Edge Station Throughput Enhancement Method Based on Energy Detection Threshold and Transmission Power Joint Dynamic Adjustment

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Abstract. With the surge in demand for wireless traffic and network quality of service, wireless local area network (WLAN) has developed into one of the most important wireless networks affecting human life. In high density scenarios, large numbers of Access Point (APs) and Stations(STAs) will be deployed in a limited area, means large amount of signals will be overlapped and coverage between Basic Service Sets (BSSs), interference and collisions will become more severe, and if the sensitivity of edge STA detection channel is not enough, such as the energy detection (ED) threshold and reception sensitivity mismatch of STAs, edge STA's throughput may slow down seriously. So in this paper, we propose an edge STA throughput enhancement method based on ED threshold and TXPower joint dynamic adjustment to solve the problem of edge STA deceleration caused by ED threshold and reception sensitivity mismatch. By appropriately adjusting the ED threshold and TXPower of the BSSs with deceleration edge STAs, improving the sensitivity of edge STAs detection channel, and opportunity of edge STA's transmission packet is not greatly affected. Through the method of establishing mathematical model and simulation verification, it has great practical significance.

Keywords: ED threshold · TXPower · Joint dynamic adjustmented · Edge STA · Throughput enhancement

1 Introduction

WLAN and cellular network have become the dominant type of wireless networks [1]. Ericsson's latest mobility report shows that the compound annual growth rate (CAGR) of mobile traffic will grow by 30% from 2020 to 2024 [2]. Therefore, the high-density scenario will be the main deployment scenario for the next generation of WLAN [3–5] with the surge in data demand and rapid rise in WLAN deployment scale and density, requiring higher wireless network throughput to ensure network transmission quality [6,7]. Large bandwidth is the main feature

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of next-generation wireless networks [8], such as IEEE 802.11ax, 802.11be. But in high dense deployment, large numbers of APs and STAs will be deployed in a limited area, means large amount of signals will be overlapped and coverage between BSSs, interference and collisions will become more severe serious [9], some STAs are difficult to compete for channel by intra-BSSs interference, coupled with inter-BSSs's interference, the probability of receiving success will be greatly reduced. The next generation of WLAN random competition channel will aggravate the interference in multi-BSSs, and then cause station's throughput, BSS's throughput, and even the whole network's throughput decreases. So how to solve the BSSs's interference and ensure station's transmission quality is a key factor to improve network service and quality.

Inter stations interference is the main reason for limiting transmission efficiency and throughput of WLAN systems in high dense environments [10]. For the interference between WLAN stations, researchers have proposed many interference management methods, mainly including power control mechanism, distributed MIMO, dynamic distribution channel and other methods [11–19]. In [11–15], the authors proposed power control mechanism, such as M. Michalski et al. considered AP can estimate the interference plus noise ratio (SINR) of STA by the received signal strength indicator (RSSI) of STA, and then adjust the transmitting power according to the set minimum SINR limit [11], Y. Cai and J. Luo provided a network traffic power control method [12], A. Tsakmalis et al. considered that the power control can be performed adaptively according to the interference situation by adding a centralized controller for channel measurement and adjusting AP power to the system in the dense WLAN network [13–15]. The interference elimination technology and interference alignment method were adopted to eliminate BSS interference problem [16,17]. R. Akl proposed a method of using AP interchannel interference state through the dynamic channel allocation algorithm of WLAN system to minimize AP interference to allocate channels [18]. S. Jang studied the problem of channel assignment in AP coexistence networks and proposed heuristic algorithms for channel assignment [19]. Partial frequency multiplexing technology was used to improved edge STA throughput, but a certain spectral efficiency would be sacrificed [20]. Huawei considered that we could enable each BSS to share all spectrum resources through soft frequency multiplexing technology to improve the average BSS throughput and reduce interference to edge STA [21].

