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RESEARCH ARTICLE

SMART ASSOCIATION CONTROL IN WIRELESS FIDELITY USING FBA

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Abstract— Wi-Fi clients must associate to a specific Access Point (AP) to communicate over the Internet. Current association methods are based on maximum Received Signal Strength Index (RSSI) implying that a client associates to the strongest AP around it. This is a simple scheme that has performed well in purely distributed settings. Modern wireless networks, however, are increasingly being connected by a wired backbone. The backbone allows for out-of-band communication among APs, opening up opportunities for improved protocol design. This paper takes advantage of this opportunity through a coordinated client association scheme where APs consider a global view of the network, and decide on the optimal client-AP association. We show that such an association outperforms RSSI based schemes in several scenarios, while remaining practical and scalable for wide-scale deployment.

Here introduce the SAC protocol in this project to improve our performance. It argue that the load imbalance and consequent unfair bandwidth allocation can be greatly alleviated by intelligently associating users to APs, termed association control, rather than having users associate with the APs of strongest signal strength. Simulation results demonstrate that such a technique can improve over purely distributed association schemes, resulting in higher fairness, better load balancing properties, and even some robustness to client mobility.

Key Terms: - Include load balancing; association control; max-flow; fairness

I. INTRODUCTION

Wi-Fi (also spelled Wi-fi or Wi-Fi) is a popular technology that allows an electronic device to exchange data wirelessly (using radio waves) over a computer network, including high-speed Internet connections. The Wi-Fi

Alliance defines Wi-Fi as any "wireless local area network (WLAN) products that are based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards".

A device that can use Wi-Fi can connect to a network resource such as the Internet via a wireless network access point. Such an access point (or hotspot) has a range of about 20 meters (65 feet) indoors and a greater range outdoors. Hotspot coverage can comprise an area as small as a single room with walls that block radio waves or as large as many square miles this is achieved by using multiple overlapping access points.

Fig 1(a) shows a small portion of WiFi network with two APs and distribution of wireless devices. In this figure, number of devices close to *AP*1 is 4, while it is 2 for *AP*2. Conventional association scheme based on Received Signal Strength Index (RSSI) [1], [2] would result in associating 4 devices (*C*1, *C*2, *C*3, *C*4) with *AP*1 and 2 devices (*C*5, *C*6) with *AP*2. With the limited capacity, every AP has a maximum limit on the number of devices that it can associate [3]. This limitation and the non-uniform device distribution may result in two undesirable outcomes: (1) inability to admit all clients, and (2) bandwidth wastage by some APs.

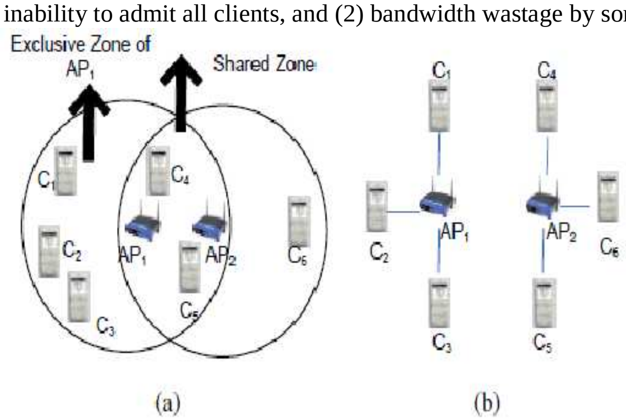

Fig .1 (a) Small portion of WiFi network with two access point and a snapshot of client distribution. (b) Probable association scenario using Max-Flow based association control algorithm

RSSI (Received Signal Strength Index) based association schemes used in in several scenarios; the main drawback of the RSSI based association scheme is that it does not take the load on APs into consideration while associating a device. To overcome this problem Least Load First (LLF) [4],[5]based association scheme has been introduced, where a device associates with the least loaded AP. As this scheme only considers load, not the signal strength, devices may suffer from low bit-rate. These traditional association schemes (RSSI and LLF) also suffer from lack of fairness [7]. By fairness mean that all the devices in the network should get admitted with equal probability, irrespective of the fact that the device belongs to a dense or sparse area. In reality, admittance probability of devices in relatively dense area is much lower compared to the devices in sparse area, which is unfair. These scenarios motivate us to design a new association scheme.

