the identification of aggressive flow whereas the deployment of OFS into the real OpenFlow Network is still an open challenge. Additionally, the proposed work is being implemented in data center.

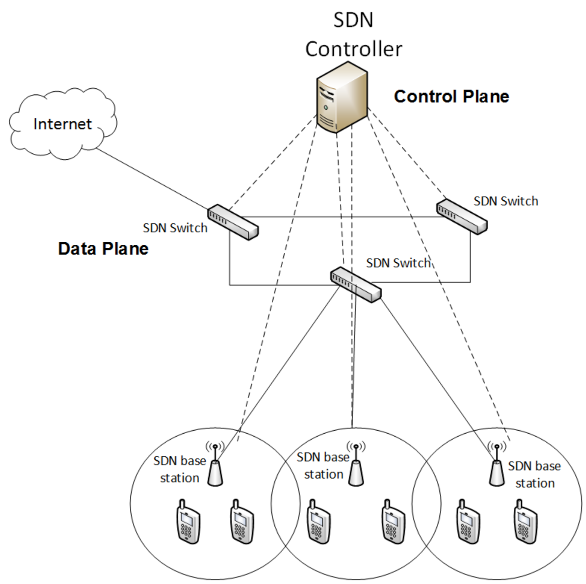


Figure 3. SDN based system Model

A new working schema known as Semi-Matching-Based Load Balancing Scheme is presented by the author runs in a centralized controller [4]. The controller runs the load-balancing algorithm if the load is unequally distributed. The uneven load is calculated by calculating channel busy time ratio. Moreover, STA-AP association set is determined through using Signal to Noise Ratio (SINR). This increases the overall network throughput load balancing performance. Hence performance could be found different in multi-rate WLANs. In addition, the computation of Channel Busy Time Ratio for the whole network involves high Computational complexity.

A new SDN based Approach introduced in [11] that use the 5G-EmPOWER platform to guarantee an effective balance on both the application and finest distribution of the network resources which improve the global performance. Wi-Balance system architecture gathers the status of ongoing transmission and channel status of client in network from the rate control algorithm runs in the APs. In [12] proposed architecture, the throughput issue needs to be addressed.

An algorithm known as an adaptive load balancing algorithm [13] to balance the network load uses load status of APs, and RSSI to improve the network throughput and user QoE. The load-balancing algorithm is implemented on top of SDN Controller. SDN controller has global view of entire network to check the network load condition of each AP, in case of unevenly distributed load, the proposed algorithm is prompted to balance the traffic, and as a result, user will be transferred to less loaded AP. While practical implementation, the user could experience low QoE, because the AP with high RSSI can be more loaded due to load of associated users. Proposed scheme should have the view of entire network to keep the network status with valid load matrices in order to ensure best performances. Interference is another notable factor to be kept under consideration.

A mechanism called APS-ANT to select an AP for stations using highest Achievable Normalized Throughput (ANTs) of station. The proposed scheme [14] implements working methodology under SDN framework hence evaluating the AP's load accurately only when all the associated stations work at the same rate. Currently station adapts to adjust their load according to specific rate control algorithm.

Decentralized AP selection architecture in which each STA selects its AP using AP selection algorithm to optimize the throughput [15]. In proposed architecture the STA stores the RSSI value of beacon frame and selects the AP with the highest RSSI. The station frequently checks the quality of the RSSI from other APs and start re-association process if other APs have higher signal strength then the connected one. The proposed architecture improves the average throughput as compared to the existing architecture. RSSI could not guarantee the best user's QoE, because APs with best signal strength could be heavily loaded due to many connected users. In addition, there could be an interference between APs and STAs because of partial overlapping of neighboring channels.

A user-association control algorithm introduced to ensure maximum-minimum fair bandwidth distribution to balance the load on APs [16]. The proposed algorithm calculates the fractional association solution to guarantee a fair bandwidth. Polynomial time algorithm has also been presented for best integral solution. It provides the best quality of bandwidth allocation. There is a strong corelation between load balancing and maximum-minimum fair bandwidth allocation and maximum-minimum fair bandwidth allocation is NP hard [17].

Fukuda & Oie [15] worked on architecture of SDWN to incorporate a set of appliances to increase the proficiencies of APs through better coordination. The architecture consists of three planes, data plane, control plane, and service plane. Data plane consists of a number of APs, responsible for data forwarding. The control plane contains a controller utilized as a controlling factor for the services and service plane consisting of different applications for load balancing and for association control. The central controller takes all the information and uses it to make smart decisions about the consignment of client to APs.

