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On Access Point Selection in IEEE 802.11 Wireless Local Area Networks

Murad Abusubaih, James Gross, Sven Wiethoelter, Adam Wolisz
Telecommunication Networks Group
Technische Universität Berlin
Email: {abusubaih,gross,wiethoelter,wolisz}@tkn.tu-berlin.de

Abstract

In wireless local area networks often a station can potentially associate with more than one access point. Therefore, a relevant question is which access point to select "best" from a list of candidate ones. In IEEE 802.11, the user simply associates to the access point with the strongest received signal strength. However, this may result in a significant load imbalance between several access points, as some accommodate a large number of stations while others are lightly loaded or even idle. Moreover, the multi-rate flexibility provided by several IEEE 802.11 variants can cause low bit rate stations to negatively affect high bit rate ones and consequently degrade the overall network throughput. This paper investigates the various aspects of "best" access point selection for IEEE 802.11 systems. In detail, we first derive a decision metric the selection can be based on. Using this metric we propose two new selection mechanisms which are decentralized in the sense that the decision is performed by each station, given appropriate status information of each access point. In fact, only few bytes of status information have to be added to the beacon and probe response frames which does not impose significant overhead. In addition, we show that our mechanism improves station quality of service and better utilizes network resources compared to the conventional one implemented today in IEEE 802.11 devices.

1 Introduction

Over the last years wireless local area networks (WLANs) [4] have become quite popular. Due to decreasing costs of the equipments (wireless access points–APs– and wireless network cards) and fixed broadband connections (digital subscriber lines), WLANs have become the preferred technology of access in homes, offices, and hotspot areas (like airports and meeting rooms). Although originally several standards for WLAN have been competing, today virtually all WLANs are based on the IEEE 802.11 standard. This technology provides users with raw transmission rates of data frames up to 54 Mbps in IEEE 802.11a/g and 11 Mbps in IEEE 802.11b, while even "faster" standard supplements are currently under discussion. For the future a further increase in wireless local area networks can be expected as, for example, the city of Chicago and the Bay Area currently consider the roll out of a city-wide WLAN based on IEEE 802.11 [5].

In current implementations of IEEE 802.11 a STA has to first pick (and associate with) an AP before it can access data transmission services of the WLAN cell. This process can be performed actively or passively and is referred to as scanning. In active scanning a STA sends a "Probe Request" frame and the AP replies with a "Probe Response" frame. This frame exchange allows the STA to obtain basic information about the cell like signal strength, available transmission modes, encryption etc. The frame exchange is repeated for all APs in the vicinity, such that the STA has a list of APs at the end of the scanning process. Alternatively, in passive scanning a STA listens to "Beacon" frames which are periodically transmitted by APs. After some time span a STA will also have a list of available APs in the vicinity. After scanning (either actively or passively), a STA always associates to the AP from which it has received the strongest signal. Afterwards, it stays associated until the STA is powered down or the AP shuts down its service.

It is obvious that this rather "simple" selection process can lead to problems regarding the network performance of larger areas with many STAs and several APs [6, 7]. For example, in [14] it has been proposed to base the AP selection decision on the number of STAs associated per AP. While this is easy to implement, specific effects in IEEE 802.11 lead to severe problems with this approach as well. The IEEE 802.11b standard defines four modes of bit rates (1,2,5.5, and 11 Mbps). APs and STAs select a specific mode based on the wireless conditions. In principle the advantages of multi-rate protocols have been shown in [12]: Usually, a mobile STA with a relatively low signal to noise (and interference) ratio chooses a low transmission rate to improve its bit error rate. However, the 802.11 medium access control (MAC) protocol provides "per-frame fairness", meaning that in the long term STAs have the same chance to access the medium and send their frames (all STAs should transmit with an equal average frame rate over a longer time horizon). As the time duration required to transmit a frame with a low transmission rate is much longer than the duration for the same frame size with a higher transmission rate, a low transmission rate STA will occupy the channel for a longer time. This phenomena degrades the throughput of high rate STAs if they are associated to the same AP. For example, in [11] it has been shown that if a STA with a transmission rate of 11 Mbps shares the channel with a STA at a transmission rate of 1 Mbps, the throughput of the 11 Mbps STA is about the same as that of the 1 Mbps STA (assuming an equal traffic load of each STA as well as the saturation mode).