The existing researches on edge STA's interference mainly focused on intra-BSS, or inter-BSSs when channel state can be well detected by stations. However, there are few studies on interference of edge STA when stations channel detection is not sensitive, such as when station deceleration caused by the mismatch between ED threshold and reception sensitivity which is a common problem of multi-BSSs interference in highly dense scenarios, and will cause a typical edge STA throughput deceleration phenomenon. This paper aims at the problem of edge STAs throughput reduction caused by the mismatch of ED threshold and reception sensitivity between multi-BSSs in highly dense scenarios, analyzes and points out that the mismatch of ED threshold and reception sensitivity caused by inherent CSMA/CA mechanism of WLAN is an important reason for the continuous intensification of multi-BSSs interference in highly dense scenarios, proposes an edge STA throughput enhancement protocol based on ED threshold and TXPower joint dynamic adjustment, improve the sensitivity of edge STA detection channel and ensure that the edge STA's delivery opportunities are not greatly affected to improve the throughput performance of edge STA. Simulation results show that this protocol can improve the throughput performance of edge STAs, especially the edge STA with severe throughput reduction in high density scenarios.

The rest of this article is organized as follows. In Sect. 2, a problem-solving model is proposed to solve the problem of edge STA deceleration caused by the mismatch between ED threshold and reception sensitivity. In Sect. 3, we will analyze the problem of mismatch between ED threshold and receiver sensitivity in detail. The fourth section designs a protocol of the above proposed. Simulation results are shown in Sect. 5. The last Section concludes this paper.

2 System Model

Aiming at edge STA throughput reduction problem caused by mismatch between ED threshold and reception sensitivity of stations, this paper proposes an edge STA throughput promotion model based on the joint dynamic adjustment of ED threshold and TXPower in Fig. 1. For the convenience of describing system model and following description, relevant symbols are described in Table 1.

In this system model, STA periodically statistics some related information, which meets certain conditions, such as the RSSI value of packets from inter-BSS, the number of inter-BSS stations, the number of packets from inter-BSSs and so on, calculates itself throughput, and then feedback the relevant information to its AP. AP integrates the received information, and then gets the maximum STA throughput value of intra-BSS, the total number of stations of inter-BSS, the total number value of packets from inter-BSS, the minimum RSSI value of packets from inter-BSS and other information, then feeds back to centralized controller C. After receiving the information from each AP, C will evaluate the speed reduction problem and severity of edge STA, and then send the evaluation results to each AP. AP will adjust and optimize the ED threshold, TXPower and other relevant parameters of intra-BSS according to the evaluation results, and sends optimized parameters to its STAs. STA will adjust ED threshold and TXPower according to the received parameters.

3 Analysis of the Mismatch Between ED Threshold and Reception Sensitivity

The mismatch between ED threshold and reception sensitivity means that the received intra-BSS packet's RSSI value of a station is between ED threshold and carrier sense (CS) threshold, so it can not well perceive the channel is busy or idle, sometimes will mistake the channel idle when channel is busying actually, then constantly sends packets, resulting in collision and station throughput

Table 1. Symbol description.