The proposed work can be integrated with other technologies. Moreover, the well management of the Quality of Service (QoS) could be attained by checking the services of APs. The scalability of system can be improved by using hierarchy of the controllers.

CHALLENGES AND OPPORTUNITIES

Challenge 1: Relationship between RSSI and Data Rate

Open flow system with SDN framework is proposed [10] to enhance the network scalability. In addition, the seamless handoff scheme and Performance Anomaly Reduction scheme (PAR) are proposed in order to improve the throughput. The relationship between RSSI and data rate has not been studied in this paper since it could affect the optimization of PAR scheme. Increase in distance from AP can cause low RSSI which could result in lesser SNR and data rate. In order to define and elaborate on the relationship between RSSI and Data rate, another parameter called Signal to Noise Ratio (SNR) could be introduced or utilized.

Challenge 2: Enterprise WLAN-Specific Application

In EWLAN, an adoptive algorithm is used for load balancing [13] which takes the new AP load value and RSSI value for decision making. This scheme improve network performance and user QoE. The system needs to extend its support to the QoS and implementation of EWLAN- specific applications. The solution of this issue is enhancement in EWLAN application.

Challenge 3: Interference in centralized SDN architecture

In centralized architecture, the data-controller interface and application-controller interface interference exist. An SDN controller may be implemented as a collection of distributed components, the interference between which are internal, and out of scope. The interference effects the network throughput. The solution of this issue is decentralized SDN architecture to limit the interference.

Challenge 4: Updating of hardware and software

To provide cost effective and efficient load balancing, user oriented load balancing scheme is developed [6]. This scheme introduced an increase in the bandwidth of the network devices, in order to increase the system throughput and network flexibility. To evaluate the designed platform more application development is required. In addition, it is needed to evaluate the effectiveness of hardware resources on Virtual access controllers. Updated hardware and software will improve performance.

Challenge 5: Energy consumption

The advent of SDN architecture solves the load balancing issue in a much better way than the traditional load balancing approaches [18]. Different load balancing schemes under the SDN architecture has been proposed. Although the schemes are efficient and cost effective as compared to the traditional schemes but there some challenges still remain. We did not take into account energy saving during load balancing. Therefore, it is a challenge to find the solution of energy saving in load balancing in order to make more progress in future. The solution of this issue is using the concept of sleeping idle node, also solar energy and wind Energy could be used to solve the energy consumption issue [16].

Challenge 6: Scalability of the system

A novel SDWN architecture [15] is presented that includes a central controller that envisions a global view of the entire network to get complete information and is therefore able to make smart decisions of the assignment of clients to APs. The system is not scalable by means of a hierarchy of controllers. This issue could be resolved using multiple controllers using the concept of master and slave controller.

Challenge 7: The detection of aggressive flows

The load balancing in an OpenFlow Network is achieved using efficient traffic splitting algorithm [10]. The algorithm detects aggressive flows and scheduling flow. The performance of OpenFlow Slice algorithm partially depends on the detecting of aggressive flows, so it is a big challenge to detect aggressive flow and applying this algorithm in the real OpenFlow network. Using SDN the controller views the whole network and takes an exact information of flow. The same algorithm can use the load metric like throughput or data rate other than flow information.

Challenge 8: Mobility of node

Delay based load balancing (DLBR) routing algorithm is proposed [19] in which traffic load is calculated at each link and preferred the high capacity link. The algorithm improves network performance and efficiency. Also, it works in static environment where nodes do not move, the performance of algorithm is not discussed for dynamic environment where node moves frequently. The proposed algorithm needs to implement an on mobile node using multiple SDN controllers. On mobile node using SDN controller EED aware routing algorithm can be used in this respect.

Challenge 9: Implementation of prototype in real environment

An SDN based load balancing method is presented to balance the load in overloaded environment. The given module is just a prototype and in real SDN network environment, it is more complex for balancing the traffic. The implementation of this module in real SDN network environment adding more functions such as authentication is still a challenge. The solution to this kind of problem can be a proper authentication mechanism using a digital signature that can be used as protection. As described in [20,21] real time environment such as video application and VoIP is very sensitive to delay; thus, it must be properly controlled and managed.