The paper is organized as follows: Section 2 discusses the brief overview of related work. Section 3 describes the SAC protocol. Section 4 shows simulation results. Finally in Section 5 the conclusion and future scope is described.

II. RELATED WORK

With the development of IEEE 802.11 MAC (Medium Access Control) protocols, efficient utilization of wireless local area networks (WLANs) has become a very important issue. In typical IEEE 802.11 networks, the association between mobile users (MUs) and access point (AP) is based on the signal strength information. As a result, it often results in the extremely unfair bandwidth allocation among MUs. Within last decade, due to the success of IEEE 802.11 MAC (Medium Access Control) standards or well-known as WiFi, the wireless local area networks (WLANs) have been deployed pervasively in many places such as homes, offices, and campuses. The increasing popularity of WLANs has led to a substantial increase in the density of WiFi access points (APs) deployed publicly. On the other hand, as already found in the mobile users (MUs) are more likely to geographically cluster around several specific APs in the network. Due to the anarchy nature of WLANs, the MUs choose its associated AP based on the information collected by probing when they roam into the network. Under this context, the potential of the network might not be fully explored. 802.11 MAC has an “anomaly” that the throughput of high data rate MUs in good channel condition is down-equalized to that of the lowest data rate peer in the network. In this way, Based on the discussion above, we can let the MUs be associated with the right APs to balance the loads. However, the default best-RSSI (receiving signal strength indicator)-based AP selection scheme which does not provide any fair sharing functionality will lead to unbalanced traffic load distribution. This is because bad MU-AP associations result in severe unfairness and even poor overall performance.

Wireless LAN administrators are often called upon to deal with the problem of sporadic user congestion at certain popular spaces (“hot-spots”) within the network. To address this problem, we describe and evaluate two new approaches; explicit channel switching and network directed roaming for providing hot-spot congestion relief while maintaining pre-negotiated user bandwidth agreements with the network. The goals of these algorithms are: (i) to accommodate more users by dynamically providing capacity where it is needed, when it is needed; (ii) to improve overall network utilization by making more efficient use of deployed resources; and (iii) to guarantee at least a minimum amount of bandwidth to users. So propose both the network and its users should explicitly and cooperatively adapt them to changing load conditions depending on their geographic location within the network. It describe how these algorithms enable the network to transparently adapt to user demands and balance load across its access points (APs).It evaluate the effectiveness of these algorithms on improving user service rates and network utilization using simulations. This algorithms improve the degree of load balance in the system by over30%, and user bandwidth allocation by up to 52% in comparison to existing schemes that offer little or no load balancing[7][8].

III. Smart Association Control (SAC) Protocol

The proposed Smart Association Control (SAC) protocol which consists of two algorithms: Fair Bandwidth Allocation (FBA)[9] and Association for Maximum Throughput (AMT) algorithm. FBA is a modified max-flow algorithm, which determines number of devices from different zones that an AP should associate. To execute FBA, map association control problem to a max-flow problem. The pure max-flow algorithm lacks fairness; hence, we suitably modify the algorithm to incorporate fairness. So theoretically justify the applicability of FBA algorithm for association control problem. In AMT algorithm, we propose a protocol which precisely determines one-to-one association between an AP and a device. It presents a distributed implementation of SAC (FBA and AMT) which is scalable and fault tolerant.