Symbol	**Symbolic meaning**
C	Centralized controller.
A_i	The *ith* AP in this network.
S_{ij}	The *jth* STA of the *ith* AP.
e_{ij}	The ED threshold set by the *jth* STA to inter-BSS.
$e_{ij}^{'}$	The optimized ED threshold set by the *jth* STA to inter-BSS.
p_{ij}	TXpower set by the *jth* STA in the current time period.
$p_{ij}^{'}$	The optimized TXpower of the jth STA of the ith AP.
c_{ij}	CS threshold set by the *jth* STA to inter-BSS.
r_{ij}^{o}	The RSSI value of received packets of the *jth* STA from inter-BSS, value r_{ij}^{o} in (c_{ij}, e_{ij}).
r_{ij}^{s}	The minimum RSSI value of received inter-BSS packets of the *jth* STA, value r_{ij}^{s} is equal to $min\left(r_{ij}^{o}\right)$.
n_{ij}^{o}	The number of the inter-BSS stations of the *jth* STA phase mutual inductance packet, when the RSSI value of the packet in (c_{ij}, e_{ij}).
n_{ij}^{r}	The number of packets received from inter-BSS by the *jth* STA within the specified time period. The RSSI value of packets in (c_{ij}, e_{ij}).
t_{ij}^{s}	Throughput of the *jth* STA within the specified time period.
a_{ij}^{o}	The recorded inter-BSS station address of the *jth* STA, when the RSSI value of packets received from the inter-BSS in (c_{ij}, e_{ij}).
r_i^{a}	The minimum RSSI value r_i^{a} of inter-BSS packets received by all the STAs of the *ith* AP, value r_i^{a} is equal to $min\left(r_{ij}^{s}\right)$.
N_i^{o}	The total number of inter-BSS stations of the *ith* AP when the RSSI value of its STAs received packets from these stations in (c_{ij}, e_{ij}), value is equal to $\sum n_{ij}^{o}$.
N_i^{r}	The total number of inter-BSS packets received by all STAs of the *ith* AP, value N_i^{r} is equal to $\sum n_{ij}^{r}$.
T_i^{s}	The maximum STA throughput in the specified time period of *ith* AP, value T_i^{s} is equal to $min\left(r_{ij}^{o}\right)$.
M_i^{a}	Stores the information of *ith* AP about received inter-BSS packet number n_{ij}^{r}, throughput t_{ij}^{s}, and inter-station address a_{ij}^{o}.
T_{m^s}	The maximum throughput of STA in the time period in this network, value T_{m^s} is equal to $max\left(T_i^{s}\right)$.
N_{m^o}	The maximum number value of statistical inter-BSS stations of each BSS in the network, value N_{m^o} is equal to $max\left(N_i^{o}\right)$.
N_{m^r}	The maximum number value of statistical inter-BSS packets of each BSS in the network, value N_{m^r} is equal to $max\left(N_i^{r}\right)$.
D	Information about whether the edge STA deceleration occurs in each BSS.
S	Information about whether each BSS have serious edge STA throughput deceleration problem.

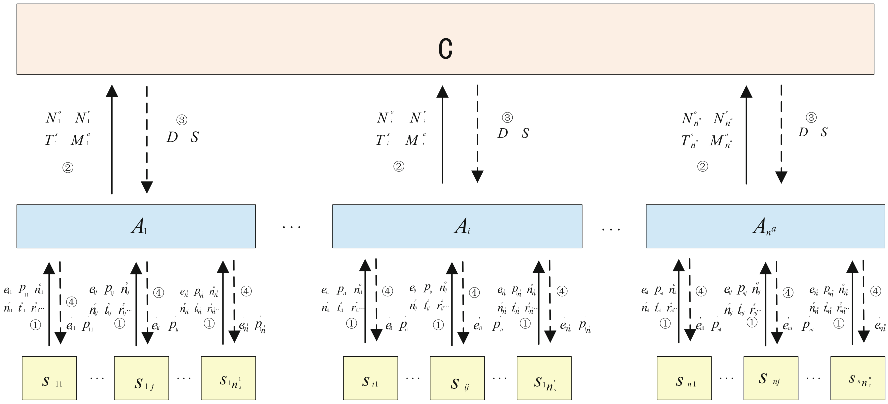


Fig. 1. System Model

decline, especially edge STA's throughput reduction. This paper mainly studies the mismatch between ED threshold and reception sensitivity between multi-BSSs.

IEEE 802.11 adopts CSMA/CA mechanism for signal transmission. CSMA/CA mainly judges the channel is busy or idle through physical carrier sense. The physical carrier sense function is realized through ED threshold and CS threshold. ED is that a station uses the energy received by physical layer to judge whether there is a signal for access. When the signal strength is greater than or equal to ED threshold, the channel will be considered busy; otherwise, the channel will be considered idle. In IEEE 802.11, CS is mainly used to identify the preamble of physical layer convergence protocol header of a data frame. If a received frame's energy is greater than or equal to CS threshold, which is considered that a signal is detected; otherwise, no signal is detected. In short, the CS threshold is the basis for judging whether a signal is received, ED threshold is the basis for a station to judge the channel busy or idle. Therefore, when the ED threshold of a station is mismatched with reception sensitivity, that is, a station detects that the energy of channel is less than ED threshold, will consider the channel idle and then sends packet. However, at this time, the destination station may be parsing the preamble in the header of corresponding physical layer for receiving inter-BSS packet (the RSSI of inter-BSS packet is greater than CS threshold but less than ED threshold), thus missing the preamble parsing of the packet actually sent to it, resulting in the packet being discarded.