In [8], a dedicated wireless load balancer has been proposed, which distributes STAs among APs to mitigate the low rate STAs effect on high rate ones. A potential drawback of this solution is that it requires a centralized entity in the WLAN such as an Access Controller (AC) or a Centralized Switch, which is dedicated to manage the network resources. Between this central unit and the STAs some signaling traffic has to be conveyed, which consumes some resources. In [9] an AP selection mechanism is proposed whereby the selection metric is based on wireless channel conditions rather than the received signal strength. However, the authors have assumed the same bit rate for all STAs which does not occur in most practical settings.

We identify the core problem of AP selection to be the choice of metric to consider and whether the choice should be (periodically) reevaluated or not. Potentially, a more effective AP selection mechanism might significantly improve the overall network throughput while also improving the individual STAs rates and delays.

In this paper we propose firstly a new static AP selection scheme for IEEE 802.11 WLANs. Secondly, the static scheme is further enhanced towards reaction to dynamic channel conditions, which is denoted as dynamic AP selection scheme in the following. For the static as well as the dynamic scheme, this work demonstrates the efficiency of both approaches for IEEE 802.11b WLANs. The AP selection decision is based on a new metric which encapsulates several important cell and connection parameters into a single value. The basic parameters are easily distributed by the APs via the Beacon and Probe Response frames. Moreover, we propose that AP selection is performed decentrally at the STAs and is repeated based on varying time durations. Unlike other AP selection solutions [9], STAs will selectively scan channels ensuring an efficient WLAN resource utilization despite varying traffic and channel conditions in a larger network.

The remainder of this paper is organized as follows: System model and the basic assumptions are described in Section 2. Section 3 derives first the new metric (Section 3.1) then we present our static and dynamic selection mechanisms in Section 3.2 and 3.3. We evaluate the performance increase of our schemes in Section 4 before we conclude our paper in Section 5.

2 System Model

We consider an area where several different access points compliant to IEEE 802.11 offer service to STAs. Each AP forms a cell and cells of adjacent APs usually overlap significantly. A STA k might decide to request service from some distinctive access point. In this case it associates to the access point and may start to send or receive data afterwards. Denote the number of STAs associated at time t to access point i by $U_i^{(t)}$. We assume that all STAs are continuously transmitting or receiving data frames, i.e we consider the saturation mode.

For the medium access we consider only the distributed coordination function (DCF) (thus, the medium access is governed by the CSMA/CA protocol). Each cell is in infrastructure mode, hence, all data transmission involves the access point even if one STA might transmit data to some other STA in the same cell.

For the physical layer, we assume similar wireless channel conditions in both uplink and downlink directions. Depending on the channel attenuation between any transmitter and receiver pair, the transmission rate is selected from the available rates of the physical layer. This rate is denoted by R_k Mbit/s, where k denotes the STA (either transmitter or receiver).

Traditionally, if a STA is powered up, it first scans the currently available access points on all channels and chooses the one with the best signal-to-noise ratio (SNR). This choice is made once and no other parameters are considered. We refer to this scheme as the legacy AP selection scheme.

3 Improving AP Selection

We identify the key question for AP selection as the metric AP selection decisions are based on. In this section, we first discuss a much more appropriate metric for AP selection. Afterwards, we present two schemes how to implement the selection mechanisms based on the proposed metric.

3.1 Decision Metric for AP Selection

Given a certain traffic characterization of a STA, ultimately a STA needs to join the cell which can serve this traffic stream best. This might be the access point which has the lowest attenuation and therefore the highest SNR. However, if the cell is crowded with other STAs operating at a much lower SNR than the currently observed STA, it might not be served very well even though the SNR indicates a good service. Furthermore, a STA might join a cell (which has the best SNR regarding this STA), but the cell is currently serving some other STA with a much higher SNR than the observed STA. Then the new STA will significantly degrade the throughput of the other STAs. That is because APs generally consume longer time serving low rate STAs. Hence, a metric is required which can capture the impact of the STA joining the cell on the performance of the other (already joined) STAs as well as one which can model better the expected throughput of the STA itself if it joins a cell.

