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On the Performance Analysis of Coexistence between IEEE 802.11g and IEEE 802.15.4 Networks

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***Abstract*—**This paper presents an intensive measurement studying of the network performance analysis when IEEE 802.11g Wireless Local Area Networks (WLAN) coexisting with IEEE 802.15.4 Wireless Personal Area Network (WPAN). The measurement results show that the coexistence between both networks could increase the Frame Error Rate (FER) of the IEEE 802.15.4 networks up to 60% and it could decrease the throughputs of the IEEE 802.11g networks up to 55%.

***Keywords*—**Wireless performance analysis, Coexistence analysis, IEEE 802.11g, IEEE 802.15.4.

I. Introduction

WIRELESS communication technologies are available in several standards. They operate at the same unlicensed band called the industrial scientific and medical (ISM) band. It is interesting to study the coexistence impact between different wireless standards. Specially, in this paper we are interested in studying the coexistence between the IEEE 802.11g wireless local area network (WLAN) devices and the IEEE 802.15.4 wireless personal area networks (WPAN) devices. These devices operate at the 2.4 GHz ISM unlicensed band which categorized as 902 MHz, 2.4 GHz, and 5.725 GHz. Thailand allowed to use the frequency at 2.4 however, if we use WLAN and WPAN in the same area such as in the building the WLAN may degrade the performance of the WPAN. Conversely, WPAN possible alleviate the performance of WLAN because they maybe use the channels that overlapping each other. Fig. 1 shows frequency allocation of the IEEE 802.11g which has 11 channels each channel has 22 MHz of bandwidth and this standard has an overlap of adjacent channel. While, the IEEE 802.15.4 classified into 16 channels each channel has 2 MHz of bandwidth and none overlapping with an adjacent channels.

Several works have paid attention on studying the deployment of the wireless devices in the same area. A great number of research is a simulation [1], [2] whereas other research used an analytical model [3]–[5]. The authors in [1] developed Matlab/Simulink model to analyze the relationship between the bit error rate (BER) and signal to noise ratio (SNR) of IEEE 802.11g and IEEE 802.15.4 when varying the data rate and power. The authors in [2] utilized the Network simulation (NS2) to evaluate data successful rate and end-to-end delay of WLAN and Zigbee standard for inter vehicle communication. The authors in [3]–[5] use analytical model to analyzed packet error rate (PER) of the IEEE 802.15.4 devices. The authors in [3] considered model to obtain an estimation the packet error rate of Zigbee (IEEE 802.15.4) network using a Zigbee evaluation kit to measure the packet loss ratio whereas the authors in [4] evaluated the PER of IEEE 802.15.4 under IEEE 802.11b and/or IEEE 802.15.1 (Bluetooth) interferences which obtained from the bit error rate and the collision time. The authors in [5] suggested a packet length to reduce the effect of the IEEE 802.15.4 interference and obtain a maximum throughput of IEEE 802.11b.The authors in [6] proposed mathematical model based on Markov chain to analyze the operation of Zigbee (IEEE 802.15.4) devices under an interfered from IEEE 802.11 (WLAN) devices. The research examines the impact of collocated between the IEEE 802.15.4 presented in [7] which the authors observed that the coexistence between the device was impair if the packet was overlap. The traffic interference from IEEE 802.11g/n was measurement in [8] which is the authors indicated that the high level of network traffic interferences from the IEEE 802.11g/n is difficult to avoid because the increased channel bandwidth so the IEEE 802.11g/n have an impact on the performance of the IEEE 802.15.4.

While the contributions of the previous works are significant, the existing studies did not consider the coexistence between IEEE 802.15.4 and IEEE 802.11g in the same area from the actual experiment measurement.