A. Fair band width allocation algorithm(FBA)

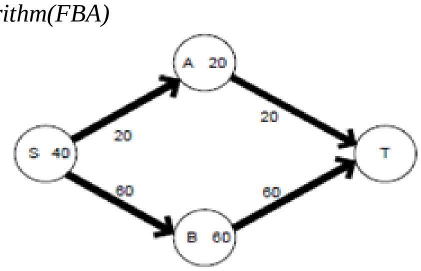

Fig. 2 Max-Flow does not maintain fairness

Let illustrate the scenario with an example. Fig2 depicts two bandwidth allocation scenarios. Zone *A* has bandwidth requirement of 20 units, and zone *B* has bandwidth requirement of 60 units and total available bandwidth of AP *S* is 40 units. Depending on the order of augmenting path selection there will be two kinds of allocation scenarios. In one case ($S - B - T$ is chosen) zone *A* does not get any bandwidth, in another case, zone *B* gets only 33% of its bandwidth requirement while zone *A* gets 100% of its requirement. So both the scenarios are unfair and hence undesirable. *Max-Min fairness* algorithm is a well-known algorithm used to ensure fairness in resource allocation. Fig 3. Illustrates an example of Max-Min fairness with a single AP and four zones. Four zones *z*1, *z*2, *z*3 and *z*4 have bandwidth requirements 5 units, 10 units, 12 units and 17 units respectively Fig 3.a, Fig. 3b and Fig.3c represent the amount of bandwidth still required by the zones after 1^{st} and 2*nd* stage of allocation. However, this kind of stage allocation policy penalizes zones having higher requirement and goes against the fairness principle of proportionate allocation.

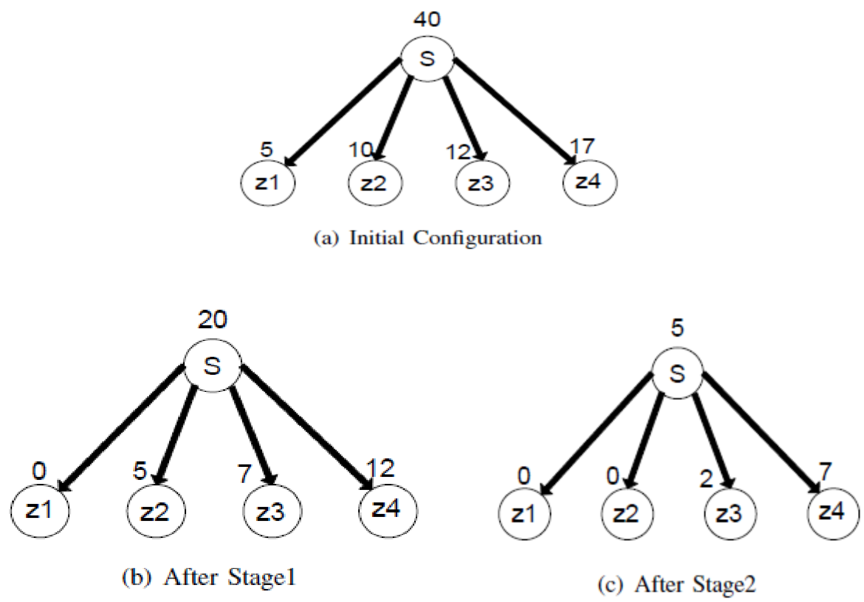

Fig 3. Three stages of bandwidth allocation according to Max-Min fairness. Fig. 4(a): Initial configuration. Fig. 4(b): After 1*st* stage of allocation. Fig. 4(c): After 2*nd* stage of allocation

Messages Exchanged in FBA: Two main jobs of FBA algorithm are flow graph formation and execution of max-flow on that flow graph. Flow graph formation requires knowledge of allocation fraction for the current stage, capacity left of APs and the current bandwidth requirement of zones. To know the bandwidth requirement of attached zones, every AP sends *bandwidth request message* (Figure 4.) to all its attached zones2. In response, every zone process sends *bandwidth response message* containing the current bandwidth requirement of the zone. Every AP waits for *p* such messages, where *p* is the number of zones under its influence. After receiving all *p* messages, AP computes the bandwidth that needs to be allocated /pushed to each zone. Each AP then sends *pushed bandwidth message* containing the amount of bandwidth pushed and zone identifier to all its attached zones. Consequently, each zone process waits for *q* number of pushed bandwidth message, while it is under influence of *q* APs. After getting all pushed bandwidth message, a zone process updates the amount of bandwidth received from all the influencing APs and re-computes the current requirement. In response to pushed bandwidth message, zone sends *pushed acknowledgement message*. Pushed acknowledgement message contains a control bit which indicates the utilization of the pushed bandwidth. The values 0 and 1 of control bit respectively indicate full and partial utilization of pushed bandwidth. In case of over allocation of bandwidth for a zone (control bit is set to 1), excess amount of bandwidth is pushed back to the APs according to their contribution. The amount of bandwidth pushed back to AP is mentioned in the pushed acknowledgement message and receiving AP adjusts their capacity accordingly. From the pushed bandwidth messages of FBA stages, every zone computes the association weight between the influencing APs and the zone.