We start deriving such a metric by considering the traffic in a certain cell i. There are currently $U_i^{(t)}$ STAs associated to the access point. Some new STA k considers the association to cell i. Hence, it has to evaluate the data rate it will receive from joining cell i. However, it also has to take into consideration how much it will degrade the data rate of other STAs, which have already joined cell i. We start with deriving the data rate STA k will receive if joining cell i.

Following the analysis in [10], STA k in cell i successfully transmits a frame of length L bits after j consecutive unsuccessful transmissions within a time period of $T_{k,i}\left(j\right)$, given by:

$$T_{k,i}\left(j\right) = T_P + T_H + T_{\mathrm{DIFS}} + \frac{L}{R_k} + \\ T_{\mathrm{SIFS}} + T_{\mathrm{ack}} + T_{\mathrm{backoff}}\left(j\right) \qquad (1)$$

T_P and T_H represent the time duration of the physical layer preamble and header overheads, respectively. $T_{\mathrm{ack}} = (T_P + T_H + \frac{112}{R_k})$ is the duration of the ACK frame, T_{DIFS} is the Distributed Coordination Function Interframe Space and T_{SIFS} is the Short Inter Frame Spacing, $L = (28 + L_{\mathrm{MSDU}}) \cdot 8$ bits where L_{MSDU} is the length in bytes of the MAC Service Data Unit (MSDU) and the 28 bytes stem from the MAC header, and $T_{\mathrm{backoff}}\left(j\right)$ is the average backoff interval in μs after j consecutive unsuccessfull transmission attempts given as:

$$T_{backoff}(j) = \begin{cases} \frac{2^j (T_{CWmin}+1)-1}{2} \cdot T_{Slot} & 0 \leq j < 6 \\ \frac{T_{CWmax}}{2} \cdot T_{Slot} & \text{j} \geq 6 \end{cases} \qquad (2)$$

where T_{Slot} is the basic slot duration, T_{CWmin} and T_{CWmax} are the minimum and maximum contention window sizes respectively.

However, $T_{k,i}\left(j\right)$ is only the *raw* average transmission time of a frame. The frame is still subject to frame errors, which requires one or several retransmissions. The average time span that STA k requires to transmit a single frame *correctly* is [10]:

$$\overline{T_{k,i}} = T_{k,i}(0) + \sum_{j=1}^{\infty}(1 - P_{k,i})P_{k,i}^j \cdot \\ \left[\sum_{m=0}^{j-1} T_f(m) + T_{k,i}(j)\right] \qquad (3)$$

where $P_{k,i}$ is the frame error rate[1] and $T_f(m) = T_P + T_H + T_{DIFS} + T_{backoff}(m) + \frac{L}{R_k} + T_{SIFS} + T_{ack} + T_{Slot}$ is the time between two consecutive transmissions if the frame transmission fails.

Assuming that STA k is the only STA in the cell i, the fraction $L/\overline{T_{k,i}}$ would yield the average throughput of STA k in the cell (assuming also that the access point does not transmit any data). However, we assume that there are in general $U_i^{(t)}$ active STAs in cell i, therefore it is quite likely that the channel is occupied by some other STA if STA k wants to start a data transmission. In general, STA k's throughput depends also on the channel occupancy time of other STAs in the cell. It has been shown in [11] that a slow STA may significantly degrade the throughput of high rate STA nearly to its rate. We capture this effect by modeling the average rate of correctly transmitted bits by:

$$G_{k,i} = \frac{\mu_{k,i} L}{\overline{T_{k,i}}} \qquad (4)$$

where $\mu_{k,i}$ is the fraction of channel time consumption "left over" for STA k, given as:

$$\mu_{k,i} = \frac{\overline{T_{k,i}}}{\overline{T_{k,i}} + \sum_{j=1}^{U_i^{(t)}} \overline{T_{j,i}}} \quad . \qquad (5)$$

Recall that STA k has not associated cell i yet. Finally, we obtain the average throughput of correct bits $G_{k,i}$ (combining Equations (4) and (5)) as:

$$G_{k,i} = \frac{L}{\overline{T_{k,i}} + \sum_{j=1}^{U_i^{(t)}} \overline{T_{j,i}}} \qquad (6)$$

From Equation (6) it is clear that STA k's throughput depends on the channel occupancy time of frames transmitted by other STAs in cell i (apart from other issues like the SNR and chosen rate). However, this equation does not consider the effect of STA k on the average throughput of all other STAs in cell i. The current average channel occupancy time of all STAs in cell i is simply given by:

$$\frac{\sum_{j=1}^{U_i^{(t)}} \overline{T_{j,i}}}{U_i^{(t)}} \qquad (7)$$

[1] See Section 3.2 for details on the acquisition of the frame error rate.

