

Effective Method of Interference Mitigation for UWB Cooperation with WiMAX

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Abstract— This paper focuses on interference mitigation schemes capable of implementing to Ultra-wideband (UWB) device and their effects. In addition, the interference analysis's process and interference mitigation effect in results are described. UWB interference mitigation schemes were introduced to reduce the potential Ultra-wideband (UWB) interference to Worldwide Interoperability for Microwave Access (WiMAX) operating at 3.5GHz bands: One is the adaptive transmit power control (ATPC) and the other is the hybrid transmit emission control (HTEC) method. The analysis in order to evaluate the UWB inference mitigation effect used the simulation based on the system and the result evaluates WiMAX's total outage rate in percentile due to the UWB interference. In simulation results, a case of nothing of the interference mitigation was compared with a case of the interference mitigation of the ATPC or the HTEC method in spatially coexisting environment between UWB devices and WiMAX stations. Finally, the HTEC method in the proposed interference mitigation schemes was the best candidate because its interference mitigation effect was improved up to 82% rather than nothing of the interference mitigation in UWB devices

Keywords— UWB, Cooperation, Interference, Mitigation, Outage

I. INTRODUCTION

Ultra-wideband(UWB) signals widely spread out in the spectrum region. Actually, the frequency band of UWB communication application was assigned from 3GHz to 10GHz bands. And, Federal communications commission(FCC) limited UWB device's averaged emission up to - 41.3dBm/MHz Equivalent isotropically radiated power(EIRP). This reason was because primary services exist and are overlapped within the operation bands of UWB device. In this case, primary services must be protected from the potential UWB interference. Here, the UWB device is the secondary or unlicensed service. In this paper, our focus is how to protect the primary service. Currently, UWB emission in Korea was tightly restricted in order to protect primary services from the UWB interference. For example, the UWB device's emission should be reduced up to - 70dBm/MHz EIRP or less at from 3GHz to 5GHz bands. This value is less than the FCC provision of - 41.3dBm/MHz EIRP. However, this UWB transmission's limitation brought about the pessimistic conclusions that UWB devices could not support high bit rates because of the low transmission

power. To solve this problem, this paper suggested the interference mitigation schemes capable of implementing to UWB device. The proposed methods could help UWB device transmit higher power than FCC provision of - 41.3dBm/MHz EIRP: One is the adaptive transmit power control(ATPC) and the other is the hybrid transmit emission control(HTEC) method. The proposed HTEC scheme combined the proposed ATPC scheme and the generic duty cycle(GDC). Also, the considered primary service for the co-existing spatially and cooperation at the same bands is Interoperability for Microwave Access(WiMAX) operating at 3.5GHz bands. The analysis in order to evaluate the UWB inference mitigation effect used the simulation based on the system and the result evaluates WiMAX's total outage rate in percentile due to the UWB interference. In simulation results, a case of nothing of the interference mitigation was compared with a case of the interference mitigation of the ATPC or the HTEC method in spatially coexisting environment between UWB devices and WiMAX stations. Finally, the suggested UWB interference mitigation methods will be given to bring better UWB coexistence with WiMAX at 3.5GHz bands and support high bit rates.

II. WiMAX FEATURES

WiMAX system's features in [reference] have the orthogonal frequency division multiplexing(OFDM) and time division duplex(TDD) scheme. Key parameters are summarized as follows: the operating frequency is 3.5GHz bands. Other parameters are the channel bandwidth of 7MHz, OFDM FFT size of 256, the used data sub-carriers of 200, the frame length of 5msec, and modulation mode of adaptive modulation & coding rate(AMC). Adaptive modulation mode supports 1/2 BPSK, 1/2 QPSK, 3/4 QPSK, 1/2 16QAM, 3/4 16QAM, 2/3 64QAM, and 3/4 64QAM. Also, the target signal to noise ratio per each modulation mode is 6.4dB, 9.4dB, 11.2dB, 16.4dB, 18.2dB, 22.7dB, and 24.4dB, respectively.