4 Protocol Design

4.1 Basic Idea

This protocol monitors network transmission status through regular collecting network status information by STAs, and feed back the related information to its AP. After AP integrates the received information, it feeds back to C, which will evaluates problem according to the feedback information and send the evaluation results to AP, and AP makes parameter optimization, then AP sends the optimized information to its STAs, and STAs make parameter adjustment. The protocol is mainly realized through three stages in Fig. 2.

Network status collection stage: STA regularly counts RSSI of the received inter-BSS packets, the RSSI value is in (c_{ij}, e_{ij}), number of inter-BSS stations n^o_{ij}, number of inter-BSS packets n^r_{ij}, address of inter-BSS a^o_{ij}, throughput t^s_{ij} and other relevant information.

Network state feedback and problem evaluation stage: STA processes the collected network status information and feeds back the relevant information to its AP. After AP performs certain information integration, it obtains the minimum RSSI value r^a_i, total number of inter-BSS stations N^o_i, total number of inter-BSS packets N^r_i, maximum throughput of intra-BSS STA T^s_i, and other information such as M^s_i, and feeds back to C.

Parameter optimization, adjustment and release stage: C judges the deceleration of edge STA according to the feedback network state information, and sends the judgment results to each AP. AP will optimize ED threshold, TXPower and other related parameters according to the judgment results, and send the optimized results to its STAs. Upon receipt, STA will adjust parameters such as ED threshold and TXPower.

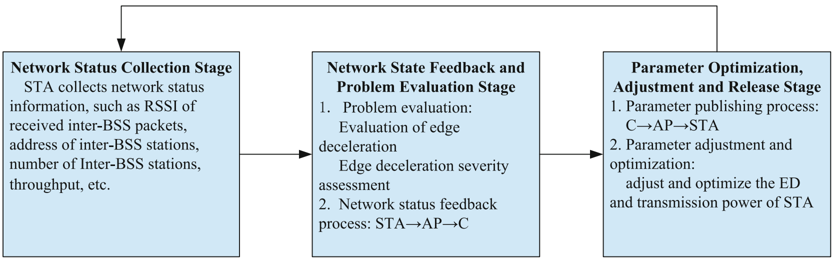


Fig. 2. Basic protocol process

4.2 Detailed Design

The basic process of this protocol is to collect, feed back, evaluate problems, optimize and adjust parameters on a regular basis. The follows is specific process.

(1) Network status collection stage.
Basic process of network state collection as in Fig. 3. STA (S_{ik}) statistics RSSI value (r^o_{ik}) of received packets come from STA (S_{jl}) of inter-BSS and get the minimum RSSI value (r^s_{ik}) of received inter-BSS packets according to the statistics of r^o_{ik}, records the address of inter-BSS STA (a^o_{ik}), counts the number of inter-BSS stations (n^o_{ik}), statistics the number of the received

inter-BSS packets (n_{ik}^r), calculates throughput (t_{ik}^s) in the time period T and other network status related information.

(2) Network state feedback and problem evaluation stage.