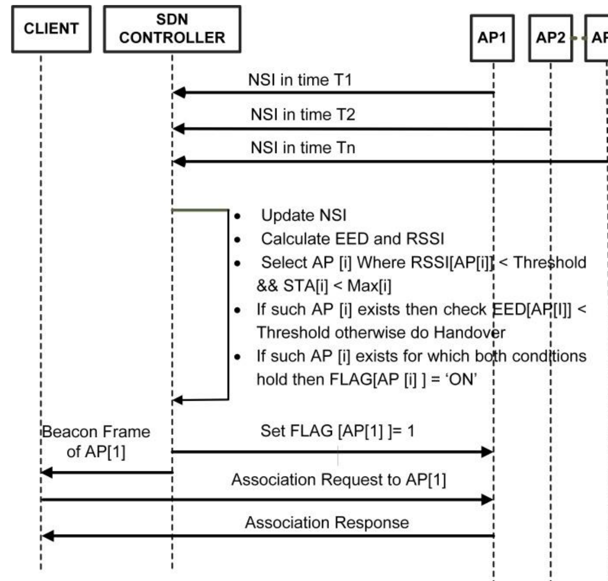


Figure 4: Sequence Diagram of User's Association

RESEARCH METHODOOGY

In Wi-Fi network, the coverage area of APs overlaps with each other. The STAs existing in overlapping areas can associate with more than two APs. In order to model the system, we consider Wi-Fi is comprised of I number of STAs and J number of APs connected with SDN controller through SDN based switches as illustrated in Figure 3.

Table 1 APs Flag Values		
AP's Load Threshold	**Flag**	**Handover**
<30%	Best	No handover
>=30% and<=55%	Average	From Average to Best
>55%	Worst	From Worst toAverage

The proposed model is based on SDN architecture in which all control is handed over to SDN controller while the switches only forward the data according to decision taken by the OpenFlow slicing mechanism [22]. The proposed model consists of two planes, control plane consist of controller and data plane consists of switches. Controller categorize the APs into worst, average and best AP by calculating APs load using network channel utilization threshold value as a parameter as shown in Table 1. An algorithm runs to categorize the APs and to move the moving STAs between these APs. Controllers use OpenFlow protocol to communicate with switches and

APs for collection of status information to know the status of load. Controller finds the overloaded AP after executing the algorithm in which controller calculates the EED to check the load and compare it with the threshold value. If yes controller switches the connected STA to a less loaded AP through control signal, while a forwarding decision is sent to switch.

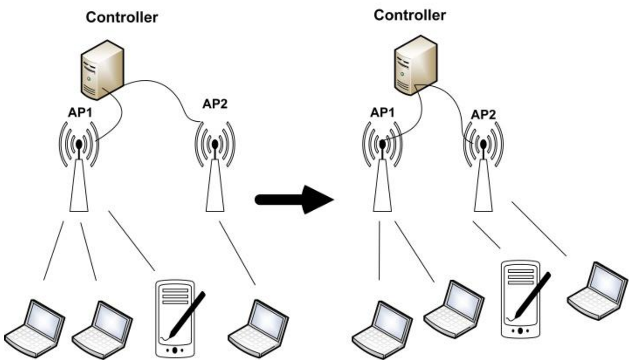


Figure 5. Handover of STA among AP's

The controller can obtained information about number of users connected with APs and the current status of every single AP. APs send their shown network status information after every T time as in Figure 4. The proposed EED based load-balancing scheme for Wi-Fi network is based on SDN controller. All APs send the network status information to SDN controller after every T time. Controller updated the network status information and selects the less loaded AP through by calculating EED and RSSI. Controller selects the AP with minimum delay and having strong RSSI and set its Flag value. The Flag bit is set to one for selected AP and zero for unselected AP.

When moving STA comes in controller range it sends the association request to Controller. Controller sends the beacon frame to STA of selected AP. STA sends the association request to select AP, in return AP sends the association response [23]. Once the connection is established successfully STA starts sending data. In case condition 1 or 2 doesn't hold as shown in Figure 6.