III. INTERFERENCE MITIGATION

In this paper, UWB service's coexistence environment with WiMAX service was defined as follows: Firstly, both UWB devices and WiMAX stations operate at the same frequency of 3.5GHz. Secondly, UWB devices regard with interferers and a WiMAX station with the victim receiver. UWB devices

distribute uniformly around a WiMAX station in the middle of the analysis unit area of 1km^2 . Thirdly, UWB devices could control their transmit power through sensing and checking the detection on the WiMAX transmission signals. Above all things, ATPC or HTEC is implemented within UWB devices for the UWB interference mitigation to a WiMAX station.

For calculating the UWB interference impact to a WiMAX station, Equation (1) shows the received interfering UWB signal powers and Equation (2) means the received interfering single UWB signal power.

$$I = 10 \log_{10} \sum_{m=1}^M 10^{\frac{i_m}{10}} \quad (1)$$

In Equation (1), i_m in dBW/MHz depicts the received interfering single UWB signal power to a WiMAX station. M means the number of active multiple UWB devices.

$$i_m = PSD - PL + G_r + BW \quad (2)$$

In Equation (2), PSD in dBW/MHz means the UWB emission power spectral density, PL in dB depicts the median path-loss between a UWB interferer and a WiMAX station, G_r in dBi is the WiMAX station's antenna gain, and BW in dB in MHz depicts the WiMAX station's channel bandwidth. In this paper, WiMAX station has the protection ratio. In a WiMAX station, the protection ratio means the WiMAX's carrier to the noise plus the interfering UWB signal power ratio ($CNIR$). It is expressed as,

$$CNIR = \{C/N \cdot [N/(N+I)]\} = C/(N+I) \quad (3)$$

In Equation (3), C/N means the carrier to the noise power ratio in a WiMAX station. $N/(N+I)$ is rewritten as $1/(1+(I/N))$. Also, I/N means the interfering UWB signal power to WiMAX's noise power ratio and is called as the UWB protection criteria in WiMAX station. I means the total interfering UWB signal power as shown in Equation (1). The outage rate is counted when the received $CNIR$ is less than the minimum target $CNIR$.

Also, UWB emission could adaptively be controlled according to the strength of WiMAX transmission. Therefore, PSD in Equation (2) is controlled within the scope of the designated dynamic range in ATPC case, and within the designated GDC and the ATPC's dynamic range in HTEC case.

IV. RESULTS

Major simulation parameters for the analysis of UWB interference impact are summarized as follows: the analysis center frequency is 3.5GHz. The analysis radius for the interference evaluation is about 0.6km, which is a derived

value from the unit area of 1km^2 . The UWB interference to the WiMAX's noise level ratio (I/N) to WiMAX station is -6dB. This protection is called as the UWB protection ratio. A median path-loss model used the free space model except for the fading. Because, a worst case scenario was assumed that the communication link between UWB devices or the interference link between UWB devices and a WiMAX station is within line of sight. In this case, the UWB interference impact to WiMAX station might be maximized. In this assumed environment, the ATPC scheme run the UWB transmit power with switching over 3 step of the maximum or the signal or the minimum power within the range of from the minimum -71.3dBm/MHz EIRP to the maximum -41.3dBm/MHz EIRP. For the HTEC scheme, the individual UWB transmission is controlled by the hybrid method using the ATPC scheme and the GDC, too. Here, the GDC method used the on-off keying of 5%. In a result of UWB interference mitigation effect, the ATSC scheme's impact was compared with the HTEC's in coexisting environment spatially between a WiMAX station and UWB devices at the same frequency of 3.5GHz.