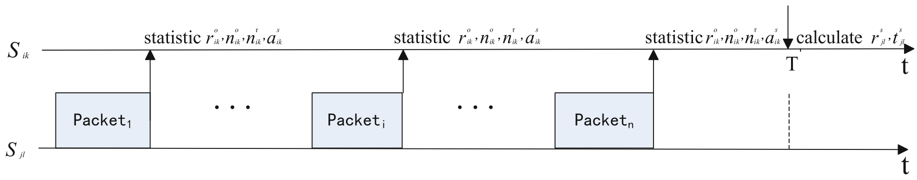


Fig. 3. Basic protocol process

1) Network state feedback phase.
   Basic process of network state feedback in Fig. 4. STA sends station network state report (SNSR) frame to its AP after processing the collected network state related information at time of nT. The SNSR frame carries network state related information such as the minimum RSSI value r_{ik}^s, the calculated throughput t_{ik}^s, the statistics inter-BSS stations number n_{ik}^o, the received inter-BSS packets number n_{ik}^r, the ED threshold e_{ik} and TXPower p_{ik} set to inter-BSS in the current time period of STA and other information. AP performs the received information processing to obtain the minimum RSSI value r_i^a, the inter-BSS's stations number N_i^o, the received inter-BSS packets number N_i^r, the maximum STA throughput T_i^s, and other information M_i^a, then send an access point network state report (ANSR) frame, which carries the related network state information, to C. And C will get the maximum STA throughput value T_{m^s}, the maximum inter-BSS stations number N_{m^o}, the maximum value of received inter-BSS packets number N_{m^r}, then enters to the problem evaluation stage.
2) Problem evaluation stage.

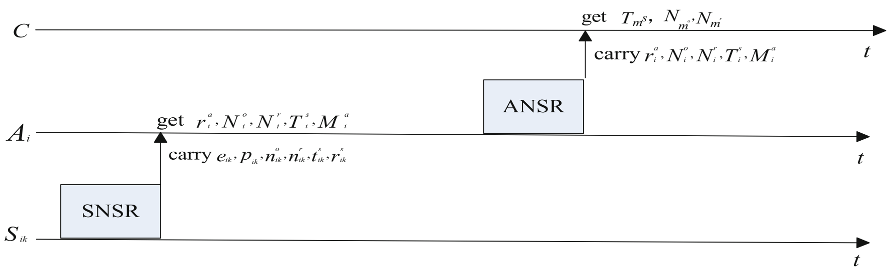


Fig. 4. Basic protocol process

Step 1: Judge STA deceleration. Judge whether the counted inter-BSS stations number n_{ik}^o and calculated STA throughput t_{ik}^s meet the Eq. (1) and (2) respectively. If so, it is considered that the current STA has an edge deceleration problem, and proceed to step 2; Otherwise, it is considered that no edge deceleration problem.

$$n_{ik}^{o} > R \tag{1}$$

where R is the edge deceleration parameter.

$$t_{ik}^{s} < k * T_{m}^{s} \tag{2}$$

where k is throughput drop parameters.

Step 2: judge the severity of edge STA deceleration. When it is judged that the inter-BSS's stations number N_{ik}^{o} and the received inter-BSS packet number N_{ik}^{r} of each BSS meets Eq. (3) and (4), it is considered that the current BSS edge reduction problem is serious.

$$N_{i}^{o} > k_1 * N_{m}^{o} \tag{3}$$

where k_1 is the edge deceleration severity parameter.

$$N_{i}^{s} > k_2 * N_{m}^{s} \tag{4}$$

where k_2 is the edge deceleration severity parameter.

The specific process of problem evaluation is shown in Algorithm 1.

Algorithm 1. Problem evaluation

Input: $t_{ik}^{s}; n_{ik}^{o}; T_{m^s}; N_i^o; N_i^r; d_{ik}; d_i^a; s_i^a; s_{ik}^s; a_i^a; n^a; n_i^s;$

Initialize: $d_{ik} = false; d_i^a = false; s_i^a = false;$

output: $D = map < a_i^a, d_i^a >; S = map < a_i^a, s_i^a >$;

for int $i = 1$ to n^a **do**
  for int $k = 1$ to n_s^k **do**
    if $(n_{ik}^o > R)\, and\, (t_{ik}^s < k * T_{m^s})$ **then**
      $d_i^a = true$
      $d_{ik}^s = true$
    else
      $d_{ik}^s = false$
    end if
  end for
  $D = map < a_i^a, d_i^a >$
  if $(d_i^a = true)$ **then**
    if $(N_i^o > k_1 * N_{m_o})\, and\, (N_i^r > k_2 * N_{m^r})$ **then**
      $s_i^a = true$
      $S = map < a_i^a, s_i^a >$
    else
      $s_i^a = false$
      $S = map < a_i^a, s_i^a >$
    end if
  end if
end for

(3) Parameter optimization, adjustment and release stage.