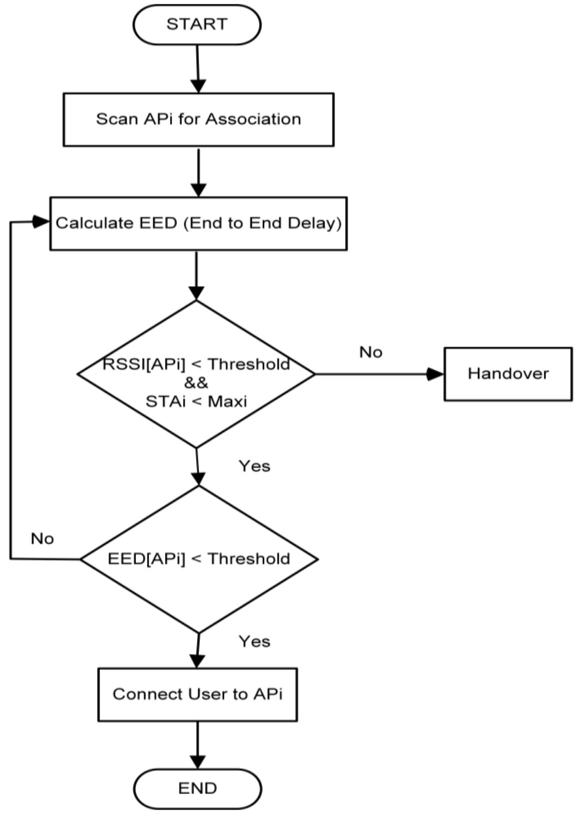


Figure 6: New User Association Using EED

The handover process [24] occurs which is explained in form of Flow Chart as illustrated in Figure 7. The Flow Chart of Association depict in Figure 6 shows that when client scans APs for association, controller checks the maximum number of STAs Associated with APs and the RSSI value and compare the RSSI value with Threshold. If the RSSI value is less than the Threshold value, controller checks the EED delay and compares it with its Threshold value which is calculated through formula. If EED delay is less than Threshold value, controller connects the STA to that AP. In case second condition does not hold, the EED will be calculated again after time interval. If the first condition is not applicable then handover will occur which is discussed through flow chart in Figure 7.

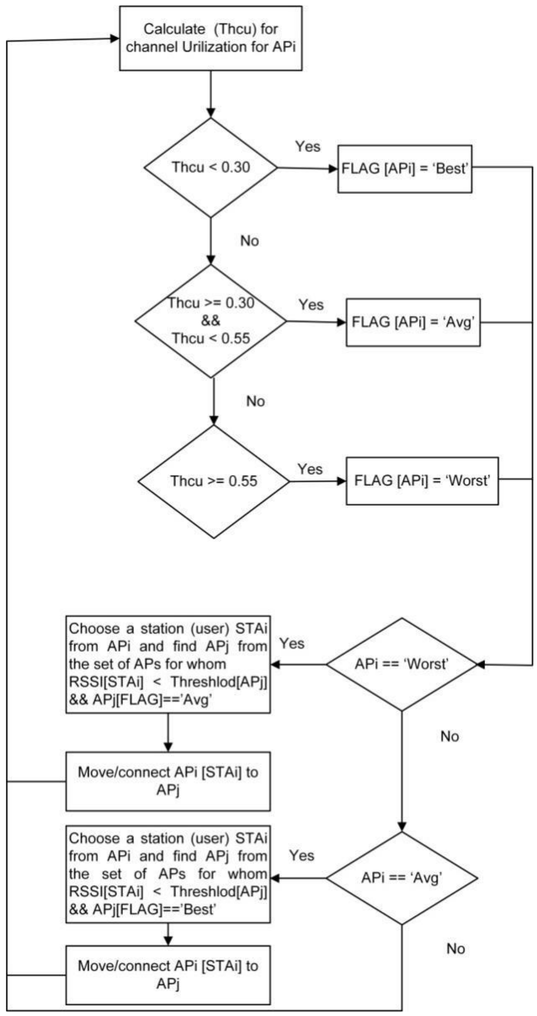


Figure 7. Handover of STAs

As shown in Figure 7, for a specific AP known as i threshold for channel utilization will be calculated. Based on which APs are categorized as best, average and worst. If the threshold value is less than 30% then the FLAG = 'Best', if it is between 30% and 55% then the FLAG = 'average', if it is greater than 55% then the FLAG = 'worst'. To achieve the load balancing STAs will move from AP with FLAG='worst' to AP with FLAG='average' and from AP with FLAG='average' to AP with FLAG='best' as shown in Table 1.

Controller checks the load of APs after a given time. Suppose a STA present in overlapping area of APs and connect with one, that was overloaded with passage of time then controller will check the load of other APs present in coverage area. If the load of the neighbor AP is less than the load of AP with whom STA is already connected, controller disassociates the STA from overloaded AP and send it to the less loaded neighboring AP as shown in Figure 5.

