A Study on the Effect of UWB Interference on Downlink UMTS System

Maan A. S. Al-Adwany
Department of Computer & Information Engineering, College of Electronics Engineering
University of Mosul
Mosul, Iraq
maanaladwany@yahoo.com

Ala'a B. Ali
Department of Computer & Information Engineering, College of Electronics Engineering
University of Mosul
Mosul, Iraq
Alaa.ali17@yahoo.com

Esra'a H. Najim
Department of Computer & Information Engineering, College of Electronics Engineering
University of Mosul
Mosul, Iraq

Amina M. Younis
Department of Computer & Information Engineering, College of Electronics Engineering
University of Mosul
Mosul, Iraq

Abstract- In this paper, we evaluate the performance of UMTS (Universal Mobile Telecommunication System) downlink system in vicinity of UWB system. The study is achieved via simulating a scenario of a building which is located within UMTS cell borders and utilizes from both UMTS and UWB appliances. The simulation results show that the UMTS system is considerably affected by the UWB interference. However, in order to battle this interference and achieve reasonable BER (Bit Error Rate) of 10^{-4}, we found that it is very necessary to carefully raise the UMTS base station transmitted power against that of UWB interferer. So, the minimum requirements for UMTS system to overcome UWB interference are stated in this work.

Keywords: UMTS, UWB, interference, simulation.

I. Introduction

Ultra Wideband (UWB) technology can be used for numerous commercial and military applications, including ranging, sensing, low-range networking and multimedia consumer products. In the networking and consumer fields, the technology is envisioned to reach the mass market, with a high density of UWB devices per home and office. The technology is based on the concept of transmitting a signal with very low power spectral density (PSD), while occupying a very wide bandwidth. In principle, the wide bandwidth offers the possibility of high data rates, in excess of 250 Mbps [1].

Understandably, the impact of UWB interference has recently been seen as a threat for existing or future radio systems. This raises the need for real co-existence studies to a high level. One particular area of interest is the impact of UWB interference on the UMTS system that is based on wideband code division multiple access (WCDMA) technique.

A. Literature Review

In order to have an insight into the effect of UWB interference on UMTS receivers, we see that it is convenient to present a detailed view on what have been written on this subject, sorted by date. In [2] and [3] (2003), the authors showed that practically; UWB system can coexist with UMTS terminal without causing dangerous interference. While in [4] (2004), the researchers reveal that UWB has considerable interference effects on UMTS, and that the additive noise models do not acknowledge these effects.

Also, some experimental trials on the coexistence of the UMTS system with an UWB device based on spread spectrum modulation have been performed in [5] (2005). In the considered scenario, the maximum UWB power level in the UMTS channel tolerable by a UMTS receiver is found to be in the range of -110 to -95 dBm; where beyond this value the BER of the UMTS receiver increases over 10^{-3}.

In [6] (2006), a severe performance degradation in UMTS link has been observed if a large number of UWB devices are simultaneously active close to the victim receiver. Also, similar results are revealed by [7] (2007).

In other research [8] (2007), the authors clarified that the UWB interference can be modeled as additive white Gaussian noise (AWGN). That is in contrast with the results shown before in [4]. Also, in [9] and [10] (2007), tests have been performed that show no significant degradation on UMTS performance when it coexists or interworks with UWB within the same device.

In [11] (2008), the authors demonstrated that, for the case of a single UWB transmitter, the UMTS can easily tolerate UWB interference when the UWB equivalent isotropically radiated power (EIRP) is −92.5 dBm/MHz or less for a distance between the UWB transmitter and the UMTS mobile of 1 m or higher. In other work [12] (2008), a conclusion is drawn that even for very large external UWB terminal densities there is almost no practical risk for UMTS receiver operations when the center frequency of the UWB interference is selected to be above 3.5 GHz.

Finally, in [13] (2009), the researchers illustrate that for the case of UWB co-transmission with WCDMA (or UMTS), the co-transmitted signals have minimal impact on each other, while the PER (Packet Error Rate) is hardly changed when the powers of the interference signals are increased.