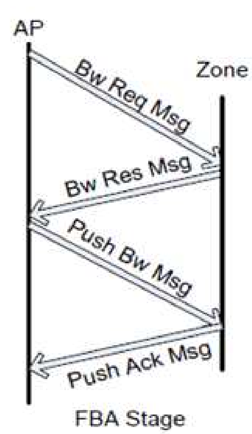

Figure 4. Message exchanged during FBA stage

B. Association For Maximum Throughput(AMT)

In FBA stage, APs collaboratively decide the number of devices they are going to associate from each zone. This number as *association weight* between the AP and the zone. However, one-to-one association between device and AP is still left after FBA stage. A protocol needs to be devised for one-to-one association between devices and APs without violating FBA constraint (association weight) such that overall network throughput is maximized. We propose an *Association for Maximum Throughput (AMT)* algorithm to achieve aforesaid objective. This algorithm is being executed in each zone process in parallel.

Message Exchanged in Interval Phase: Before describing AMT in detail, we briefly describe the association mechanism in the interval period of two successive executions of SAC. As soon as a device enters in WiFi network, it receives *beacon message* from all the APs in its range. If the device is interested for association, it checks the RSSI field from all received beacon and sends *probe request message* to the AP from which it is getting strongest signal (Figure 5.) and the AP associates the device if possible. It is worth mentioning here that the probe request message contains some additional information like AP identifier of all the APs in device's range and corresponding bit rate from those APs. On receiving probe request message, AP takes the following actions: 1) sends *probe response message* and associates device if possible 2) extracts the extra information from probe request message and construct *share bit-rate message*.

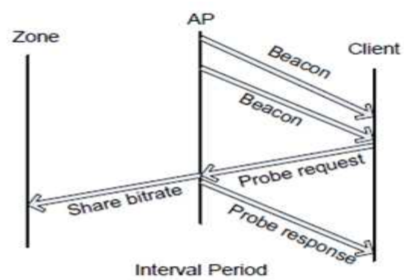

Figure 5. Message exchanged during interval period

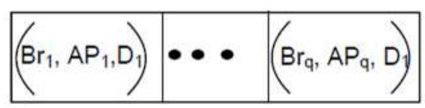

Figure 6. Structure of share bit-rate message of a device

Figure 6. Shows structure of share bit-rate message of a device *D*1 where q is the number of influencing APs for the zone. AP identifier, bit-rate from that AP and the device identifier of client are kept as a 3-tuple in share bit-rate message. AP identifies the zone to which device belongs from the list of APs in share bit-rate message and sends share bit-rate message to the corresponding zone process. However, zone process for a zone may not exist (just after network setup) and in such case, a new zone process has to be formed. The AP receiving the first probe request message from any device of that zone initiates the process of electing a responsible AP for the new zone process; it sends a control message to all others APs in the list of share bit-rate message, indicating that a new zone has to be formed (i.e. an AP needs to be elected for handling the zone process for this new zone). All the APs getting this message generate a random number and exchange among themselves. The AP which generates the minimum number is elected as the responsible AP for the new zone. Once the zone process is active, share bit-rate message is forwarded to the zone process. Thus in interval period, zone process receives detail of all the devices that belong to it and make an aggregated list of messages.

Message Exchanged in AMT Phase: At the beginning of AMT stage, every zone has obtained the association weight of all influencing APs. Moreover, zone process has complete information of the devices belong to that zone and the bit-rate that each device can avail from all APs. This information is stored in a common share bit-rate message structure as shown in Figure 7. The zone process sorts the (bit-rate, AP, D) tuples contained in all the share bit-rate messages in non-increasing order of the bit-rates. Let the tuple with the highest bit-rate among all share bit-rate messages in this zone be noted as (peak.bit-rate, peak.AP, peak.device). The devices are then associated as follows. The zone process checks if peak.AP can still accommodate more devices from this zone according to current association weight. If peak.AP can still accommodate devices from this zone, the zone process sends association message (Figure 7.) containing the identifiers of peak.device and peak.AP to all the influencing APs for this zone. If peak.device is already associated with peak.AP, then no further action is required except for reducing the association weight for the AP-zone pair. However, if peak.device is associated with some other AP, that AP sends disassociation notification message to peak.device. Disassociation notification message contains the identifier of peak.AP to guide peak.device in re-association. Then peak.device sends re-associate request message to suggested AP (i.e. the peak.AP) and association is done. The above process is repeated until all the devices in this zone are associated or all APs influencing this zone finished their quota of association weight. Once a device is associated, all tuples of that device are ignored henceforth. When association weight reaches zero for some AP-zone pair, the zone process ignores all tuples corresponding to that AP.

