Energy Efficient Coexistence of WiFi and WiMAX Systems Sharing Frequency Band

Jongwoo Kim[1], Suwon Park[1], Seung Hyong Rhee[2], Yong-Hoon Choi[3], and HoYoung Hwang[4]

[1] Dept. of Electronics and Communications Engineering
[2] Dept. of Electronics Convergence Engineering
[3] Dept. of Information Control Engineering
[4] Dept. of Computer Engineering,
Kwangwoon University, Seoul, Korea
{jongwoo_kim,spark,rhee,yhchoi,hyhwang}@kw.ac.kr

Abstract. Various wireless communication systems in a shared frequency band such as 2.4GHz ISM band are operating. This causes the mutual interference among the wireless communication systems, and makes worse the performance of each of them. They should use more energy to achieve the desired quality of service. Many studies have been carried out to solve the mutual interference problem, called the coexistence problem. In this paper, we quantitatively analyze the effect of the mutual interference between Wi-Fi and WiMAX systems, and propose a method to solve the problem and evaluate its performance by simulation.

Keywords: Coexistence, mutual interference, power saving mode, PS-Request.

1 Introduction

To support various users' diverse services, various types of wireless communication systems are needed. Among the wireless communication systems, several wireless communication systems share a frequency band such as 2.4GHz industrial, scientific and medical (ISM) band. Well known wireless communication systems in the ISM band are WiFi as wireless local area network (WLAN) system, and Bluetooth and ZigBee as wireless personal area network (WPAN) systems. The coexistence in the shared frequency band causes mutual interference among the wireless communication systems, and makes worse the performance of each wireless communication system. Many researches have been carried out to reduce or avoid the mutual interference, so called coexistence problem. The coexistence of WiFi and Bluetooth systems is dealt in [1], [2] and [3], that of WiFi and ZigBee is done in [4], [5].

Recently, WiMAX subscribers at home or in office want to use high speed wireless internet service with low price or for nothing. As a result, WiMAX system is being considered as another candidate system operated in the ISM band. Because WiFi system is one of the popular wireless communication systems in the ISM band and is deployed in many indoor or outdoor places, WiFi and WiMAX systems sharing a frequency band may be operated in adjacent or the same area as shown Fig. 1. In that

T.-h. Kim et al. (Eds.): FGIT 2010, LNCS 6485, pp. 164–170, 2010.

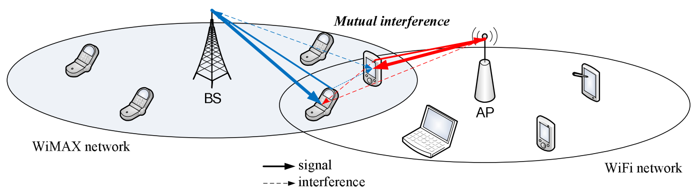

Fig. 1. Coexistence of WiFi and WiMAX system

case, they may interfere mutually. This may degrade the performance of each system such as frame error rate (FER), block error rate (BLER) or throughput. Consequently, many studies for coexistence of WiFi and WiMAX systems have been carried out to solve the coexistence problem. The studies are classified as two categories. One is how much interference is there between them [6][7], and the other is how to avoid or mitigate the mutual interference [8][9][10][11][12][13].

2 Proposed Solution

Fig. 2 shows a desiring time division operation (TDO) of WiFi and WiMAX systems.