Hence, the STA can compute the new average channel occupancy time once it joined the cell. If this new value increases, the STA can deduce that it will decrease the throughput of all STAs in the cell. If the new value decreases, the STA will not harm other STAs but could achieve a higher throughput if the other STAs had a better SNR, for example. Hence, the difference between current average channel occupancy time of the STAs in cell i and the new average channel occupancy time per STA in cell i if STA k joined this cell is a measure for the impact of STA k on cell i. This measure is given by:

$$\frac{\sum_{j=1}^{U_i^{(t)}} \overline{T_{j,i}}}{U_i^{(t)}} - \frac{\overline{T_{k,i}} + \sum_{j=1}^{U_i^{(t)}} \overline{T_{j,i}}}{U_i^{(t)}+1} = \frac{\sum_{j=1}^{U_i^{(t)}} \overline{T_{j,i}} - U_i^{(t)} \cdot \overline{T_{k,i}}}{U_i^{(t)} \cdot \left(U_i^{(t)}+1\right)} \tag{8}$$

3.2 Static AP Selection

To select an AP, a STA will try to maximize its throughput in the cell it wishes to associate to - but should also minimize its impact on already associated and active STAs in the corresponding cell. Therefore, it computes the following "impact" value for all candidate APs and sends its association request frame to the AP that maximizes this function.

$$W(i) = \alpha \frac{L}{\overline{T_{k,i}} + \sum_{j=1}^{U_i} \overline{T_{j,i}}} + (1-\alpha) \frac{\sum_{j=1}^{U_i} \overline{T_{j,i}} - U_i \overline{T_{k,i}}}{U_i(U_i+1)} \tag{9}$$

where α is a weighting factor between 0 and 1, whose value depends on the variance of (6). Therefore, a STA tries to minimize its negative effect on other STAs if its theoretical throughput from the candidate APs does not differ significantly. Note that the two parts of the cost function represent different quantities. For this reason, each part have to be normalized e.g. by the maximum value among all values obtained from the different APs.

The first part of the cost function in (9) constitutes the theoretical throughput a STA will get in some cell i, while the second part is a measure of its impact on the other STAs in the same cell. To do so, a STA needs three pieces of information, which namely are the number of STAs the AP currently accommodates $U_i^{(t)}$, the summation value in equation (6) and the current SNR between AP and STA. The AP could include the first two values in a new information field in the Beacon and Probe Response frames. Obviously, the length of this field is only a few bytes, so that it does not impose a significant overhead. For computing $\overline{T_{k,i}}$ and $\overline{T_{j,i}}$, $P_{k,i}$ and $P_{j,i}$ can be evaluated as described in [13], where a STA can use the perceived SNR and the AP can use the uplink SNRs for the users as we assume similar wireless channel conditions in both uplink and downlink directions.

3.3 Adaptive Dynamic AP Selection

As the wireless environment is dynamically changing, after a period of time any currently selected AP may no longer remain the best one to ensure a continuous and efficient utilization of WLAN resources. Therefore, a STA should be required to evaluate the function $W(i)$ after some time period T_c and reassociate if it found a better AP. Unlike previous solutions in which the time period T_c is constant and STAs always scan all supported channels, as proposed in [9], we propose an enhanced version of this adaption algorithm. Specifically, the value of T_c is dynamically adjusted so as to avoid unnecessary scanning. Moreover, a STA has to scan all channels only after it has been powered up. Afterwards, a mask is used to filter out all channels from which a beacon or probe response frame have not been received. The set of all non-overlapping channels (Channels 1,6, and 11 in IEEE802.11b for example) are also masked since those channels are most likely to be used by APs. This will considerably reduce both the number of scans and the scanning time which is obviously very critical with delay sensitive applications. Considering for example voice over IP (VoIP traffic), which has very strict requirements, the maximum tolerable end-to-end networking delay is about 150 ms only. The typical scanning and reassociation time with the legacy 802.11 approach is between 1 and 2 seconds, which will hardly allow a good VoIP quality. This time could be reduced with the use of dynamic selection. However, this reduction is still not satisfactory. Actually, dynamic selection mechanism will fit nicely with the emerging 802.11k and 802.11r standards. The 802.11k [1] enables a STA to request a list of candidate neighboring APs from the AP to which it is associated while the 802.11r defines mechanisms for fast and secure transition between APs for VoIP applications. Therefore, we expect the dynamic selection mechanism to be possible with VoIP without harming ongoing calls.

