Channel Assignment for Higher Throughput in Densely Deployed Personal Mobile Wireless LANs

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***Abstract*—This paper investigates Quality of Service (QoS) of personal mobile wireless LANs (m-WLANs). QoS characteristics in densely located WLAN are found to be significantly different from that in traditional WLANs. The channel assignment method is proposed and evaluated by using real devices to accurately evaluate the interferences for the total throughput of the densely located m-WLANs.**

Keywords—mobile WLAN, Interference, Channel

I. INTRODUCTION

Recently, personal mobile wireless LANs (called m-WLANs), which consist of light weight battery-operated mobile Access Points (APs) and a small number of connected personal devices or terminals such as smartphones, are becoming popular. When such WLANs are densely located, for example, in crowded meeting points, QoS parameter such as throughput of the m-WLAN could be degraded due to interference among multiple m-WLANs which share the same or adjacent channels. Effects of interference of multiple m-WLANs are similar with those of multi-hop or ad-hoc networks. In the m-WLAN, terminals reside closest to associated AP compared to APs which belong to different m-WLAN. Thus, capture effects and cumulative noise would dominantly effect on the QoS. Such inter-m-WLAN interference could be avoided by using different non-overlapping channels. In 2.4.GHz unlicensed spectrum, only three non-overlapping channels (channel number 1, 6 and 11) are available. For dense deployment of m-WLANs, performance degradation due to interference among m-WLAN is inevitable. Thus, we investigate QoS characteristics of densely located multiple WLANs for various combinations of channel usage including settable channels and fixed (non-settable) channels. Also, a preferable channel assignment is proposed for QoS improvement.

II. RELATED STUDY AND CONVENTIONAL TECHNOLOGY

A. Related Studies and Issues

In conventional fixed WLAN, AP is typically mounted at a fixed location, e.g., ceiling fan. To avoid performance degradation due to radio interference, channel assignment at APs became a significant part of a WLAN deployment planning. However, due to mobility of m-WLAN, interference map around mobile AP changes dynamically. This makes planned channel selection at AP challenging, especially in densely deployed WLANs. Studies of conventional wireless LAN channel assignment scheme have already been performed in a variety of environments, for example, [1]. However, personal mobile wireless LANs densely deployed have different characteristics in QoS [2]. There are two reasons for it. First, when data packets of multiple WLANs collide, packets are not error packets due to capture effect. As a distance among m-WLANs decreases and/or the number of m-WLAN increases, a degree of interference becomes stronger. Secondly, there are fixed-channel devices, where users cannot change channel number, for example, in some commercial mobile APs and tethering devices such as iPhone 4S.

In this study, results of performance evaluation for various channel assignments are introduced and preferable channel assignments are proposed for densely deployed WLANs with the fixed-channel devices.

B. Throughput Characteristics and Channel Distance

In dense deployment, m-WLANs bound to coexist on same channel or adjacent (overlapping) channel. As shown in [2], the only method which uses non-ovelapped three channels can obtain the maximum throughput in the 2.4GHz band. Since an AP and associated terminals of an m-WLAN reside in a very narrower range than APs of different m-WLANs, it is observed that channel distance between channels must be 4 or more (for example, channel 1 and 5) to avoid being overlapped in the experiments. That is, multiple m-WLANs mostly belong to the different carrier sensing domains in the case of the channel distance 4 or more. On the contrary, multiple m-WLANs mostly belong to the same carrier sensing domain in the case of the channel distance 3 or less.

C. Contention among WLANs in Overwrapping Channel

Let us assume that the channel distance among multiple m-WLAN is less than 3. In overlapping channels case, there are two reasons for reduction of throughput. First reason is frame errors due to collision between packets transmitted on same as well as adjacent channels. Second reason is that carrier is busy. A sender has to wait for a transmission opportunity when the sender detects carrier signals even though the carrier comes from different channels. Due to fading or other statistical factors, these two reasons effect on throughput characteristics between two channels. Reference [2] shows throughput is reduced more in the case of channel

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difference being 1, 2, and 3 than in 0. Therefore, it is better not to use adjacent channels but to use the same channel or non-overlapping channels. In practice, however, many WLANs that are densely located and include fixed channel WLANs have to use the same or adjacent channels.

The challenge is that controlling channel assignment to flexible channel WLAN could improve throughput performance. Assume that there are WLANs which use overwrapping channels, for example, channel 1 and 3. The interference between channel 1 and 3 can be reduce by appending a WLAN which uses channel 5. WLANs of channel 5 can suppress the activity in channel 3 by using channel 5. As a result, although total throughput of WLANs of channel 3 decreases, there is the possibility that the throughput of WLANs of channel 1 increases.

