A study on transmission power control for wireless LAN under overlapping BSS environment

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Abstract: Recently, with the widespread use of wireless local area network (WLAN), many access points (APs) and stations (STAs) of WLAN are densely employed. Since the dense deployment of APs causes an overlapping basic service set (OBSS) environment which results in increased interference, the area spectral efficiency decreases. In this paper, in order to improve the area spectral efficiency under OBSS environment, we proposed a transmission power control scheme using an indicator issued from a neighbor AP. If the AP knows that the channel occupancy rate (COR) of OBSS is increasing by reporting from associated STAs, it issues an indicator, and other AP hearing the indicator change their transmission power accordingly. We evaluate the performance of the proposed scheme by computer simulation with different AP separations. Simulation results show the proposed scheme achieves high area spectral efficiency.

Keywords: wireless LAN, OBSS, transmission power control

Classification: Wireless Communication Technologies

References

[1] IEEE 802.11 Standard for Local and Metropolitan Area Networks, “Part 11: Wireless LAN medium access control (MAC) and physical layer (PHY) specifications,” IEEE Std. 802.11, Mar. 2012.

[2] IEEE P802.11axTM/D1.2, Draft Standard for Information Technology-Telecommunications and Information Exchange between Systems-Local and Metropolitan Area Networks—Specific Requirements. “Part 11: Wireless LAN medium access control (MAC) and physical layer (PHY) specifications,”
1 Introduction

Recently, wireless local area network (WLAN) [1] has become one of the major communication technologies with the increase of correspondence terminals. With the widespread use of WLAN, many access points (APs) and stations (STAs) of WLAN are densely employed. The dense deployment of APs causes an overlapping basic service set (OBSS) environment that brings an interference with each other. In the OBSS environment, multiple APs share the same frequency channel, and packet collision frequently occurs. Furthermore, the amount of available radio resources in each BSS reduces by sharing the resources. Although these problems can be avoided by arrangement of AP position, it is not practical because one user cannot manage the location of other user’s AP. For this reason, clear channel assessment (CCA) threshold control is considered in a next-generation wireless LAN standard IEEE 802.11ax [2] as a method of improving area-spectral efficiency in high-density environments. Raising CCA threshold enables spatial reuse of radio resources and improves space utilization efficiency. However, it is also necessary to adaptively control transmission data rate or the CCA threshold according to instantaneous signal-to-interference-and-noise ratio. Another way to improve the area-spectral efficiency is to control transmission power so that the amount of available resources in each BSS increases, i.e. channel occupancy rate (COR) of OBSS reduces. In this paper, we propose a transmission power control scheme using an indicator issued from a neighbor AP. If the AP knows the COR of OBSS increases, it issues the indicator, and other AP hearing the indicator change their transmission power according to their previous action. We evaluate the performance of the proposed scheme by computer simulation with different AP separations. Simulation results show the proposed scheme achieves high area spectral efficiency.

2 Issues of the conventional WLAN

IEEE 802.11 WLAN employs distributed coordination function (DCF) to make channel access based on carrier sense multiple access with collision avoidance (CSMA/CA). If there is other AP out of the detection range of an AP and there is an STA that is in the communication range of both AP, a hidden node problem occurs, and area throughput is degraded by frequent packet collision. On the other hand, if there are many APs and STAs within the communication range of each other, area throughput is degraded by sharing the same radio resources among them. Moreover, if transmission power is decreased so as to avoid falling into the
OBSS environment, area throughput may decrease because the transmission data rate of each link becomes low.

3 Overview of proposed scheme

To solve this trilemma, this paper proposes a transmission power control scheme using an indicator issued from a neighbor AP in order to reduce the amount of available resources in each BSS and to realize efficient sharing of radio resources among OBSS. We assumed a multi-BSS environment as shown in Fig. 1. In the proposed scheme, each STA periodically change its transmission power and then it measures COR of other BSSs, and it reports the measured COR to its associating AP. Each AP compares the maximum value of the reported COR ($\gamma_{\text{max}}$) with that in the previous measuring period ($\gamma_{\text{prev}}$). If $\gamma_{\text{max}}$ is higher than ($\gamma_{\text{prev}} + n$) where $n$ is a margin for avoiding a misjudgment due to measurement error, the AP sends the indicator to other AP. The detail for issuing the indicator is shown as Algorithm 1. Next, we explain the processing of transmission power control shown as Algorithm 2. If each AP receives the indicator, it carries out the opposite operation of the previous power control. (If it raised its transmission power and received the indicator, it reduces its transmission power in the next interval, and vice versa.) Otherwise, it makes the action in the previous interval again. As a result, the proposed scheme can reduce the COR of each BSS by raising the transmission rate with the aid of increasing transmission power when the distance of BSSs is small. On the other hand, the proposed scheme can avoid generating OBSS by reducing the transmission power when the distance of BSSs is large.