We summarize our Dynamic AP Selection algorithm as follows:

1. ChannelList = set of all supported channels

2. Non-Overlapped = set of nonoverlapping channels

3. Send Probe Request Frames or Listen to Beacons over ChannelList.

4. Select AP based on $W(i)$ (as explained in Section 3).

5. ChannelList =Non-Overlapped *Union* $\{$Set of channels over which Probe Responses or Beacons were received$\}$

6. Communicate for time period T_c.

7. Send Probe Request Frames or Listen to Beacons over ChannelList.

8. Select AP based on $W(i)$.

9. If found AP_{new} that is better than current AP then $\{$Set $T_c = T_c/2$, Reassociate **and** go to step 5$\}$. Else: $\{$Set $T_c = 2 \cdot T_c$ **and** Go to step 5$\}$.

4 Performance Evaluation

This section compares the performance of the proposed static and dynamic selection mechanisms with the default one implemented in IEEE 802.11b WLAN cards, in which STA-AP selection is based on the Strongest Received Signal. The performance results are obtained by means of simulation using the NCTUns [2] simulator.

4.1 Real-World Scenario

The real-world case, which serves as a basis for this work, consists of a large area like a departure hall in an airport. Due to the large area as well as a potentially high number of users, four 802.11b APs that operate on different IEEE 802.11b channels are placed within this hall.

Users appear in this hall at different points in time and at different places. They have nomadic mobility degree, i.e., users start their devices and stay at a constant position during their active session. Two different user types may be present: either FTP or VoIP clients.

4.2 Parameter Settings

The environment above has great influence on the wireless channel. Radio signals are not only attenuated by the path loss itself, but are also affected by multi-path propagation. Due to movements of objects within the environment as well as obstructions, the multi-path fading component varies in the time domain. In order to accurately model these effects, the path loss has been combined with a Rayleigh component. For the path loss we have used a two ray ground reflection model with the received power P_{rx} given as:

$$P_{\mathrm{rx}} = \frac{P_{\mathrm{tx}} G_{\mathrm{tx}} G_{\mathrm{rx}} h_{\mathrm{tx}} h_{\mathrm{rx}}}{d^2} \tag{10}$$

where P_{tx} is the transmit power (in mW), G_{tx},G_{rx} denote the transmitter and receiver antenna gains respectively, h_{tx} and h_{rx} are the antenna heights of transmitter and receiver, and d is the distance between them. We assume that APs and STAs use the same transmission power level.

Wireless terminals choose their transmission rates dependent on the perceived SNR and try to assure a bit error rate BER less than 10^{-5}. This rate remains constant during the simulation, i.e, no rate adaptation mechanism has been implemented. For IEEE 802.11b the possible rates actually are $1\ \mathrm{Mbit/s}$, $2\ \mathrm{Mbit/s}$, $5.5\ \mathrm{Mbit/s}$ and $11\ \mathrm{Mbit/s}$.

STAs are uniformly distributed in an area of $500 \cdot 500\mathrm{m}^2$ while their arrival time is uniformly distributed over 40 seconds.

Table 1 lists the values of the parameteres as used in simulations.