III. Proposal of Channel Assignment and Total Throughput Evaluation

A. Proposal of Channel Assignment

In this section, a channel assignment method is proposed based on the method mentioned above. If all WLANs are settable in their channel numbers, assignment is not so difficult because it is simply optimal to use non-overlapping three channels. Then, detailed channel assignment method will be explained for the case where several WLANs which have non-settable channels (called fixed-channels) and settable channels (called switchable-channels) in this paper.

The proposed method is based (a) on the channel distances that are used by fixed-channel WLANs and (b) on the numbers of WLANs of fixed- and switchable-channel, respectively. According to (a) and (b), six cases are categorized as shown in Figure 1. Figure 2 shows the proposed channel assignment for the corresponding cases.

B. Total Throughput Evaluation

Total throughput is defined as a sum of all WLAN throughputs. Total throughput is evaluated by using devices such as mobile APs and smartphones. Smartphones were located within several centimeters to their APs and sent saturated UDP traffic. Each AP has only one smartphone. IEEE 802.11g was used. Each WLAN was placed at lattice pattern with 1 meter distance to neighbor APs.

Results of cases (1) and (2) cases are obvious. For cases (3)-(4), one of the worst fixed-channel combinations is channel (4 and 8). Two sets of fixed-channel WLANs were assigned to channel 4 and 8, respectively, and the number of switchable-channel WLANs varied with 12, 5 and 2 sets, which correspond that 75, 55, and 33% ratio of numbers of switchable-channel WLANs over numbers of all WLANs, respectively in the evaluation.

Results show that assignment (3) achieved the best total throughput. For example, for 75% of switchable-channel WLAN, which corresponds to case (3), assignments (3), (5) and (x) were tried. In the assignment (x), each switchable-channel WLAN was evenly assigned to either channel 4 or channel 8. In the results, assignment (3) showed 25% better throughput than assignment (5) and (x).

For 55% of switchable-channel WLAN, which corresponds to case (4), assignment (4), (5) and (x) were also examined. The results showed that assignment (4) achieved a little bit better performance than assignment (5) or (x).

In the cases (5) and (6), 33% of switchable-channel WLANs were employed. Unfortunately, the results showed that very slight difference was obtained in total throughput between assignments (5) and (6).

By additional experiments, it was shown that it is important to categorize the cases into (3)~(6) by fractions of switchable-channel WLANs in order to obtain the largest throughput. For 0~50, 50~67 and 67~100% of switchable-channel WLANs, assignment (5), (4) and (3) was the best, respectively.

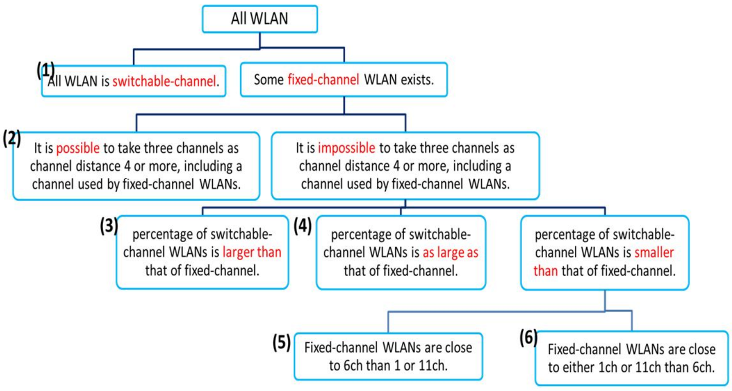

Figure 1. Six cases

(1)	All switchable-channel WLAN assign to channels of which channel 1, 6 and 11, and more WLANs assign to the channel 1 and 11 which is exist on the edge of the frequency.
(2)	In the state that fixed-channel WLANs using as it is and increase only WLANs of channels which is exist on the edge of the frequency.
(3)	Fixed-channel WLANs using as it is. And all switchable-channel WLAN assign to channels of which channel 1, 6 and 11. Number of the WLAN which uses channel 6 have larger than the number of fixed-channel WLAN. And, more WLANs assign to the channel which is exist on the edge of the frequency.
(4)	Fixed-channel WLANs using as it is. And all switchable-channel WLAN assign to channels of which channel 1, 6 and 11. More WLANs assign to the channel 1 and 11 which is exist on the edge of the frequency.
(5)	Switchable-channel WLANs use the channel used by fixed-channel WLANs. Or in the state that fixed-channel WLANs using as it is and, increase only WLANs of channel 1 or 11.
(6)	In the state that fixed-channel WLANs use as it is and, switchable-channel WLAN connect to channel that is distant from channel 6 as much as possible (so that channel distance between the fixed-channel WLAN and switchable-channel WLAN is maximum).

Figure 2. Assignment corresponding to the six cases

IV. Conclusion

In the case of densely deployed mobile WLANs which include some fixed-channel WLANs, a channel assignment which improves the throughput is proposed. By assigning switchable-channel WLANs to appropriate channels is proposed. Experiments by using real devices showed the proposed assignment achieved 25% improvement than other assignments in typical combinations of channels.

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