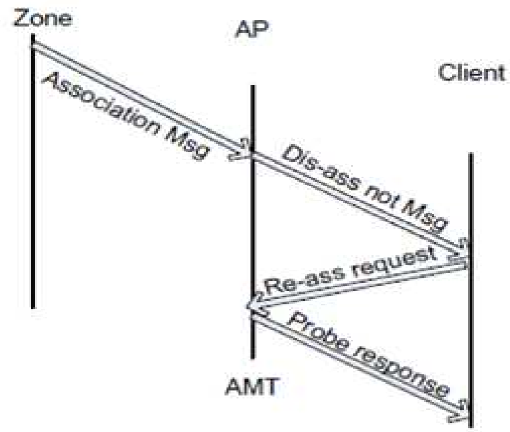

Figure 7. Message exchanged during the AMT phase

IV. Simulation Setup

We perform a simulation-based experiment in order to show the effectiveness of our proposed association control protocol over the RSSI and LLF. We present our simulation results to show that SAC outperforms traditional association control algorithms based on RSSI and LLF. First, we show that fairness of SAC is maintained even in very high load. Next, we show that SAC can accommodate the number of devices which is near to optimal and maintain a high network throughput. Finally, we show that SAC is robust in face of movement and the effect of interference on SAC is almost negligible in terms of PCA and throughput. However, SAC has some extra message overhead which is the additional cost incurred to achieve aforesaid performance. We show that this cost is tolerable.

NS2 is the main simulation used here. All possibilities that are NAM, GNU simulations are used. Some results are shown below.