![Fig. 1. Overview of network configuration and proposed scheme.](image-url)
Algorithm 1 Judgment of indicator transmission to other AP

1: Input
2: \( \gamma_{\text{prev}} \): Maximum COR of previous measuring period
3: \( \gamma_{\text{max}} \): Maximum value of the reported COR
4: procedure
5: if \( \gamma_{\text{max}} \geq \gamma_{\text{prev}} + n \) then
6: Transmit the indicator to other AP
7: else if \( \gamma_{\text{max}} \leq \gamma_{\text{prev}} + n \) then
8: Do not transmit the indicator to other AP
9: end if
10: end procedure

Algorithm 2 Power control in AP

1: Input
2: \( P_t \): Transmission power [dBm]
3: \( P_i \): Power increase step [dB]
4: \( P_d \): Power decrease step [dB]
5: \( f \): Power control history of previous
6: procedure
7: if Indicator not received then
8: \( P_t \leftarrow P_t + P_i \); \( f \leftarrow 0 \)
9: else Indicator received
10: if \( f = 1 \) then
11: \( P_t \leftarrow P_t + P_i \); \( f \leftarrow 0 \)
12: else if \( f = 0 \) then
13: \( P_t \leftarrow P_t - P_d \); \( f \leftarrow 1 \)
14: end if
15: end if
16: end procedure

4 Performance evaluation

We have evaluated the performance of the proposed scheme by computer simulation using Riverbed Modeler ver. 18.5 [3]. Fig. 1 shows the assumed network configuration. There are 3 APs, and the distance between APs is set to 400 m (initially, in non-OBSS environment) or 125 m (always in OBSS environment). Moreover, in order to simplify the evaluation, STAs do not move. The propagation loss is subject to free-space propagation loss at a frequency of 2.4 GHz. The WLAN is based on IEEE 802.11n, and the transmission data rate is determined from the received power. The number of STAs in each BSS is 10. Each STA is randomly located within a radius of 125 m (in a communication range at a transmission power 0 dBm) from its associating AP. The packet size is set to 1500 bytes, which is the maximum Ethernet frame size, and only downlink traffic is assumed. In the paper, initial transmission power is set to 0 dBm, and the transmission power is changed every 5 seconds. It is increased by 1 dB and decreased by 1 dB or 3 dB. The power
margin \( n \) is set to 0.1 because this value gives a good performance for these simulation configurations in the preliminary simulation.

Fig. 2(a) shows the average throughput of the proposed scheme when the distance between APs is 400 m. Until 35 seconds (7 dBm), the average throughput is improved due to the increase of the transmission rate, and the OBSS does not occur. After 35 seconds, the average throughput is decreased because the OBSS occurs and APs share the radio resources. At this time, the average transmission power is also decreased as shown in Fig. 2(b). By this control, the OBSS is cleared and the average throughput is improved, and then this control is repeated. As a result, the proposed scheme improves the average throughput by about 1.8 times compared with the case of 0 dBm. The throughput performance of the proposed scheme with power decreasing by 1 dB is also shown in Fig. 2(c). The performance degrades compared with that with power decreasing by 3 dB. It implies that the optimal step of power change exists, and the optimization of transmission power-changing step (and the margin \( n \)) is left as future work.

![Fig. 2](image)

**Fig. 2.** Throughput performance of proposed scheme when distance between APs equal 400 m.

Fig. 3(a) shows the average throughput performance of the proposed scheme when the distance between APs is 125 m. In this evaluation, we have assumed APs are densely employed such as a railway terminal station and an airport lobby. In this case, the OBSS occurs since the start time of the simulation. In Fig. 3(b), the proposed scheme uses the higher transmission rate by increasing the transmission
power. Therefore, the proposed scheme improves the average throughput performance by about 5 times at the maximum compared with the case of 0 dBm by the decreasing of the COR. The performance of the proposed scheme with power decreasing by 1 dB and 3 dB are the same, because the proposed scheme does not decrease the transmission power under this condition. The reason why these results do not transition drastically is that the evaluation is Monte Carlo simulation, that is to say the timing at which the AP changes the transmission power differs due to the arrangement of the STAs.

![Graph](attachment:image.png)

**Fig. 3.** Throughput performance of proposed scheme when distance between APs equal 125 m.

## 5 Conclusion

In this paper, we have proposed the transmission power control scheme using an indicator issued from a neighbor AP in order to reduce the amount of available resources in each BSS and to realize efficient sharing of radio resources among OBSS. The simulation results shows that the proposed scheme improves the average area throughput performance with different AP separations. In the future, we will consider modifying our transmission power control scheme to keep the optimum power. Moreover, since the proposed scheme can be employed into multi-band WLAN [4], we will evaluate the proposed scheme for the multi-band WLAN.

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