

A Novel Prediction Tool for Indoor Wireless LAN under the Microwave Oven Interference

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Abstract — In this paper, the coverage region of communication quality degradation would be indicated. The index of PER (UDP packet frame error rate) is employed to evaluate the communication quality and verify the prediction results. Moreover, by measuring the interference in terms of PER, the dependence of the microwave oven interference on the whole communication channels in the IEEE 802.11 DSSS wireless LAN card has been described. Particularly, the dependence of the UDP packet size on the communication quality under the microwave oven interference will be discussed.

Index Terms — Indoor wireless communication, UDP packet frame error rate, coverage prediction, local area network, IEEE 802.11 DSSS wireless LAN card.

I. INTRODUCTION

To maintain a high quality of communication in an Infrastructure network, the construction of one or more access points (AP) are necessary. For economic reasons and radio spectrum conversation, AP should be placed well to achieve the optimum coverage region for wireless communication. Nevertheless, optimum locations of AP are difficult to determine by the fact that indoor propagation losses are highly dependent on the architectural design of building, placement and composition of walls, and indoor partition and furniture arrangement. To obtain the suitable locations of AP, there have been the two methods of the ray-tracing technique [3] and the path loss model [1], [5] to compute the behavior of the radio wave in indoor surrounding. Recently. The investigation of the prediction techniques for wireless LAN under the interference of active sources, e.g. a microwave oven, have not been considered yet.

In this paper, a simple and practical methodology to predict the coverage region under the microwave oven interference and compute the coverage region of the interference is proposed for the first time. The index of PER was employed to evaluate the communication quality and verify the prediction results. Moreover, by measuring the interference effect in terms of PER, the dependence of the microwave oven interference on the whole communication channels in the IEEE 802.11 DSSS wireless LAN card has been described. Particularly, the dependence of the UDP packet size on the communication quality under the microwave oven interference will be discussed. Furthermore, two experiments were designed to verify the performance of this tool and then the characteristics of short computation time and high prediction accuracy were demonstrated.

II. MODELING OF MICROWAVE OVEN INTERFERENCE

In this paper, the effective interference radius model will be employed to predict the coverage region affected by the interference of microwave oven. The interference radius R under the interference of microwave oven can be expressed as

$$R = D - \sum_{i=1}^n W_i O_i \quad (1)$$

where D is the maximum interference radius evaluated by the index of PER under the microwave oven interference, n is the index of a specific wall or obstrucater composition, W_i represents the effective shrinking distance within the maximum interference radius D while the microwave signal passes through the i th wall or obstrucater, and O_i is the number of a specific obstrucater with the same composition along the radial direction between the microwave oven and the receiver.

Because the microwave is obstructed by walls, the region interfered by the microwave oven will be changed consequently. Parameter of n , W_i and O_i are dependent on the surrounding environment factors, and D is determined by the microwave oven. However, the effective interference radius model is characterized by the parameters of D and W_i ,

and these parameters will be discussed later.

To investigate the distribution of the spectrum, we recorded the spectrums of an operating microwave oven and the radio wave signal transmitted from the DSSS wireless LAN cards by using a spectrum analyzer. In this measurement, a normal residential microwave oven was utilized, and its oscillation frequency and rated microwave output power are 2450MHz and 750W, respectively. In addition, although there are several kinds of ISM-band wireless LAN, the typical system by using the DSSS scheme is considered in this measurement. Thus, we used two notebook computers which were connected by IEEE 802.11 DSSS wireless LAN cards and recorded the spectrum of the signal in different channels. Additionally, based on the IEEE 802.11 standard, the channels in the DSSS system are separated each other by 5MHz from 2412MHz to 2462MHz, as referred to Table . Fig.1 (a) and (b) show the background spectrum and the microwave leakage spectrum measured in the surrounding of the operating microwave oven. From Table 1, it can be found that the frequency bands of the microwave leakage and the DSSS wireless LAN cards are overlapping each other at some channels. Therefore, it was expected that the microwave oven interference would degrade the communication performance seriously at these channels.

In this section, the maximum oven interference imposed on the IEEE 802.11 wireless LAN card in terms of PER was characterized by determining the maximum interference radius D . When the microwave oven was operating, the UDP packets were sent consecutively by the transmitter(Tx) and then PER was recorded at the receiver(Rx). The UDP packet size was chosen as 400bytes. By increasing the length L which is the distance between the microwave oven and the receiver, we would observe whether the PER reaches to zero. If the condition was reached, it means that the receiver is located out of the interference coverage region which is obtained from maximum interference radius D . The measurement result is shown in Table 2. From this table, it has been found that the communication quality in channel 1 to channel 4 (2412MHz-2427MHz) are almost not affected by the micro-wave oven interference. In view of the other channels, the maximum interference radius for the microwave oven under the condition of the packet size of 400 bytes were obtained. In other words, the unaffected communication quality while operating beyond the maximum interference radius would be obtained. Among these channels, when channel 8 (2447MHz) is utilized to communicate, the interference region of an operating microwave oven would reach the maximum ($D=23m$).

Following the similar experiment scheme, a wall was located between a microwave oven and the receiver. In our experiments, the walls made of cement (c) and wood (w) have been considered, because these composition are common partition stuff in the indoor environment. Moreover, considering the worst case, channel 8 was selected to proceed this experiment. For the cases of the cement wall and the wood wall, the measured interference radius d_i are 17.2m and 21.8m, respectively. Comparing the values of D and d_i , the microwave interference distance is reduced because of the wall obstruction effect. The effective shrinking distance is defined as

$$W_i = D - d_i \quad (2)$$

Therefore, at this case, W_c and W_w are 5.8m and 1.2m, respectively.