Load balancing metric

Proposed load balancing metric use EED and RSSI value to elect the AP. EED is the delay a packet takes from source to destination. D(s, d). Four type of delays are considered in EED, these are Queuing Delay (Dq), Transmission Delay (Dt), Processing Delay (Dpr) and Propagation Delay (Dp). Processing delay is neglected in case of same route.

A. Queuing Delay

It is the delay a packet suffers while waiting in queue for processing. Initially when the queue is, empty the packet process without any delay. The second packet will have to wait for the transmission of first packet and so on the Similarly, Nth packet will have to wait for the transmission of the (N-1) packet [15]. The equation 1 is to calculate the queuing delay.

$$Dq = (N-1)Dt \qquad (1)$$

Where Dt is the transmission delay and N is the number of packets.

B. Transmission Delay

It is the delay packets take to be serviced, a period in which a packet begins to be serviced by the MAC layer to the time it either transmit successfully or dropped after a predefined number of retransmission. Suppose Pl is probability of the transmission failure over link l, and Sl is the service time over link l and R is the maximum number of retransmissions. The average transmission delay is as described in equation 2

$$\sum_{R=1}^{R+1} pl^{R-1}(1-pl)^{I\{r<R+1\}} \sum_{i=1}^{r} (E[Wi] + L \div B) \qquad (2)$$

Where L is length and B is the bandwidth of the packet. Wi is the contention window at the ith back off stage.

C. Propagation Delay

It is the time a packet spends on physical medium. The equation of the propagation delay is given in eq.3.

$$Dpr = d(i, j)/s \qquad (3)$$

Where d is the length of physical link between STA and AP. S is the propagation speed in medium. The summation of these delays give the one hop delay. The equation of one hop delay is given in 4

$$D_i^j = D_{q(i)} + D_{p(i,j)} + D_{t(i,j)} + D_{pr(i,j)} \quad (4)$$

The summation of hop delays is called EED. The equation of EED delay is as given in 5.

$$EED = \sum_{(i,j)=1}^{n} D(i,j) \quad (5)$$

The controller will calculate the EED and RSSI value from STA to AP and from one AP to another AP using equation 6.

$$\sum_{(i,j)=1}^{n} D(\mathrm{i,j}) + \sum_{(i,j)=1}^{n} RSSI(i,j) + \sum_{(j)=1}^{n} RSSI(j,j) \quad (6)$$

Controller selects the AP whose RSSI value will be less than the threshold value and whose EED will be minimum. This will balance the load among AP. Controller also calculates the channel utilization value to categorize the APs based on Load.

$$Cu = Tt / (Tt + 2 * Tp) \quad (7)$$

Where Tt is the transmission time and Tp is the propagation time. Channel utilization could be due to interference so SINR value can be found out by subtracting this value to find the actual channel utilization value [3]. SINR value calculates using the given formula.

$$SINR = Pdij / Ir + \sigma^2 \quad (8)$$

Where Ir is the cumulative interference produced by all other transmitting STAs and σ^2 is the value of additive white Gaussian noise power.

After calculating the channel utilization and SINR value the channel utilization threshold value could be calculated by using given formula.

$$ThCu = Cui / n - SINR \quad (9)$$

Calculated threshold value will be used to categorize the APs into worst, average and best on the basis of load so that the STAs from AP having worst load will move to AP with average load to achieve the load balancing.

LOAD BALANCING ALGORITHM

In previous studies, different load balancing algorithms using SDN have been proposed. SDN brings an unprecedented evolution in wireless communication. SDN controller uses OpenFlow protocol to communicate with its lower layer that is infrastructure layer [25]. To improve its performance and to achieve the real time application services fast, considerable work could be done in these fields. Increasing the resource utilization eventually enhances the performance of the network to provide the best QoS and QoE. In our research work, we proposed EED based Load Balancing Algorithm (EED-LBA) to seamlessly balance the load among available APs after assigning the STAs to less loaded APs.