Parameter	Value	Parameter	Value
PLCP header T_H	48 μs	T_{SIFS}	10 μs
PLCP preamble T_P	144 μs	T_{DIFS}	50 μs
Cell overlapp	20 %	T_{Slot}	20 μs
Fading Variance	10 dB	T_{CWmin}	31
APs/STAs Tx Power	100 mW	T_{CWmax}	1023
APs/STAs Tx Range	300 m	G_{tx} , G_{rx}	0 dBi
h_{tx} and h_{rx}	1 m	T_c	20 s

Table 1. Constant Parameters

4.3 Traffic Models

Every FTP user downloads a file, whereby its size is indefinitely large. All TCP users utilize greedy TCP with packet length of 1000 bytes. The TCP traffic was generated with Jugi's Traffic Generator (jtg) [3].

Each VoIP call is modeled by a bi-directional, isochronous audio flow. With ITU-T's G729 codec (which is widely used in 802.11 devices) and an audio frame length of 10ms, this results in an audio packet size of 10 bytes.The VoIP traffic was generated using the RTP/UDP traffic generator which comes with NCTUns simulator [2].

4.4 Metrics

As the throughput of the whole system should be maximized, every AP measures the throughput every second in up- as well as downlink directions. The sum of the four AP throughputs is the first metric, which is denoted as *aggregated throughput* in the following.

Despite packet loss, the end-to-end delay is the most critical component for VoIP. In simulations investigating VoIP, the *average round-trip time* is measured additionally. The *average round-trip time* averaged over all STAs is a second metric.

4.5 Simulation Scenarios

This work considers two scenarios: Firstly it investigates the real-world case with 60 FTP users, while secondly only 30 VoIP users are present within the WLAN area. FTP as well as VoIP sessions terminate at the wired part of the network at a single server. The latency for packets between APs and the server was set to 10μs. The cables connecting the APs to the server (via an 802.3 switch) have a 100 $\mathrm{Mbit/s}$ bandwidth. Simulation has been carried out for 5 different independent STAs locations cases. Each case has been simulated 15 times. In all simulations, the simulation time was set to 350 seconds.

4.6 Results

In this section we present the simulation results of the proposed AP selection mechanisms. Figures 1 and 2 present the minimum and maximum improvements (among the 5 different locations cases) obtained from the FTP-scenario, respectively. The figures depict the aggregate throughput of the four APs for the legacy selection policy and our proposed static one. It can be observed that the aggregate throughput obtained from the proposed mechanism is the same or in the best case about 14.7 % (Figure 2) higher than that one obtained from the legacy mechanism. On the other hand, Figures 3 and 4 show the minimum and maximum improvements (among the 5 different locations cases) with the use of the dynamic selection mechanism also regarding the FTP-scenario. Notice that a significant gain in the aggregate throughput is achieved. Table 2 shows minimum, maximum and average throughput of both static selection and dynamic selection mechanisms compared to legacy mechanism for the five different STAs distributions. The results show that with the dynamic selection mechanism, the average network throughput can be improved by about 33% (Case 2).

Figures 5 and 6 present the minimum and maximum improvements (among the 5 different locations cases) obtained from simulating scenario two (VoIP scenario) respectively. The figures depict the aggregate throughput of the four APs for the legacy selection policy as well as our proposed static one. Table 3 also shows the average round trip delay in milliseconds (ms) of the RTP packets resulted from the two selection mechanisms. A great reduction in the round trip might be gained with our proposed mechanism.

Figure 7 finally presents the effect of periodic selective scanning compared to default scanning proposed in [9] for a FTP client. One can see that the minimum throughput is greater and the recovery time is shorter when selective scanning has been used.

Since the re-scanning latency is larger than the the maximum tolerable end-to-end delay for VoIP (150 ms) with our dynamic selection mechanism, the second scenario (VoIP scenario) has not been investigated with the dynamic selection criterion.

Min., Max., and Avg. Throughput (KB/s)				
Case	**Scheme**	**Min.**	**Max.**	**AVG.**
1	Legacy	821.79	897.82	855.81
1	Static	912.72	968.77	936.74
1	Dynamic	889.14	1075.46	992.73
2	Legacy	813.17	893.56	856.18
2	Static	952.79	1022.81	982.8
2	Dynamic	1044.45	1225.2	1141.24
3	Legacy	793.46	848.92	819.81
3	Static	839.45	908.3	871.1
3	Dynamic	839.66	1054.22	976.81
4	Legacy	858.63	955.81	910.92
4	Static	983.54	1063.06	1021.86
4	Dynamic	1076.25	1187.94	1139.11
5	Legacy	833.6	903.47	866.24
5	Static	927.13	982.33	949.52
5	Dynamic	932.45	1074.82	1011.88