By using channel 8 in the experiment, the transmitted packet sizes were varied from 100 to 400bytes in different cases, and the PER was recorded at receiver. The results are shown in Fig.2, while the packet size is smaller than 400 bytes, this result demonstrates that the communication quality is barely affected by the microwave oven interference. On the contrary, while that is larger than 400bytes, the phenomenon of interference becomes obvious. This is resulted from the periodic high level burst interference characteristic of the microwave oven. Hence, it is easy to be affected in communication quality if a larger packet size is chosen to transmit. As we know, although a smaller packet size would degrade the throughput, the interference effect generated by the microwave oven could be ameliorated.

IV. CONCLUSION

In this paper, the performance of the DSSS wireless LAN communication under the microwave oven interference was investigated. While a microwave oven was operating, the UDP packet signals were measured in different communication channels, which were generated from IEEE 802.11 DSSS wireless LAN card. Based on the index of PER, it was found that channel 1 to channel 4 were the unaffected communication channels under microwave oven interference. Moreover, the effect of packet size on communication quality was discussed. Because of the burst impulsive characteristic of microwave oven interference, the communication performance can be ameliorated by reducing the packet size. On the other side, we proposed an effective interference radius model to calculate the coverage region affected by the microwave

oven interference. According to this model, a novel prediction tool for wireless LAN under the microwave oven interference was proposed for the first time. After a simple parameter setting process, the coverage region subject to the microwave oven interference would be indicated by this prediction tool real time. Furthermore, from the verification results, it is demonstrated that this tool offers the advantages of high prediction accuracy. Owing to the serious interference property of a microwave oven, it is believed that this prediction tool should be very helpful in the design of an indoor wireless LAN.

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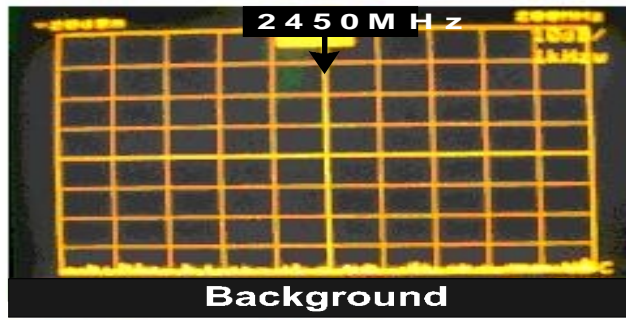
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Table 1 The frequency distribution of IEEE 801.11 DSSS wireless LAN card.

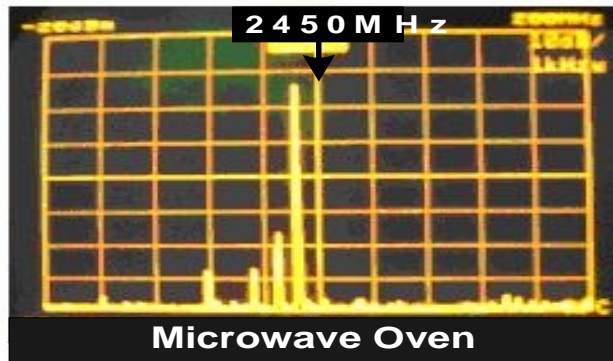
| Channel | Frequency |
|---------|-----------|
| Ch1 | 2412 MHz |
| Ch2 | 2417 MHz |
| Ch3 | 2422 MHz |
| Ch4 | 2427 MHz |
| Ch5 | 2432 MHz |
| Ch6 | 2437 MHz |
| Ch7 | 2442 MHz |
| Ch8 | 2447 MHz |
| Ch9 | 2452 MHz |
| Ch10 | 2457 MHz |
| Ch11 | 2462 MHz |

Table 2 The maximum interference radiuses D measured at different communication channels.

| Channel | D |
|---------|------------|
| Ch1 | unaffected |
| Ch2 | unaffected |
| Ch3 | unaffected |
| Ch4 | unaffected |
| Ch5 | 9 m |
| Ch6 | 20.5 m |
| Ch7 | 22 m |
| Ch8 | 23 m |
| Ch9 | 22.5 m |
| Ch10 | 22 m |
| Ch11 | 22 m |



(a)



(b)

Fig. 1 Measured spectrum in the surrounding of the operating microwave oven, (a) the background spectrum, (b) the microwave leakage spectrum.

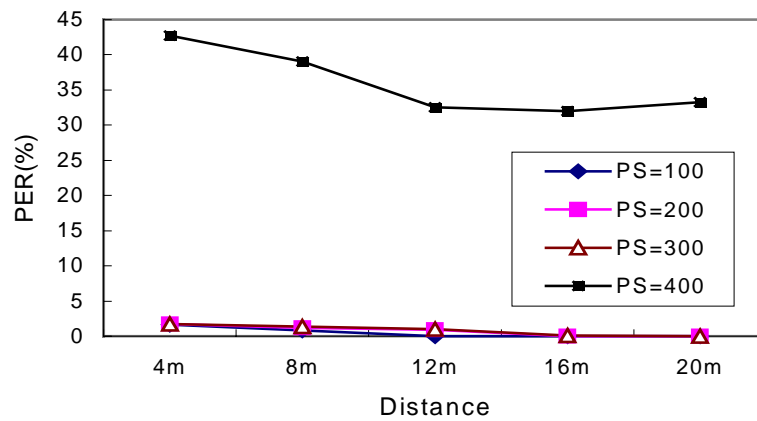


Fig. 2 The measurement results of PER under the different packet size (PS)