Algorithm 1 End-to-End Delay based Load Balancing Algorithm (EED-LBA)

Input: *Tt, Tpr, Tp, Tq, EED, RSSI, SDN*
/ Tt: Transmission Delay; Tpr: Processing Delay; Tp: Propagation Delay;*
*Tq: Queuing Delay; */*
Of new associations

```
1:  Define APs and STAs
2:      After Every Time Interval T
3:   SDN Controller gets the value of RSSI and EED using formula.
4:   SDN Controller compares the obtained value with the threshold value.
:   for APs (1 to n)
6:       EED= (Tt+Tp+Tq)
7:       if RSSI (APj) < Threshold && STAi<max) then
8:           if EED< Threshold then
9:               Connect user to APj
10:          else
11:              Move to Point 6 after Time Interval T
12:          end
13:      else
14:          Handover the STAs to less loaded AP
15:      end
16:  end for
```

This load balancing improves network performance through by providing user QoS. In proposed Algorithm, the SDN controller gets the status information of STA and APs after every T time. Status information includes the value of RSSI and EED delay. EED is calculated using the given formula. After calculating the values, it compares the obtained value with the threshold value. If the RSSI of AP is less than it threshold value and total number of STAs connected with target AP is less than maximum number of STAs that could attach with AP, controller compare the EED delay value with threshold if it is less than the threshold value, the controller assigns the

FLAG bit 1 to that AP and assign its beacon frame to STAs. If not, the process will be repeated after each time interval. If the first condition does not match, then a handover occurs. The algorithm of handover is given below. In handover controller, first characterize the APs based on load. Load is calculated using channel utilization threshold value. If the STAs connected with AP having worst load controller will disassociate the STA and will move it to AP having load status is average. Load consists of both APs side and STAs side information is required as the input of the algorithm.

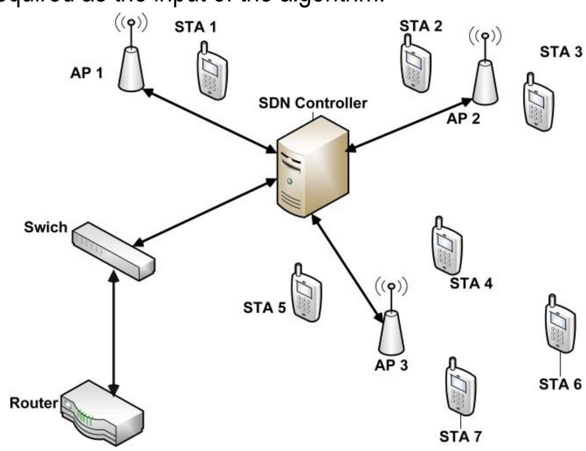


Figure 8.SDN based Wi-Fi Topology

In proposed algorithm SDN controller, we get the status information of STA and APs after every T time, which includes the value of RSSI and EED delay. EED is calculated using a given formula. After calculating the values, it compares the obtained value with the threshold value. If the RSSI of AP is less than it threshold value and total number of STAs connected with target AP is less than the maximum number of STAs that could attach with AP, controller compares the EED delay value with threshold if it is less than the threshold value controller assign the FLAG bit 1 to that AP and assigns its beacon frame to STAs. If not, the process will be repeated after time interval. If the first condition does not match, then handover occurs. The algorithm of handover is given below. In handover controller, first characterize the APs based on load. Load is calculated using channel utilization threshold value. If the STAs connected with AP having worst load controller will disassociate the STA and will move it to AP having an average load status. Load in both APs side and STAs side information is required as the input of the algorithm.

RESULTS AND DISCUSSION

Let us consider a small WLAN network in which three APs connecting five STAs. APs are connected to SDN controller as depicted in Figure 8. STA1 is connected with AP1, STA2, STA3 is connected with AP2 and STA4 is connected with AP3. Suppose all STAs are active and are using equal bandwidth. Based on this assumption AP3 and AP1 could be considered as best AP according to their load. AP2 Could be considered with average load. STA5 is out of coverage area and is not connected to any AP. When STA5 start moving it will connect with AP with whom controller allow after running the user association algorithm which in algorithm 1.

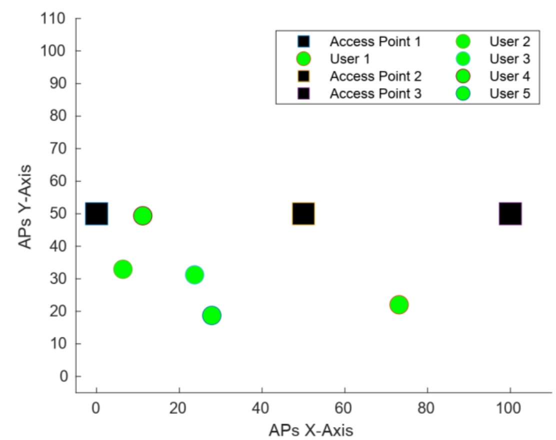
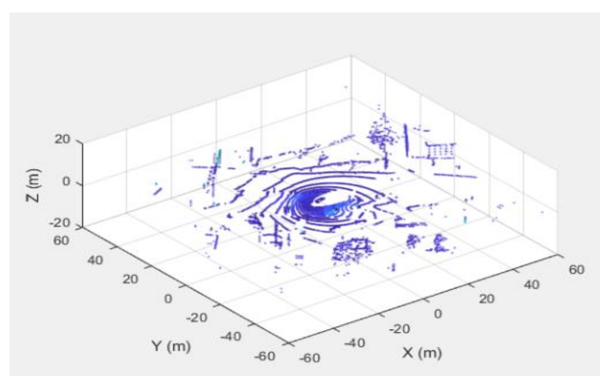