However, from the previous literature review; we can note various conclusions about the effect of UWB interference on UMTS system, some of these conclusions are in agreement and others are in contrast.

In this paper, we will study and investigate the effect of UWB interference on UMTS downlink system, and how we can overcome this interference to get a good performance for UMTS.

Our paper is organized as follows: section II presents the interference scenario, while in section III, the simulation results are discussed. Finally, the conclusions are drawn in section IV.

II. The Interference Scenario

In this work, we simulate a scenario of a building which is located within UMTS cell borders and utilizes from both UMTS and UWB appliances. Hence, we will study the effect of UWB interference on the UMTS mobile phone receiver.

In this simulation, the distance between the UMTS base station and the mobile phone receiver is denoted as *R*. While the distance between the UWB transmitter and the UMTS mobile phone receiver is denoted as *d*.

It is worth to mention that the path loss models used in our simulation are: the vehicular test model for downlink UMTS, and the free space model for the effect of UWB on UMTS. Also, we adopt the BPSK modulation for the UMTS system.

III. Results and Discussion

In this section we will evaluate the performance of the UMTS downlink system in vicinity of UWB system. Fig. 1 shows the effect of the UWB interference on the BER (Bit Error Rate) of the UMTS mobile phone receiver for UMTS downlink channel with only path loss model. It is obvious that in general as *R* increases; the BER increases because as *R* increases; the received UMTS signal power decreases due to path loss which in turn reduces the UMTS signal power in relative to that of UWB interference and hence increasing BER. Also, we can note that for certain distance *R,* the BER decreases as the distance *d* increases. This is because as *d* increases; the UWB interference decreases which improves the UMTS performance. Furthermore, in order to achieve a target BER of 10^{-4}, the distance *R* must not exceed 350 m, and this target BER can not be achieved at large cell distances (i.e. *R*=400m ~ 600m).

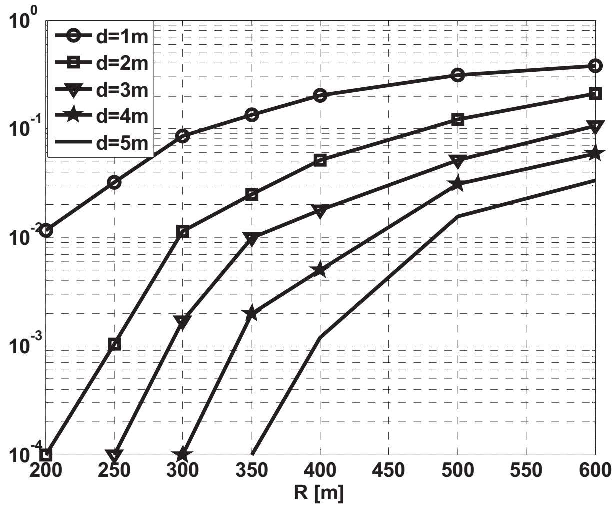

Figure 1. Effect of *R* on the BER of the UMTS mobile phone receiver for different values of *d*, and for downlink channel of vehicular test model.

However, for safe operation of UMTS system, it is necessary to ensure that the target BER is achieved till cell borders. So, in order to achieve this requirement, we need to increase the signal to interference ratio at the mobile receiver. This can be done by either raising the UMTS base station transmitted power in relative to that of UWB, or decreasing the UWB transmitted power in relative to that of UMTS. In both cases, the UMTS transmitted power must be larger than that of UWB by certain amount, say *K*; where:

K= UMTS base station transmitted power [dB]-UWB transmitted power [dB]

Note that *K* does not equal to the signal to interference ratio at the mobile receiver, but it does indicate to it.

Fig. 2 illustrates that in order to achieve the target BER at cell borders (R=600 m), we need to keep the values of *K* to be no less than 50 dB for *d*= 4m, and no less than 56, 60, 62 dB for *d*= 3, 2, 1m respectively.