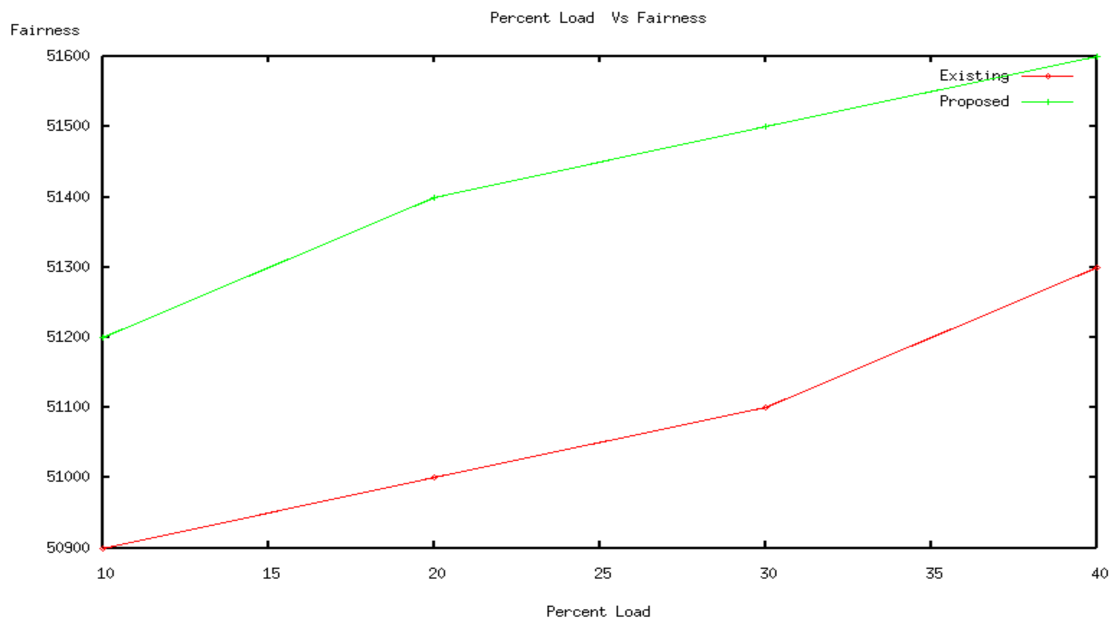

Figure 8. Percentage load vs. fairness

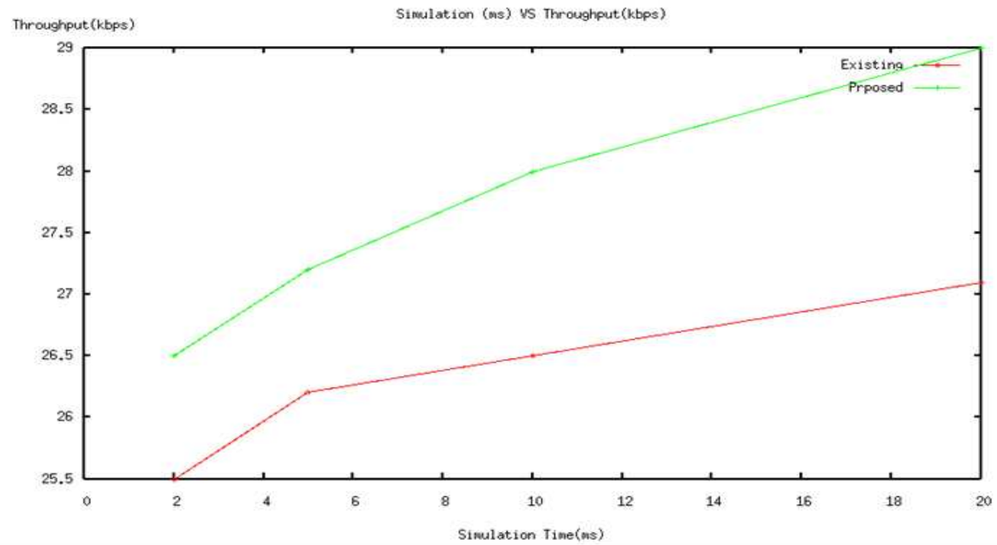

Figure 9 .Simulation Time vs. Throughput

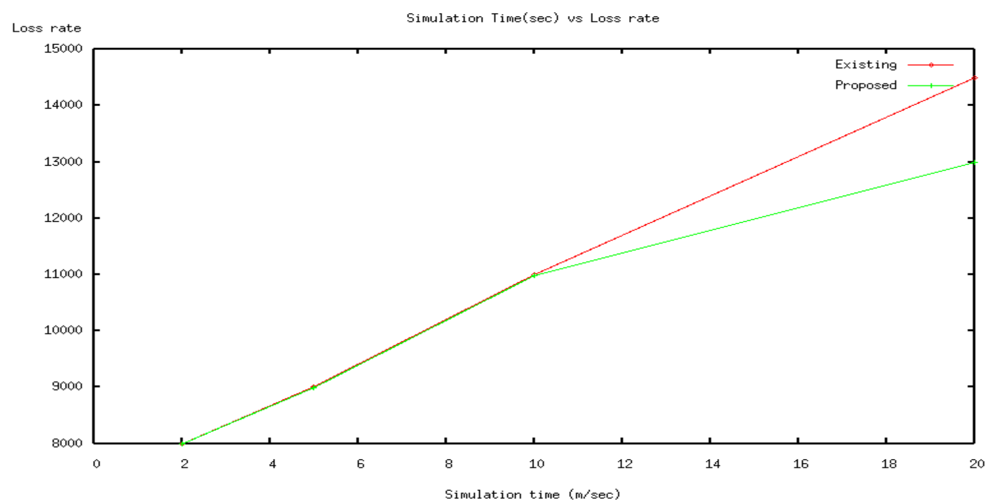

Figure 10. Simulation time vs. loss rate

V. CONCLUSION AND FUTURE WORK

This paper combines results from traditional graph theory with the emerging opportunities in wireless setting to target the pressing problem of association control. SAC improves client association techniques in wireless networks by exploiting the wired backbone among Wi-Fi APs. The key idea is to share local information from multiple APs, model it as a maxflow problem, and derive the optimal client-to-AP assignment. Simulation results demonstrate that such a technique can improve over purely distributed association schemes, resulting in higher fairness, better load balancing properties, and even some robustness to client mobility. Further the proposed algorithm also improves the overall throughput of the entire network and is also resilient to client mobility. The most important observation from the result is that our algorithm is better suited for higher load, in fact when the load is less than 75%, RSSI is a better choice. However, beyond 75% load SAC outperforms RSSI. Our future work is focused towards augmenting the system with sophisticated channel and traffic models and with support for multimedia traffic.

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