Figure 9. STAs and APs Association



End-to-end delay is the described as time interval in which a packets travels from one node to another node. As mentioned above, it is inefficient to wait for all packets to arrive in an organized order; therefore, some packets may be dropped if they do not arrive in time and this can cause short periods of silence in the audio stream and can cause bad VoIP quality. Ideally, the delay constraint for VoIP packets is not above 80ms.

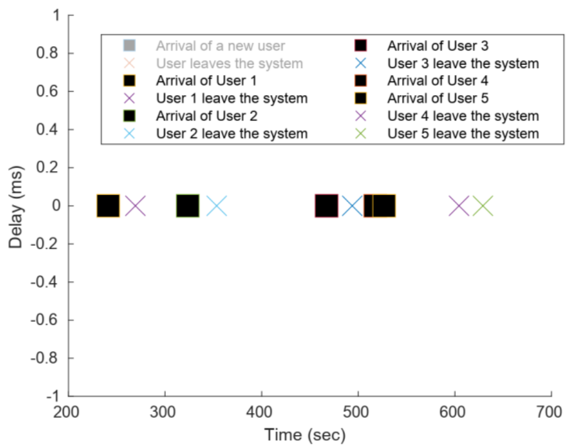


Figure 10. Arrival and Leaving of User

Simulation is performed in MATALB to execute the proposed algorithms. These simulation results shows the association and disassociation of STAs with AP in different time interval as shown in Figure 9.

A wireless LAN consists of six outdoor APs connected to one Gbps switch as shown in Figure 10. A number of wireless workstations (WSs) are connected to each AP. WSs are suggested to be at the fixed place. Step by step, increasing the number of workstations (WSs), four scenarios were implemented, for 4, 6, 8 and 10 WSs at each AP. Then the values of QoS parameters were

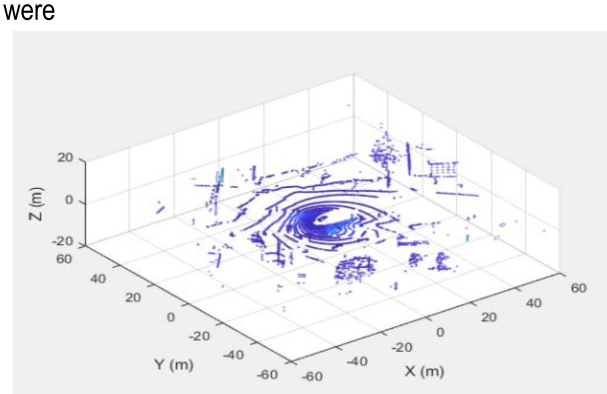


Figure 11. Load Coverage Area

In order to examine the efficiency of load balancing we deploy the simulation using MATLAB tool wherein the IEEE 802.11 based a module is provided as shown in Figure 11. This graph is basically an area graph which shows the load over the area and it is balanced overtime.

As shown in the given graph some areas are overloaded, after time interval load is distributed, and shifts from one AP to another. The target of this dissertation was to distribute the load to achieve better network performance in network. To show a graph a delay and time parameter is used that shows the balancing the load after every given time.

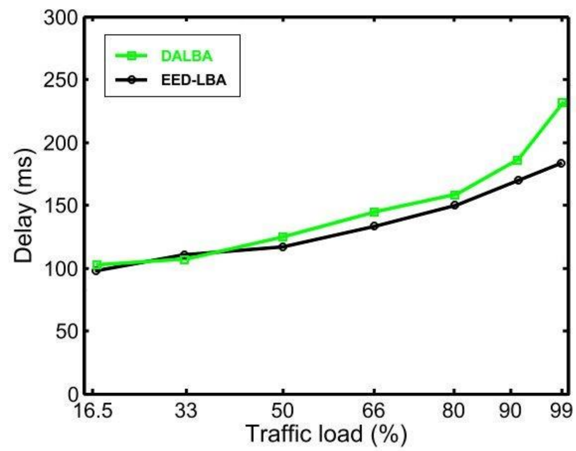


Figure 12. Delay

In this research, we proposed the EED based load balancing in Wi-Fi network taking the advantage of SDN controller. SDN controller possesses a full view of entire network [26]. APs send their status information to controller. Controller runs the algorithm and selects the less loaded AP using EED load metric.

