Comparison of Indoor Propagation Characteristics at 2.4 and 5 GHz for IEEE802.11n Wireless Local Area Network

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Abstract

In this paper, measurements of indoor propagation characteristics in the 2.4 GHz and 5 GHz bands are taken for commercial wireless local area network systems based on an IEEE802.11n standard. Comparison of these results helps you choose the best product for your site.

Keywords: Mobile network, IEEE802.11n, Indoor propagation, FDTD simulation.

1. Introduction

Recently commercial dual band wireless local area network (WLAN) products based on the IEEE802.11n standard operating in the 2.4 and 5 GHz bands are available [1]. The IEEE802.11n standard defines optional data rates of 130 Mbps in 20 MHz channel as the normal mode, and 300 Mbps in 40 MHz channel as the high-power mode [2]. Besides its wide range coverage includes multi-storey office buildings and whole residential houses. Site surveys concerned with communication environments and data transmission rates are useful to decide a minimum amount of equipment and optimal locations [3]. The IEEE802.11n standard adopts MIMO-OFDM [4] that improves the data throughput using many multipath channels in the environment. The references [5], [6] performed measurement campaigns to evaluate the performance of MIMO-OFDM in the various indoor environments. However it is not clarified whether the commercial WLAN system also has similar characteristics corresponding to those mentioned above or not because they are fabricated under the constraint of a cost performance and device compactness. In our previous works [7], [8] we carried out the measurement campaigns of commercial IEEE802.11n WLAN access point operating at 2.4 GHz in the two different office environments. As a result, it was shown that the data throughput was linearly proportional to the RSSI throughout all of measurements.

This paper compares indoor propagation characteristics in a residential house in the 2.4 and 5 GHz bands using two different commercial IEEE802.11n dual band WLAN access points. First, the organization of measurements and the evaluation method are shown. Next, characteristics depending on the operating frequency bands and the products are discussed based on the measured RSSI and throughput. Finally, conclusions are presented as well as future works.

2. Organization of Measurements

Figure 1 shows a setup of access point and measurement equipments. The access point is located on the desk beside the staircase. The commercial access points, APB and APN are IEEE802.11n devices based on the 2×2 MIMO-OFDM operating simultaneously at 2.4 and 5 GHz. The antenna elements of APB mounted on the circuit box radiate vertically polarized electric fields. On the other hand, APN includes two cross-polarized antenna elements inside of the case. In the experiment, we choose the 7th channel with the centre frequency of 2442 MHz and the W52 40th channel with the centre frequency of 5200 MHz. Moreover, two laptop personal computers (PC) are used in the measurements. One is a server PC connected to the access point by a 1000 Base-T
Ethernet cable. Another is a client PC linked to the access point by the IEEE802.11n wireless handset. As can be seen in these pictures, a plastic wagon is used to support the laptop client PC. These allow the measurements to be taken without a user near the measurement platform. An open source software, WiFi tool inSSIDer version 1.2.8 and iPerf version 2.0.5 are used in the measurements of RSSI profile and average throughputs, respectively.

3. Measurement Results

Figure 2 illustrates overhead views of a residential two-story house for measurement campaigns. Figures (a) and (b) correspond to the first and second floors, respectively. The circular marker represents observation points for RSSI and throughput. Their number is 21 and 18 for the first and second floors. And the route distances are 27.1 m and 30.1 m for the first and second floors, respectively.

3.1 Measured and Calculated RSSI Profiles

Figures 3 and 4 depict the measured RSSI profiles in the two different floors for APB and APN where the markers and lines denote results of measurement and calculation, respectively. As can be seen from Fig. 3, the similar RSSI profiles are measured and calculated for APB in the two different frequency bands. Its reason is derived from the antenna elements attached on the top of the circuit board. In the case of APB, RSSI at 5.2 GHz is a little higher than that at 2.4 GHz in the first floor that is thought to be almost line-of-sight. On the contrary, an opposite characteristic is observed in the second floor that is thought to be non-line-of-sight. In the case of APN in Fig. 4, RSSI at 2.4 GHz is higher than that at 5.2 GHz. Since the antenna elements are included inside of APN, their interactions with the circuit board can not be ignored. So it is thought that their radiation characteristics are deteriorated in the higher frequency band of 5.2 GHz. On the other hand, it is concluded that the similar RSSI profiles are obtained in both of the normal and high-power modes for the two different access points. Additionally the calculation results agree well with measurements and are useful to estimate RSSI distributions.

3.2 Measured Throughput

Figures 5 and 6 show the relationships between RSSI and average throughput of APB and APN where Figs. (a) and (b) depict results measured in the frequency band of 2.4 and 5 GHz. The constant buffer length of 64 kB and the two different window sizes of 64 kB and 256 kB are assumed for all cases. The relationships between RSSI and average throughput distribute almost along the straight lines. Moreover, the high-speed data transmission is realized by APB because APB always achieves higher average throughput for the specified RSSI than APN.
Figure 3: RSSI Profiles for APB in the First Floor (a) and the Second Floor (b).

Figure 4: RSSI Profiles for APN in the First Floor (a) and the Second Floor (b).

Figure 5: Relationships between RSSI and Throughput for APB at 2.4 GHz (a) and 5.2 GHz (b).

Figure 6: Relationships between RSSI and Throughput for APN at 2.4 GHz (a) and 5.2 GHz (b).

The measured maximum throughput is 80 Mbps for APB and 55 Mbps for APN, respectively. Additionally APB achieves RSSI of more than -65 dBm and throughput of more than
35 Mbps in all cases. Compared with APB, APN does not offer sufficient WLAN properties because its antenna elements are put inside of the plastic case and have an orthogonal polarization for each other. The discussion mentioned above is confirmed from the fact that there are no remarkable differences between throughputs in the normal mode and the high-power mode.

4. Conclusions and Future Work

The WLAN system based on the IEEE802.11n standard obtain significant higher data rates and increase range performance at the same time by using MIMO-OFDM. However commercial WLAN systems are fabricated under considering the market forces pushing for low cost, miniaturization and communication performance. So it is important to understand previously their properties in various communication environments by the site survey or numerical simulations.

The paper discusses the indoor propagation characteristics of the two different commercial dual band WLAN access points based on the IEEE 802.11n standard operating at 2.4 and 5 GHz simultaneously. Two different dual band IEEE802.11n wireless access points are compared each other for the various parameters, for instance the frequency band, the communication mode and the window size. All of measured indoor propagation characteristics support that RSSI and throughput have a high correlation and their relationship is probably approximated by a linear equation. And also FDTD calculations of indoor propagation characteristic are compared with the experimental results to confirm their validity.

References


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