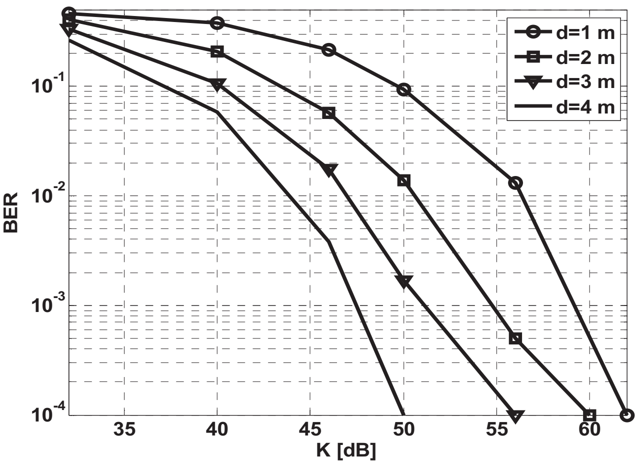

Figure 2. Effect of *K* on the BER of UMTS receiver for *R*=600m and for different values of *d*, and for downlink channel of vehicular test model.

Actually, in addition to path loss; the UMTS downlink channel may suffer from various channel impairments such as AWGN and multipath fading channels. So, it is convenient to study the effect of these channel impairments on the UMTS performance in vicinity of UWB interference.

However, in order to consider the worst case conditions; we will assume that the UMTS user is near cell border (*R*=600m); and it is very close to UWB interferer (*d*=1m). The effect of AWGN channel on UMTS mobile phone receiver is shown in fig. 3. It is worth to remember that the UMTS system is based on WCDMA technology which spreads the transmitted signal to shallow levels and it may be under noise level at the mobile phone reception side.

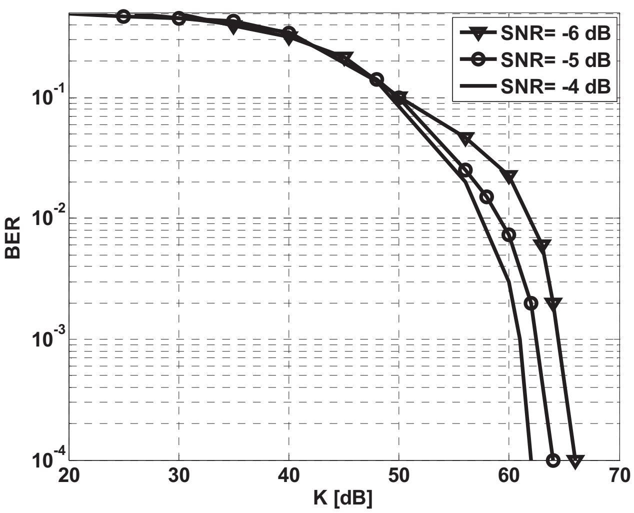

Figure 3: Effect of *K* on the BER of UMTS receiver for AWGN downlink channel, and for *R*=600m and *d*=1m.

TABLE 1 UMTS DOWNLINK CHANNEL CHARACTERISTICS

	Channel 1	Channel 2
SNR [dB]	20	7
Relative delay of received multipath signal [ns]	[0 976]	[0 260 521 781]
Average power of received multipath signal [dB]	[0 -10]	[0 -3 -6 -9]
Speed of terminal [km/h]	3	3
Number of Rake Receiver fingers that are used at the UMTS mobile phone receiver	2	4

From the figure, it is obvious that in order to achieve the target BER; the value of *K* must not be less than 62 dB for SNR=-4 dB, and also *K* must not be less than 64 dB and 66 dB for SNR= -5 dB, -6 dB respectively.

Moreover, the effect of multipath fading channels on UMTS downlink system is considered. Table 1 illustrates the characteristics of two multipath fading channels that are considered in our simulation.

However, the simulation results shown in fig. 4 illustrate that for multipath fading channels, the values of *K* that are required to achieve the target BER are generally larger than that for AWGN channels (see fig. 3). This is because the multipath fading channels have worse effect on UMTS signal comparing to that of AWGN channels. Also, we can note that for channel model 1; the required value of *K* to achieve the target BER is 81 dB, while only 70 dB is required for channel model 2. It is worth to note that in comparison with channel model 1, we can observe that channel model 2 is more contaminated by multipath components (see table 1), in despite of that; the required value of *K* for channel model 2 is less than that for channel model 1 !?. This can be interpreted as follows: in channel model 2; we used a Rake receiver at the UMTS mobile phone with four fingers, while only two fingers were used in channel model 1. So, as the Rake receiver utilizes from the multipath phenomenon to increase the received signal power, and improves the data reception, we expect that as the number of fingers is increased; the UMTS performance will be improved; and hence the required *K* to achieve the target BER will decrease.