According to the above evaluation results, C sends it to each AP, stations for corresponding parameter optimization and adjustment. The adjustment and optimization process of specific parameters is as follows:

Step 1: after receiving the parameters issued by C, the AP determines whether the edge deceleration problem occurs in BSS. If it does, execute step 2; Otherwise, proceed to step 6.

Step 2: judge the severity of edge deceleration problem in BSS. If the problem is serious, proceed to step 3; Otherwise, go to step 4;

Step 3: optimize the TXPower and inter-BSS ED threshold parameters of each STA, send the optimization results to each STA, and execute step 5;

Step 4: optimize the inter-BSS ED threshold parameters of each STA in BSS, send them to each STA, and execute step 5.

Step 5: STA adjusts the parameters according to the optimized parameters distributed by its AP.

Step 6: STA does not make any parameter adjustments.

ED threshold and TXPower optimization meet Eq. (5) and (6). Specific parameter optimization process, such as Algorithm 2.

$$e_{ik}^{'} = r_i^a \tag{5}$$

$$p_{ik}^{'} = p_{ik} + e_{ik} - e_{ik}^{'} + P \tag{6}$$

where P is a TXPower optimization parameter.

Algorithm 2. Parameter optimization

Input: $d_i^a; s_i^a; e_{ik}; p_{ik}; r_i^a; n_s^i;$
Initialize: $d_{ik} = false; d_i^a = false; s_i^a = false;$
output: $e_{ik}^{'}; p_{ik}^{'};$
if $(d_i^a = true)$ **then**
  for int $k = 1$ to n_s^k **do**
    $e_{ik}^{'} = r_i^a$
  end for
end if
if $(s_i^a = true)$ **then**
  for int $k = 1$ to n_s^k **do**
    $p_{ik}^{'} = p_{ik} + e_{ik} - e_{ik}^{'} + P$
  end for
end if

5 Performance Evaluation

In this paper, we adopt integrated system & link level simulation platform [22, 23], and set two simulation scenarios, four simulation verifications in total.

5.1 Basic Simulation Parameter Settings

The location of BSS main channel is 36, and STA number is 3 in each AP. The transmission bandwidth is 40 MHz in Fig. 5, and 80 MHz in Fig. 7. The traffic is saturated. Other simulation parameters are shown in Table 2.

Table 2. Simulation parameter

Simulation Parameter	Value	Simulation Parameter	Value
Protocol mode	IEEE 802.11ax [24]	UL/DL	UL
Transmission Mode	SU	AMSDU	7
TX Power (initial)	15dBm	AMPDU	21
TXOP(Yes/No)	Yes	CW_{min}	15
RTS/CTS(Yes/No)	Yes	CW_{max}	1023
NSS Number	2	SIFS	16us
Traffic Type	BE	DIFS	43us
ED (initial)	40 MHz: -72 dBm 80 MHz: -62 dBm	Data Rate(DL)	0
CS (initial)	40 MHz:-79 dBm 80 MHz: -76 dBm	Data Rate(UL)	1e9