Table 2. Minimum, Maximum, and Average APs Throughput (FTP Scenario)

Average Round Trip Delay of RTP packets (ms)		
Case	**Legacy**	**Static**
1	68.7	62
2	101	64.3
3	112	84.3
4	151.46	81.3
5	53	49.5

Table 3. Average Round Trip Delay of RTP packets (VoIP Scenario)

5 Conclusions

This paper proposes a framework for AP selection in IEEE 802.11 WLANs. The simple selection mechanism implemented currently in IEEE 802.11 WLANs does not effectively utilize WLAN resources as it bases the selection decision on RSSI values and ignores all other parameters which are important for the effective throughput of a station. In addition, as several IEEE 802.11 physical layer variants support multiple transmission rates, the currently implemented selection mechanism of IEEE 802.11 WLANs also does not consider the impact of association on the effective throughput of other (already associated) stations.

In this paper we propose to take both issues into account when selecting an AP: the "own" effective throughput as well as the impact on other (already associated) stations. We present a new AP Selection policy to mitigate this problem where the selection metric encapsulates several cell and connection parameters into a single value. Basically the mechanism tries to maximize STA's throughput as well as minimize its negative effect on high rate STAs currently accommodated by the AP to which it wishes to associate. Simulation results show that the proposed mechanisms can utilize WLAN resources much better and enhances users QoS through improving aggregate network throughput and reducing the delay for VoIP applications. We expect further improvements when an optimal value of the weighing coefficient α in the cost function (equation 9) is used. It is our future goal to investigate this issue.