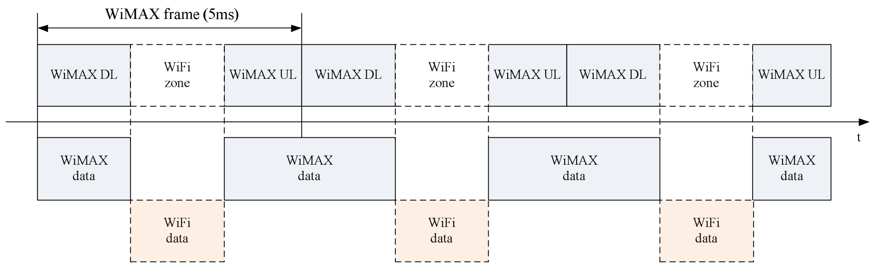

Fig. 2. Time Division Operation of WiFi and WiMAX Systems

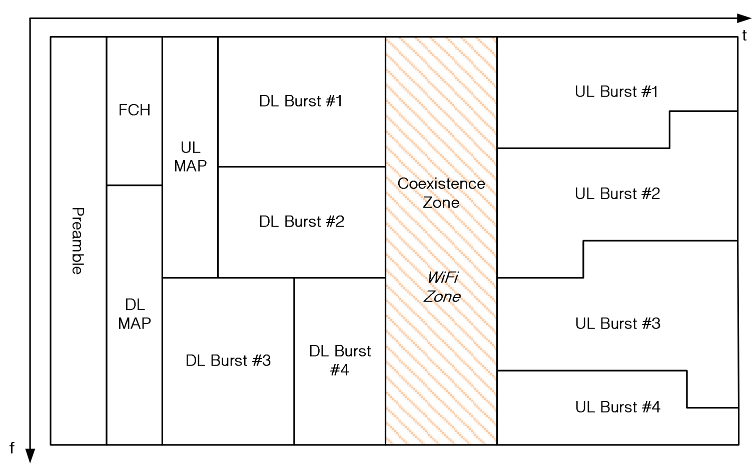

Fig. 3. WiFi transmission duration in WiMAX frame structure

For the TDO such as Fig. 2, the master system such as BS of WiMAX or AP of WiFi should control the transmission of its terminals. But conventional WiFi system can not control the transmission of STAs. Thus, we proposed a novel PS-Request protocol which makes the AP control the transmission of STAs [8]. It was based on use of vestigial power management bit within WiFi frame structure of access point (AP) which has not been used in the conventional power saving mode (PSM) of WiFi system, and coexistence zone such as WiFi zone shown in Fig. 3 was proposed for TDO of WiMAX and other systems. By using the proposed coexistence zone, the proposed PS-Request protocol guarantees the transmission duration of each system without the mutual interference. In this paper, the performance of the proposed one will be evaluated by computer simulation.

3 Simulation and Result

We allocate the transmission duration to each system as shown in Fig. 3. We assume that the transmission duration of WiFi system is 1.8432ms, and that of WiMAX system is 2.9952ms. The transmission duration is allocated based on the OFDM symbol duration of WiMAX system.

3.1 Simulation Conditions

Table 1 shows used parameters for computer simulation.

Table 1. Simulation parameters

	WiMAX	WiFi
Bandwidth(MHz)	8.75	20
Sampling Frequency	10	20
Over-sampling Ratio	2	1
Extended Sampling Frequency (MHz)	20	20
FFT Size	1024	64
Subcarrier Allocation	PUSC	-
Pulse Shaping Filter	Raised Cosine (Roll-off factor=0.25)	Raised Cosine (Roll-off factor=0.25)
Channel Coding	Convolutional coding (R=1/2, K=7)	Convolutionalcoding (R=1/2, K=7)
Modulation	QPSK	QPSK
Subcarrier Space (kHz)	9.765	312.5
Channel	AWGN	AWGN
Allocated Time Interval	2.9952 ms	1.8432 ms

3.2 Simulation Results

Higher SIR (Signal-to-Interference Ratio) in the figures means that at the interferee, average received signal power for the interferee is relatively larger than the average received interference power from the interferer. The relative quantity of interference is inversely proportional to the SIR shown in the legend of the figures. "without interference" in the legend is equivalent to SIR = ∞ dB.

Fig. 4 and 5 shows the performance of WiMAX and WiFi systems not using the proposed PS-Request protocol, respectively.

Fig. 4 shows the throughput vs. received E_b/N_0 of WiMAX system under the interference from WiFi system sharing the same frequency band. The noise spectral density N_0 in the received E_b/N_0 does not contain the interference for separately analyzing only the effect of the interference. For simplicity, it is assumed that WiMAX system consists of one BS and one MS, and all of the radio resources are allocated to the MS.

Fig. 5 shows the throughput vs. received E_b/N_0 of WiFi system under the interference from WiMAX system sharing the same frequency band [14].

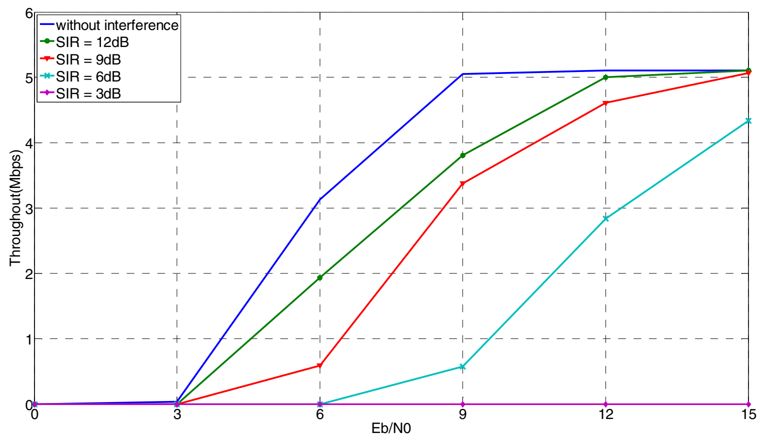

Fig. 4. WiMAX Throughput (Intereferee = WiMAX, Interferer = WiFi)