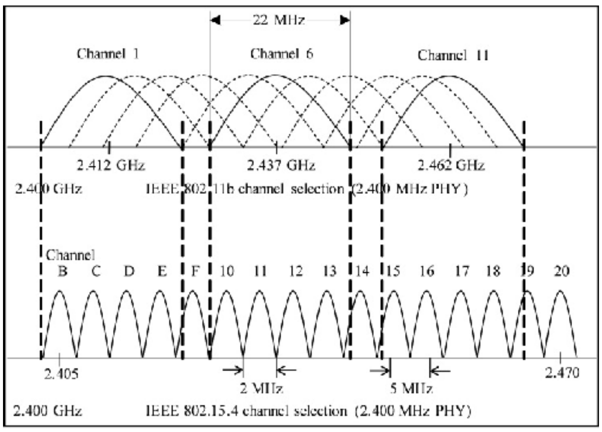

Fig. 1 Frequency channels of IEEE802.11g and IEEE802.15.4

In our paper we propose the performance analysis between the IEEE 802.11g and the Zigbee (IEEE 802.15.4) from the result experiment. The remainder of this paper is organized as followed. Section II provides the performance analysis for the

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IEEE 802.15.4. Section III presents the performance analysis for IEEE 802.11g. Finally, Section IV concludes the paper.

II. Effects of the Coexistence on IEEE 802.15.4

This section we present a study and analysis the effect of WLAN in the IEEE 802.11g on a performance of WPAN in the IEEE 802.15.4 when using both devices in the same area. In our experiment, we send 32 bytes of data frame sizes via the IEEE 802.15.4 network. We use Xbee-pro module transceiver to analyze the frame error rate (FER) that calculate from the accuracy percentage at different power level and channel in each experiment. Moreover, we consider the received signal strength at Xbee-pro device by considering the effect of noise and interference from the IEEE 802.11g. We distribute our experiment into two sub section. The 1st experiment we study an interference of WLAN to IEEE 802.15.4 that receive and transmit data in line of sight. The 2nd experiment we studying an interference of WLAN to IEEE 802.15.4 in the building that receive and transmit data in non-line of sight.

A. Line of Sight between IEEE 802.15.4

We use the result in this section to compare the efficiency of IEEE 802.15.4. We set the Xbee-pro module in the line of sight (LOS) which a distance of a transmitter Xbee-pro module and receiver are 5 meters. When the devices are transmitting and receiving data continuously we will consider two cases. The 1stcases, the transmitter Xbee-pro module which connect with computer notebook not have a communication via WLAN in the IEEE 802.11g. And the 2nd case, the computer notebook that connection with transmitter Xbee-pro module will download file 10 MB via WLAN which the Access point (AP) operate using channel 11 as shown in Fig. 2.

The result from the experiment from the 1st case shows that the received signal strength is -40 dBm and the frame errorrate equal 0 for all channels of Xbee-pro module.

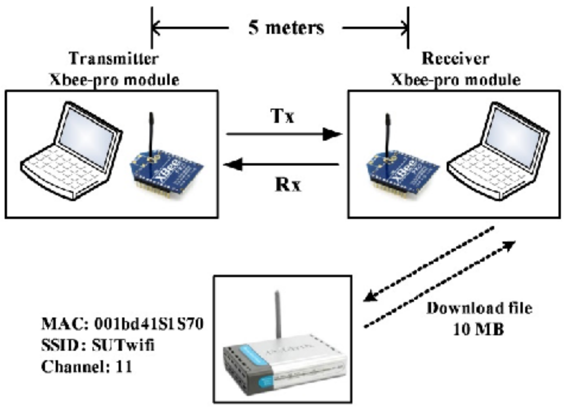

Fig. 2 Xbee-pro in a line of sight when using WLAN

In the 2nd case, the result shows that when we set up the Xbee-pro to use channel 15, 16, and 17 which overlap with the channel 11 of WLAN in the IEEE 802.11g. The signal strength that received at Xbee-pro is less than -40 dBm as shown in Fig. 3. The received signal strength is approximately -53 dBm if we set power level 1 to the transmitter Xbee-pro. However, the frame error rate will also equal 0 because even though the signal strength of Xbee-pro in the IEEE 802.15.4 will be degrade but this high value of signal strength could exceed the interference from the WLAN communication.

B. Non-line of Sight between IEEE 802.15.4

For the experiment in this sub section, we demonstrate in the building 70m 80min which there has the installation of the IEEE 802.11g overall the building. We test data transmission of the Xbee-pro module in the non-line of sight (NLOS) in which 45 meters between receiver and transmitter module. We classified the experiment into two cases. The 1st case no interference from WLAN and the 2nd case has interference from WLAN that operate by using channel 11 because of download data at transmitter Xbee-pro.