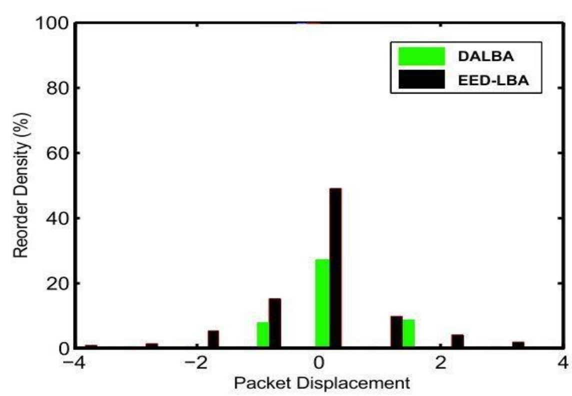


Figure 13: Reorder Density over Packet Displacement

Delay over Traffic Load

Figure 12 shows that the proposed algorithm that is EED-LBA has better delay performance as compared to existing algorithm known as DALBA. X-axis shows the traffic load while delay is given on Y-axis. The total delay time is 300 ms. As the traffic load increases the end-to-end delay also increased but the proposed algorithm has a smaller delay with the increasing of traffic load.

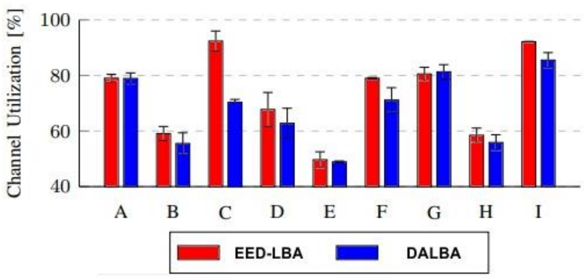


Figure 14: Channel Utilization

Reorder Density

Figure 13 depicts the reorder density at traffic load. The proposed algorithm that is EED-LBA has lower packet reordering then DALBA. EED-LBA keeps the packet reordering below five packets, which is the price to pay if we want to reduce the packet loss. DALBA has higher packet loss. EED-LBA handles to keep mean displacement of packets below five packets even at high traffic load. Packet displacement metric is being used to analyze the reorder density.

Channel Utilization

Figure 14 shows the improvement in channel utilization of proposed algorithm that is EED-LBA as compared to DALBA.

Throughput

Figure 15 shows the improvement in throughput as compared to other RSSI and Random association scheme.

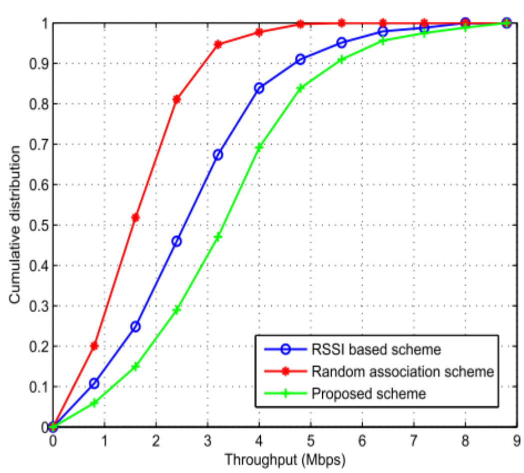


Figure 15. Throughput

CONCLUSION

In this paper, we propose an EED-LBA algorithm utilizing the benefits of SDN controller to balance the load in Wi-Fi network. In proposed work for two scenarios are being discussed, load balancing during new user association in which APs send their network status information to SDN controller. Load balancing algorithm runs on centralized controller. The controller executes the algorithm and finds the less loaded AP and assign it to STAs, if condition does not match the requirements than the second scenario is discussed that is handover in which STA connected with heavy loaded AP move to less loaded AP according to the decision taken by the controller. Simulation is performed in MATLAB to show the proposed algorithm. Simulation results shows how users connect with the AP and leave after increasing the load on AP and connect itself with less loaded AP. The distribution of load is also shown through simulation displaying the distribution of load.

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