A. UWB interference mitigation effect on ATPC method

Figure 1 shows results of the WiMAX outage rate due to UWB interference impact. WiMAX's antenna gain is 0dBi in Figure 1(a) and 8dBi in Figure 1(b). This difference of WiMAX's antenna gain corresponding to interfering UWB signal's reception rate to a WiMAX receiver. As a result, interfering UWB signals in case of WiMAX antenna gain of 8dBi are much received to a WiMAX receiver rather than that of WiMAX's antenna gain of 0dBi. That is to say, higher WiMAX's antenna gain means higher UWB inference impact to WiMAX receiver. In this reason, the WiMAX performance due to the reception of strong UWB interference is degraded. Secondly, WiMAX outage rate corresponds to UWB density, which depicts the number of UWB devices per unit area of 1km^2 . As a mention above, the WiMAX performance is related to the reception of UWB interference through the WiMAX antenna. In addition to antenna gain above, UWB density is also an important factor for evaluating UWB interference effect. As shown in Figure 1, WiMAX outage rates were evaluated over UWB density from 1devices/ km^2 to 40devices/ km^2 . Figure 1 was shown that higher UWB density is higher WiMAX outage rate. Finally, evaluation results of WiMAX outage rates were compared UWB devices' case without ATPC scheme with the other UWB devices' case with ATPC coexisting spatially with WiMAXs operating at 3.5GHz bands. As an example, when WiMAX antenna gain is 0dBi and UWB density is 10devices/ km^2 , Figure 1(a) shows that WiMAX outage rate in UWB devices' case with ATPC was improved up to 23.7% rather than in UWB devices' case without any interference mitigation methods. Also, when WiMAX antenna gain is 8dBi and UWB density is 10devices/ km^2 , Figure 1(b) shows that WiMAX outage rate in UWB devices' case with ATPC was improved up to 46.2% rather than in UWB devices' case without any interference mitigation methods. In addition, the more WiMAX outage rates are high, the more ATPC help mitigate the effects of UWB interference.

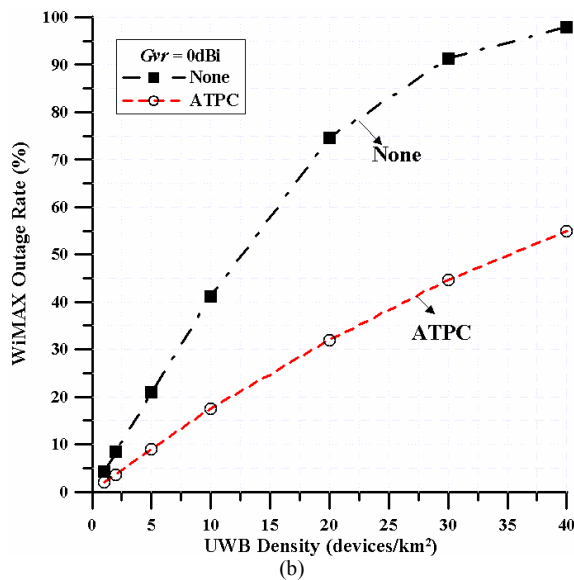
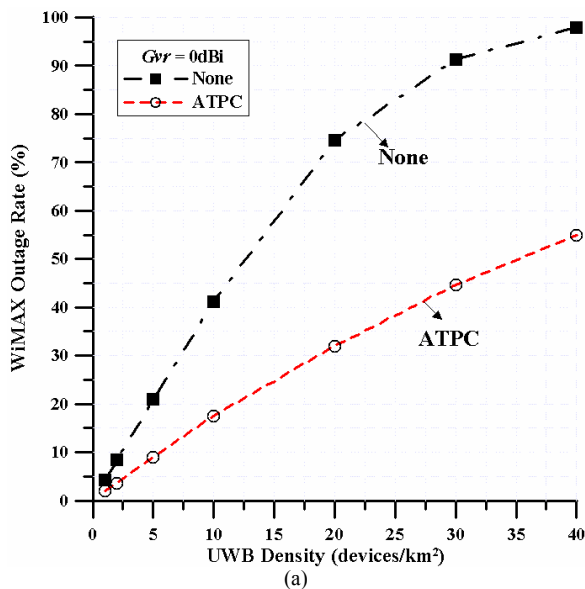


Figure 1. Results of the WiMAX outage rate due to UWB interference impact: (a) WiMAX's antenna gain of 0dBi, (b) WiMAX's antenna gain of 8dBi