The results from an experiment shows that the data communication of the IEEE 802.15.4 in the non-line of sight is degrade when compare with the line of sight experiment at 5 meters distance between transmitter and receiver. In case no interference from WLAN the frame error rate is up to 20%. While in the case that has interference the frame error rate is mainly 60%.

In case of no interference from WLAN in which no download data file via WLAN. The result shows that the frame error rate occur if the Xbee-pro use a low power level transmission such as at power level 0 (10 dBm). This makes the frame error rate up to 20% but if we use the highest power level at power level 4 will make the less frame error rate as shown in Fig. 4.

Fig. 5 shows the result when it has an interference from WLAN in which the transmitter Xbee-pro module downloads file via WLAN when transmission data packets. The result reports that if the Xbee-pro module uses channel 15, 16, and 17 for transmission the frame error rate is up to 60% because these channels of Xbee-pro is overlap with channel 11 of WLAN. Whereas, if the Xbee-pro module use channel C which no overlapping with WLAN so not occurrence of the frame error rate.

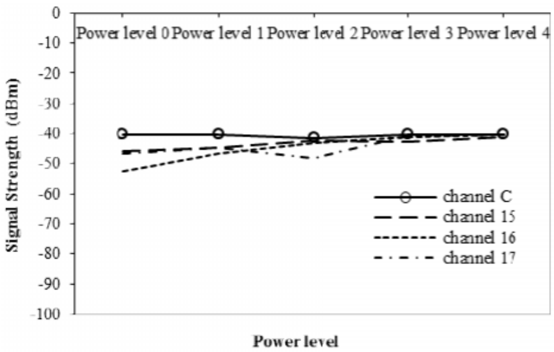

Fig. 3 Signal strength in a line of sight and interfered from WLAN

Figs. 6 and 7 show quality of signal for the IEEE 802.15.4

in a non-line of sight we can see that the signal strength is lower than -70 dBm. In case of no disturbance from WLAN if we use channel C the signal strength is between -80 to -70 dBm. When we use channel 15, 16, and 17 the signal strength is decrease equal -90 to -75 dBm as shown in Fig. 6.

Fig. 7 shows a similarly received signal strength but lower than Fig. 6 because the effect of an interference from WLAN when it use channel 15, 16, and 17 the signal is degrade equal -95 to -80 dBm.

III. Effects of the Coexistence on IEEE 802.11g Networks

This section we propose a study and analysis the effect of a data transmission of Xbee-pro module in the IEEE 802.15.4 on the working of WLAN in the IEEE 802.11g when we use both devices in the same area. In our experiment we set a transmitter Xbee-pro download file size 10 MB via WLAN which use channel 6 for operating to the users. When the Xbee-pro is downloading data we determine the Xbee-pro module using channel 11 at power level 18 dBm continuously transmission data at the same time. Then, we analyze an efficiency of WLAN through the throughput when the distance of Xbee-pro transceiver from Access point increases.

Fig. 8 reports a result of throughput when the distance increases. We can see that in case no interference from the IEEE 802.15.4 a throughput will decrease when the distance increases. In the case of the transmitter Xbee-pro modulenears the access point a throughput will decreases from 20 Mbps to 6 Mbps when the distance increases from 5 meters into 20 meters.

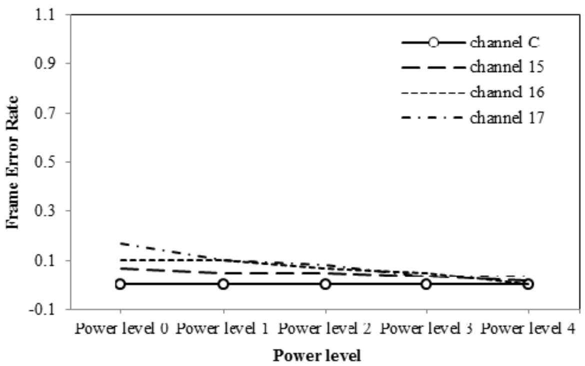

Fig. 4 Frame error rate of NLOS and not interfered from WLAN

When the WLAN has been disturb from a working of Xbee-pro module in the IEEE 802.15.4 which is operate near the access point of the IEEE 802.11g. The throughput decreases from 8 Mbps at 5 meters into 6 Mbps at 20 meters. In the case of the transmitter Xbee-pro module operates near the receiver Xbee-pro module that connect with computer notebook. A throughput is constantly equal 7 Mbps for all distances.