5.2 Simulation Scenario Setting and Analysis

(1) 40 MHz-3AP simulation scenario

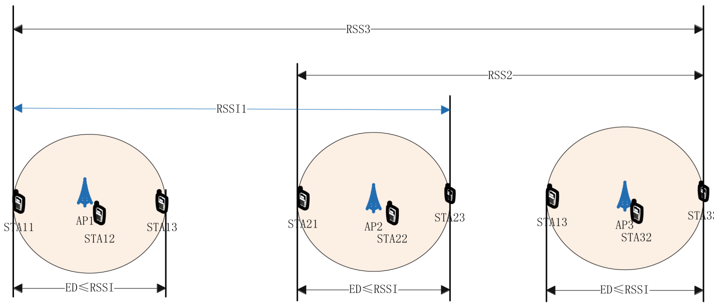


Fig. 5. 40 MHz-3AP Simulation scenario

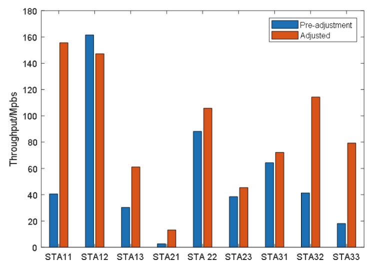
In Fig. 5, two different AP distance and BSS radius are set to make RSSI perceived by stations between BSSs different in Table 3 and 4. In Table 3 and (a) of Fig. 6, BSS radius is 6 meters (m), and AP's distance is from about 26 m to 60 m. In Table 4 and (b) of Fig. 6, BSS radius is 8 m, and AP's distance is from about 40 m to 90 m. The simulation results as shown in Fig. 6.

Table 3. 3AP-Radius(6m)-RSSI.

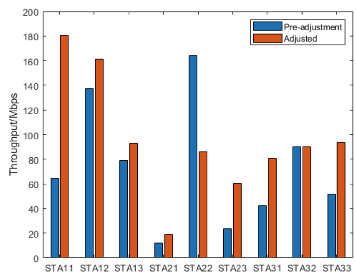
RSSI	Pre-adjustment	Adjusted
RSSI1	ED ≤ RSSI1; CS<RSSI1<ED	ED ≤ RSSI1
RSSI2	ED ≤ RSSI2	ED ≤ RSSI2
RSSI3	CS<RSSI3< ED	ED ≤ RSSI3

Table 4. 3AP-Radius(8m)-RSSI.

RSSI	Pre-adjustment	Adjusted
RSSI1	CS<RSSI1<ED	ED ≤ RSSI1
RSSI2	ED ≤ RSSI2; CS<RSSI2 <ED	ED ≤ RSSI2
RSSI3	RSSI3 < CS	ED ≤ RSSI3



(a) BSS radius = 6m



(b) BSS radius = 8m

Fig. 6. 40 MHz-3AP-Throughput Comparison

In Fig. 6, the overall throughput of each BSS has increased after adjustment, especially the throughput of edge BSSs. In (a) of Fig. 6, the throughput of each STA in the BSS is increased by from 12.4% to 438%, except STA12. Each STA's throughput in edge BSS is obvious (increased by 18.0% to 438%). The number of STA with decreased throughput decreases from 7 to 4, a decrease of 42.86%. In (b) of Fig. 6, each STA's throughput is increased by from 2.75% to 276%, except STA22. Each STA's throughput in edge BSS is obvious (increased by from 17.24% to 276%). The number of STA with decreased throughput decreases from 6 to 4, a decrease of 33.3%. And whether in (a) or (b) of Fig. 6, the number of edge STA with reduction throughput decreased from 6 to 4, a decrease of 33.3%.