B. UWB interference mitigation effect on HTEC method

Figure 2 shows results of the comparison on UWB interference mitigation effect between ATPC scheme and HTEC. As an example, when WiMAX antenna gain is 0dBi and UWB density is 10 devices/km², Figure 2(a) shows that WiMAX outage rate in UWB devices' case with HTEC was improved up to 16.5% rather than in UWB devices' case with ATPC method. And, WiMAX outage rate in UWB devices' case with HTEC was improved up to 40.2% rather than in UWB devices' case without any interference mitigation methods. Also, when WiMAX antenna gain is 8dBi and UWB density is 10 devices/km², Figure 2(b) shows that WiMAX outage rate UWB devices' case with HTEC was improved up to 36.3% rather than in UWB devices' case with ATPC methods. And, WiMAX outage rate in UWB

devices' case with HTEC was improved up to 82.5% rather than in UWB devices' case without any interference mitigation methods. In addition, the more WiMAX outage rates are high, the more HTEC help greatly mitigate the effects of UWB interference.

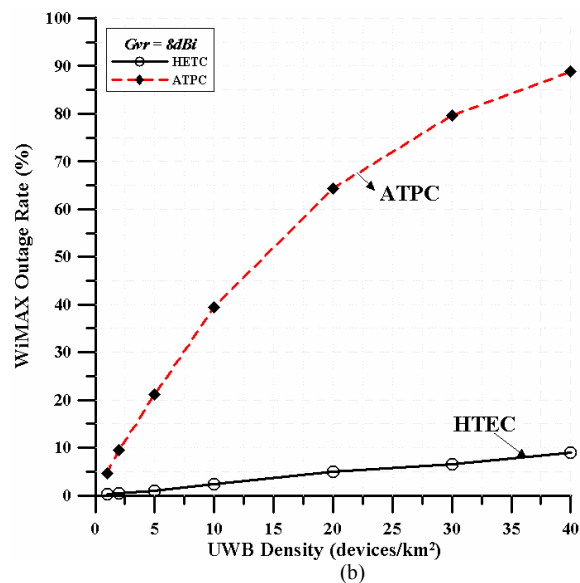
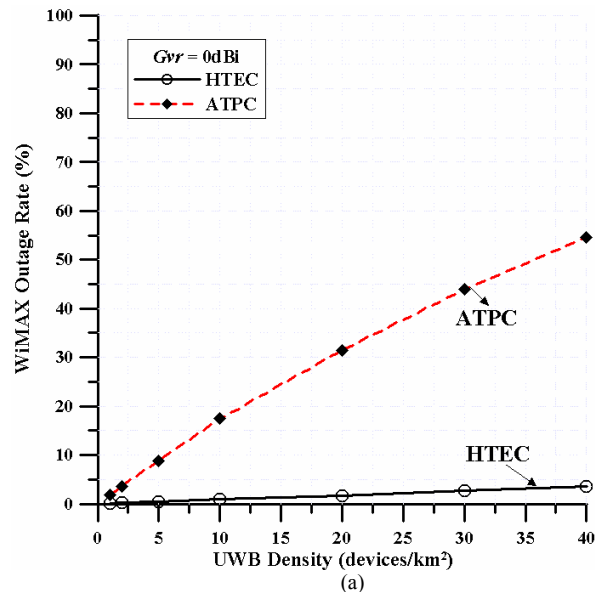


Figure 2. Results of the comparison on UWB interference mitigation effect : (a) UWB device's case with ATPC, (b) UWB device's case with HTEC

V. CONCLUSIONS

In this paper, the adaptive transmit power control(ATPC) and the hybrid transmit emission control(HTEC) method were suggested to reduce the potential Ultra-wideband(UWB) interference to Worldwide Interoperability for Microwave Access(WiMAX) operating at 3.5GHz bands. Results showed UWB interference effects according to UWB density or WiMAX's antenna gain. In evaluation, HTEC mitigation method was given to bring better UWB coexistence with

WiMAX using the frequency of 3.5GHz bands and higher averaged UWB emission power corresponding to the FCC provisional limit of - 41.3dBm/MHz EIRP.

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