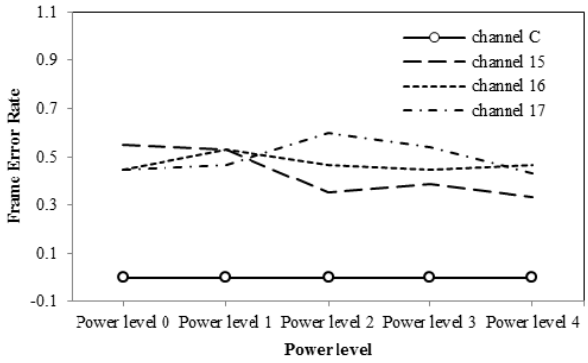

Fig. 5 Frame error rate of NLOS and interfered from WLAN

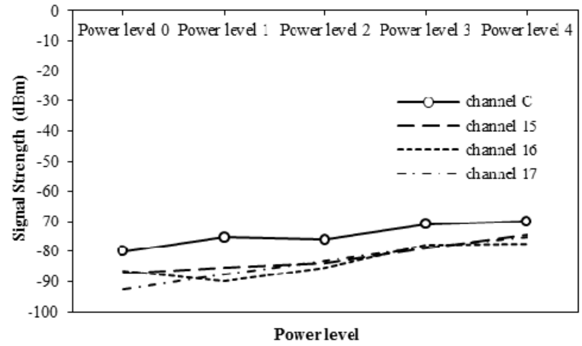

Fig. 6 Signal strength of NLOS and not interfered from WLAN

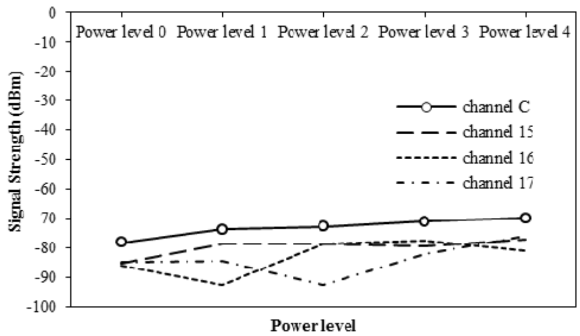

Fig. 7Signal strength of NLOS and interfered from WLAN

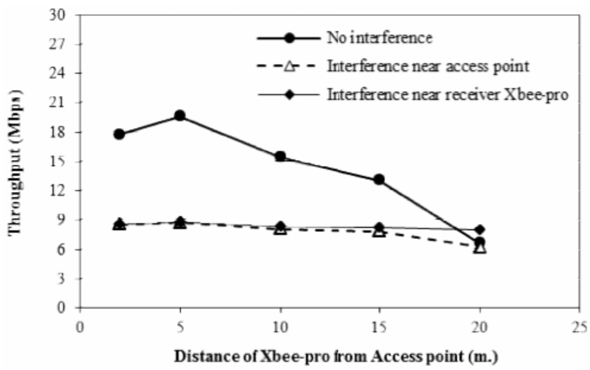

Fig. 8 Throughput of data communication via WLAN

IV. Conclusion

In this paper, the efficiency of wireless communication was investigated in case of coexistence between IEEE 802.11g and IEEE 802.15.4 networks. We observed the interference effects of IEEE 802.11g that could degrade the efficiency of data transmission in the IEEE 802.15.4 networks and conversely the IEEE 802.15.4 on the IEEE 802.11g networks. The measurement results experiment shows that the signal from the IEEE 802.11g networks could interfere the communication of the IEEE 802.15.4 when the both standard use an overlapping channel. However, if the range of data transmission is less than five meters, the overlapping channel does not cause the frame error in the IEEE 802.15.4 networks. But In case of the IEEE 802.15.4 transceiver is non-line of sight in which the distance is more 5 meters. The transmitting channel will influence to a quality of signal. When the IEEE 802.15.4 use channel frequency that overlap with the IEEE 802.11g the frame error rate will increase 60%. On the other hand, the IEEE 802.15.4 will degrade the quality of a data transmission of IEEE 802.11g when both networks use overlapping frequency channels. This results in decreasing the throughput of the IEEE 802.11g by 55%.

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