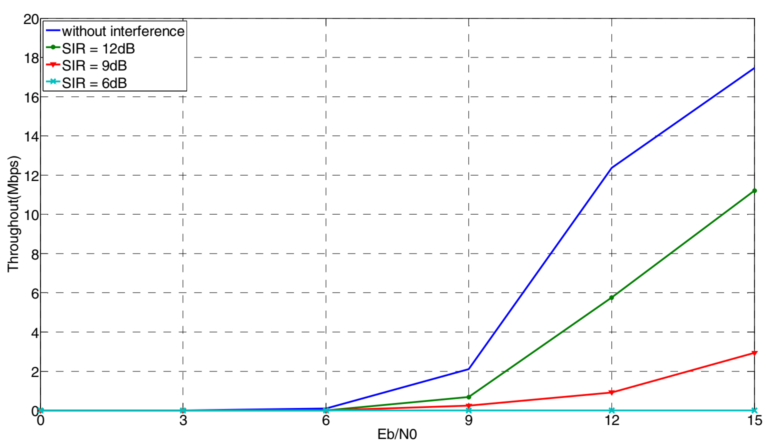

Fig. 5. WiFi Throughput (Intereferee = WiFi, Interferer = WiMAX)

Fig. 6 and 7 show the performance of WiMAX and WiFi systems using the proposed PS-Request protocol, respectively.

Fig. 6 shows the throughput vs. received E_b/N_0 of WiMAX system under the interference from WiFi system sharing the same frequency band.

Fig. 7 shows the throughput vs. received E_b/N_0 of WiFi system under the interference from WiMAX system sharing the same frequency.

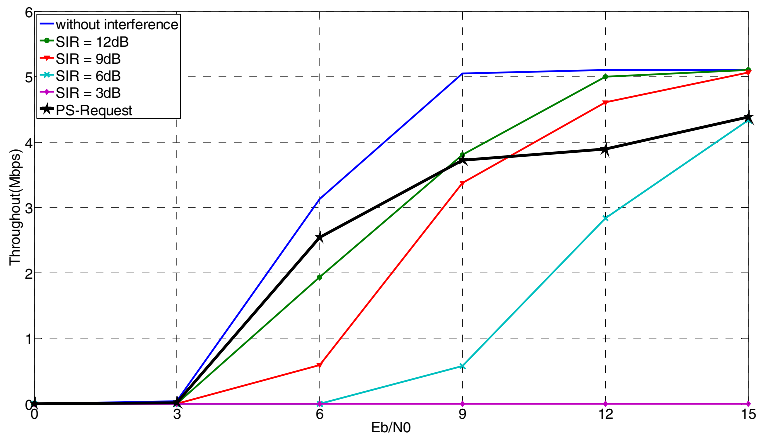

Fig. 6. WiMAX Throughput (Intereferee = WiMAX, Interferer = WiFi)

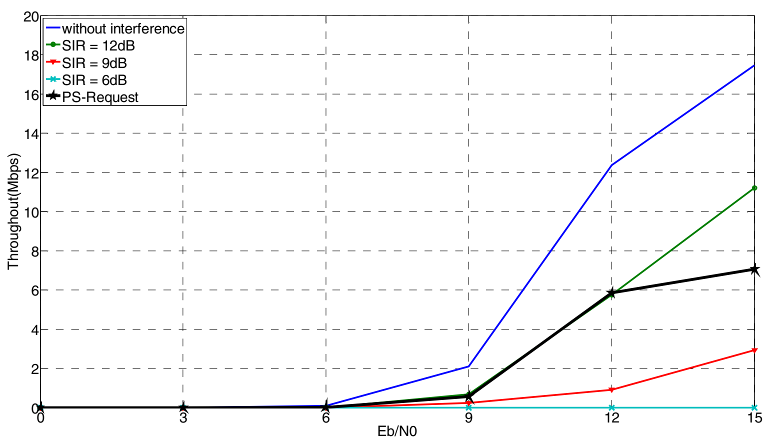

Fig. 7. WiFi Throughput (Intereferee = WiFi, Interferer = WiMAX)

The throughput of each system is decreased due to the mutual interference. Higher interference corresponding to smaller SIR causes smaller throughput for the same received Eb/No. As shown in Fig. 6 and 7, the proposed PS-Request based TDO has better performance in moderate or large level of interference environment. For small level of interference environment including interferenceless (without interference) environment, it can have worse performance because allowed transmission interval for each system can not be used by the other system.