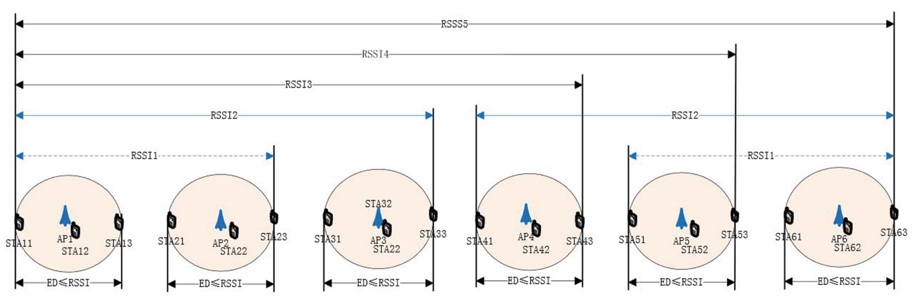


Fig. 7. 80 MHz-6AP Simulation scenario

(2) 80 MHz-6AP simulation scenario

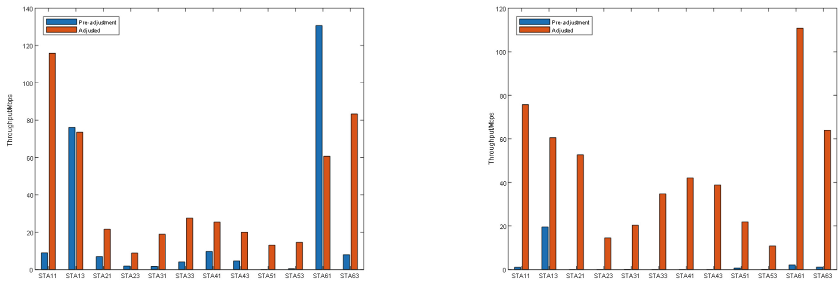
Table 5. 6AP-Radius(6m)-RSSI.

RSSI	Pre-adjustment	Adjusted
RSSI1	RSSI1 $\leq$ CS	ED $\leq$ RSSI1
RSSI2	RSSI2 $\leq$ CS; CS<RSSI2<ED	ED $\leq$ RSSI2
RSSI3	CS $<$ RSSI3 <ED	ED $\leq$ RSSI3
RSSI4	CS $<$ RSSI4 <ED	ED $\leq$ RSSI4
RSSI5	CS<RSSI5 <ED; RSSI5 $<$ CS	ED$\leq$RSSI5; RSSI5$\leq$CS

Table 6. 6AP-Radius(8m)-RSSI.

RSSI	Pre-adjustment	Adjusted
RSSI1	ED $\leq$ RSSI1; CS<RSSI< ED	ED $\leq$ RSSI1
RSSI2	CS $<$ RSSI2 <ED	ED $\leq$ RSSI2
RSSI3	CS<RSSI3<ED; RSSI3 $<$ CS	ED$\leq$RSSI3; RSSI3 $<$ CS
RSSI4	RSSI4 $<$ CS	ED $<$ RSSI4
RSSI5	RSSI5 $<$ CS	RSSI5 $\leq$ CS

In Fig. 7, two different AP distance settings are made to make RSSI perceived by stations between BSSs different in Table 5 and 6. In Table 5 and (a) of Fig. 8, the BSS radius is 6 m, and the distance between AP is about 17.5 m. In Table 6 and (b) of Fig. 8, BSS radius is 8 m, and the distance between AP is about 30 m. The simulation results as shown in Fig. 8.



(a) BSS radius = 6m (b) BSS radius = 8m

Fig. 8. 80 MHz-6AP-Throughput Comparison

In (a) of Fig. 8, edge STAs's throughput is increased by at least 2.6 times after adjustment, except STA13 and STA61. In (b) of Fig. 8, all edge STAs's throughput is greatly improved after adjustment, especially for almost starved edge STAs such as STA11, STA21, STA23, STA31, STA33, STA41, STA43, STA51, STA53, STA61, STA63.

(3) Simulation Analysis

After the ED threshold of the throughput reduction of edge STAs is lowered, the detection channel is more sensitive, which reduces the collision probability between the packets sent by the edge STAs and inter-BSS's STA, and improves the throughput. However, when the ED threshold of a STA is lowered, the STA's sending opportunities will decrease, which may lead to a decrease of STA's throughput. Therefore properly increasing the transmission power of the BSS can ensure that the sending opportunities of the BSS's edge STA will not decrease as much as possible, so as to improve the edge STA's throughput.

6 Conclusion

Aiming at the edge STA's throughput serious reduction caused by mismatch between ED threshold and reception sensitivity of multi-BSSs in highly dense scenes, this paper proposes a throughput increase protocol and method for edge STAs based on the joint dynamic adjustment of ED threshold and TXPower. Through the adjustment and optimization of the inter-BSS ED threshold and TXPower of some BSSs, edge STA's throughput is improved. According to the above simulation results, it can be seen that this method can better improve the serious throughput reduction edge STAs. The design of this protocol is simple. It can greatly improve the throughput degradation of edge STAs caused by mismatch between ED threshold and reception sensitivity in BSSs. It has a strong application prospect and value.

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