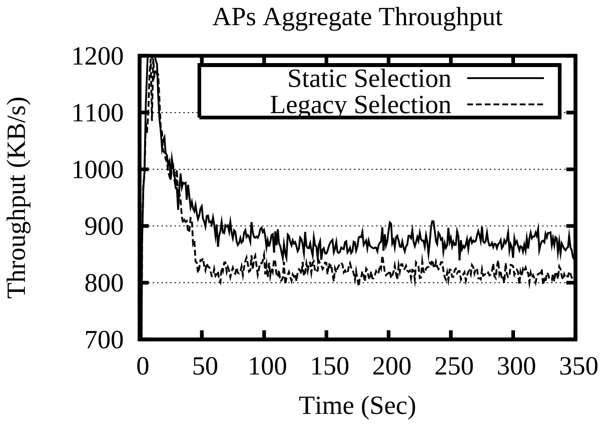

Figure 1. Static Selection (Minimum Improvement) - FTP Scenario

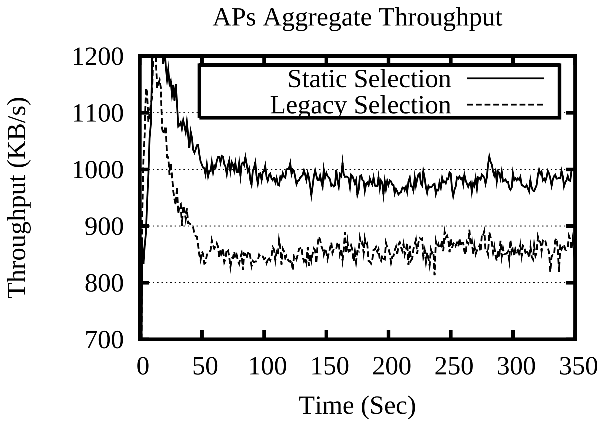

Figure 2. Static Selection (Maximum Improvement) - FTP Scenario

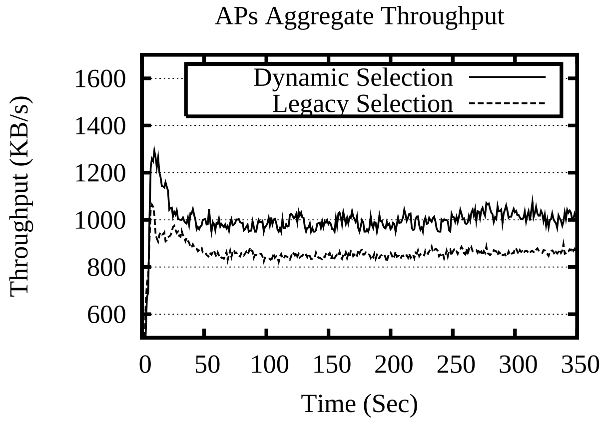

Figure 3. Dynamic Selection (Minimum Improvement) - FTP Scenario

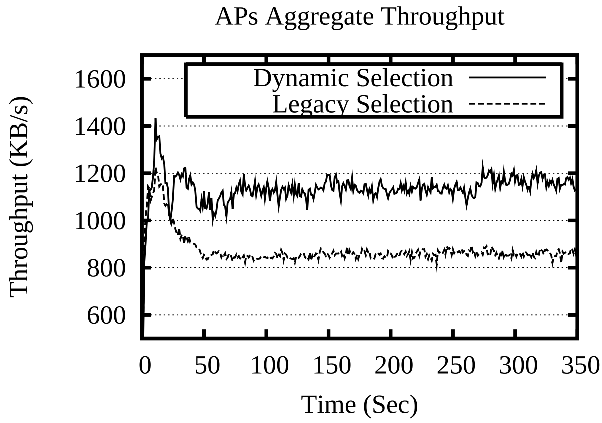

Figure 4. Dynamic Selection (Maximum Improvement) - FTP Scenario

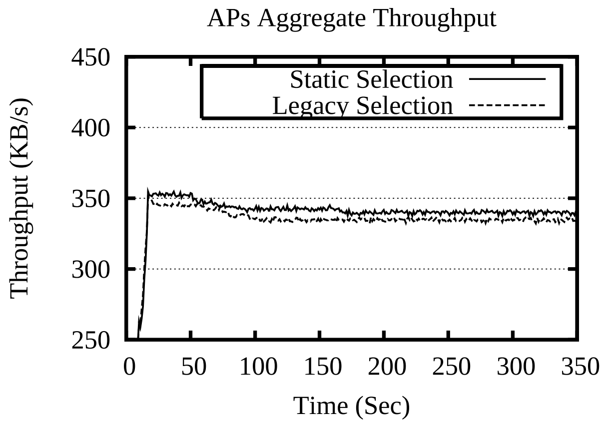

Figure 5. Static Selection (Minimum Improvement) - VoIP Scenario

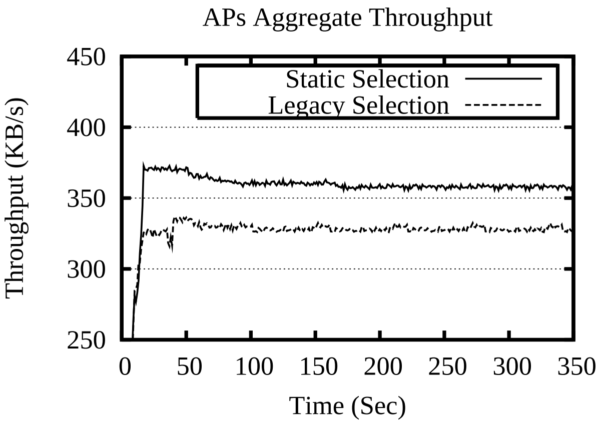

Figure 6. Static Selection (Maximum Improvement) - VoIP Scenario

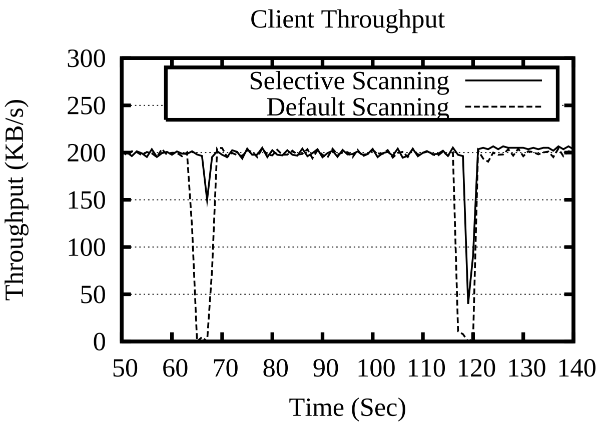

Figure 7. Comparison between Selective and Default Scanning

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