4 Conclusion

In this paper, we evaluated the performance of the proposed PS-Request protocol using the vestigial power management bit of AP of WiFi system for the coexistence of WiFi and WiMAX systems in a shared frequency band by computer simulation. For smaller or zero interference environment, the proposed one can have worse performance such as smaller throughput because allowed transmission interval for each system can not be used by the other system. However, for smaller or zero interference environment, the proposed one can have better performance such as relatively higher throughput.

Acknowledgments. This work was partly supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2009-0086288), and the present research has been partly conducted by the Research Grant of Kwangwoon University in 2009.

References

1. Chiasserini, C.F., Rao, R.R.: Coexistence Mechanisms for Interference Mitigation between IEEE 802.11 WLANs and Bluetooth. In: Proceedings of INFOCOM 2002, pp. 590–598 (2002)
2. Glomie, N., Chevrollier, N., Rebala, O.: Bluetooth And Wlan Coexistence: Challenges And Solutions. IEEE Trans. Wireless Commun. 10, 22–29
3. Hsu, A.C.-C., Wei, D.S.L., Jay Kuo, C.-C.: Coexistence Mechanism Using Dynamic Fragmentation for Interference Mitigation between Wi-Fi and Bluetooth. In: MICOM 2006 (2006)
4. Sikora, A., Groza, V.F.: Coexistence of IEEE 802.15.4 with other Systems in the 2.4GHz-ISM-Band. In: Proceedings of IEEE Instrumentation & Measurement Technology Conference, pp. 1786–1791 (2005)
5. Yuan, W., Wang, X., Linnartz, J.-P.M.G.: A Coexistence Model of IEEE 802.15.4 and IEEE 802.11b/g. In: Philips research (2007)
6. Kim, J., Kim, D., Park, S., Rhee, S.H.: Interference Analysis of Wi-Fi System and WiMAX System in Shared Band: Interference from WiMAX System to Wi-Fi System. In: Proceedings of The 19 Joint Conference of Communication and Information (2009)
7. Kim, D., Kim, J., Park, S., Rhee, S.H., Kang, C., Han, K., Kang, H.: Interference Analysis of Wi-Fi System and WiMAX System in Shared Band: Interference form Wi-Fi System to WiMAX System. In: Proceedings of The 19 Joint Conference of Communication and Information (2009)
8. Kim, J., Kim, D., Park, S., Rhee, S.H., Han, K., Kang, H.: Use of Vestigial Power Management Bit within Wi-Fi Frame Structure of Access Point for Coexistence of Wi-Fi and WiMAX Systems in Shared Bands. In: Proceedings of The First International Conference on Ubiquitous and Future Networks, pp. 220–224 (2009)

9. Kim, D., Kim, J., Park, S., Rhee, S.H., Kang, C., Han, K., Kang, H.: Circulator-Based Collocated System for Coexistence of Wi-Fi and WiMAX Systems in Shared Bands. In: Proceedings of The First International Conference on Ubiquitous and Future Networks, pp. 214–219 (2009)
10. Berlerman, L., Hoymann, C., Hiertz, G.R., Mangold, S.: Coexistence and Interworking of IEEE 802.16 and IEEE 802.11(e). In: IEEE 63rd Vehicular Technology Conference, VTC 2006, vol. 1, pp. 27–31 (Spring 2006)
11. Berlerman, L., Hoymann, C., Hiertz, G.R., Walke, B.: Unlicensed Operation of IEEE 802.16: Coexistence With 802.11(a) in Shared Frequency Bands. In: IEEE 17th International Symposium Personal Indoor and Mobile Radio Communications, pp. 1–5 (2006)
12. Jing, X., Raychaudhuri, D.: Spectrum Co-existence of IEEE 802.11b and 802.16a Networks Using Reactive and Proactive Etiquette Policies. In: 2005 First IEEE International Symposium New Frontiers in Dynamic Spectrum Access Networks, DySPAN 2005, pp. 243–250 (2005)
13. Jing, X., Mau, S.-C., Raychaulhuri, D., Matyas, R.: Reactive Cognitive Radio Algorithms for Co-existence between IEEE 802.11b and 802.16a Networks. In: IEEE Global Telecommunications Conference, GLOBECOM 2005, vol. 5, pp. 2465–2469 (2005)
14. Kim, J., Park, S., Choi, Y.-H., Rhee, S.H.: Performance of Wi-Fi System due to Interference from WiMAX System in a Shared Frequency Band. In: Proceedings of The China-Korea Joint Conference on Information and Communications, JCIC 2010, pp. 103–104 (2010)