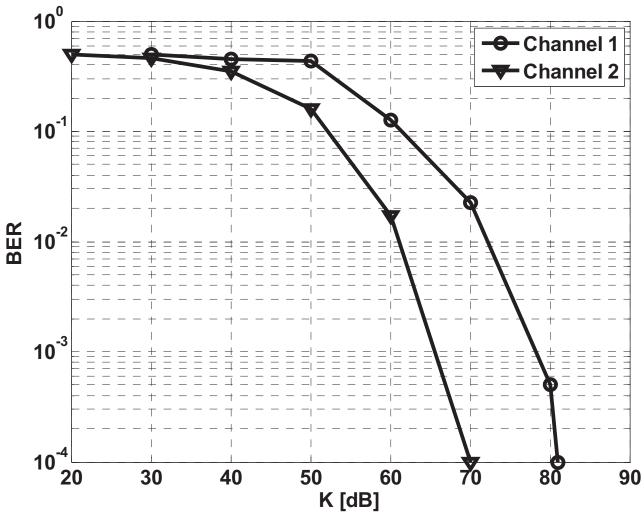

Figure 4. Effect of *K* on the BER of UMTS receiver for multipath fading channels, and for *R*=600m and *d*=1m.

IV. Conclusions

From the simulation results, we can conclude that in order to achieve a reasonable BER at the UMTS mobile phone receiver and overcome the UWB interference, we need to keep the UMTS base station transmitted power above that of UWB by considerable amount. We denoted this amount as *K* in units of dB. Then, we have determined the required values of *K* that ensure reasonable performance for UMTS system when it operates in vicinity of UWB system and for various channel models.

However, we expect that the stated values of *K* could help the designers to estimate the required UMTS transmitted power in relative to that of UWB that ensure good performance for UMTS system.

References

[1] Nader, G., Annamalai, A., "A Method for the Analysis of the Impact of UWB Interference on the Performance of UMTS Networks", 2nd International Symposium on Wireless Pervasive Computing (ISWPC'07),2007.

[2] R. Giuliano, F. Mazzenga, F. Vatalaro, "On the interference between UMTS and UWB systems", IEEE Conference on Ultra Wideband Systems and Technologies, 2003, pp. 339-343.

[3] R. Giuliano, G. Guidoni, F. Mazzenga, F. Vatalaro, "On the UWB coexistence with UMTS terminals", IEEE International Conference on Communications, Vol. 6, 2004, pp. 3571-3575.

[4] D. Barker, T. Norman, "A study of UWB emissions upon the UMTS WCDMA downlink power control", IEE Seminar on Ultra Wideband Communications Technologies and System Design, 2004, pp. 41-46.

[5] D. Cassioli, S. Persia, V. Bernasconi, A. Valent, "Measurements of the performance degradation of UMTS receivers due to UWB emissions", IEEE Communications Letters, Vol. 9 , Issue 5, 2005 , pp. 441 – 443.

[6] M. Hamalainen, J. Iinatti, I. Oppermann, M. Latva-aho, J. Saloranta, A. Isola, "Co-existence measurements between UMTS and UWB systems", IEE Proceedings-Communications, Vol. 153, Issue 1, 2006 , pp. 153 – 158.

[7] G. Nader, A. Annamalai, "A Method for the Analysis of the Impact of UWB Interference on the Performance of UMTS Networks", 2nd International Symposium on Wireless Pervasive Computing, 2007, pp. 109-114.

[8] G. Nader, A. Annamalai, "Ultra Wideband (UWB) Interference on UMTS Receivers", 2nd International Symposium on Wireless Pervasive Computing, 2007, pp. 105-108.

[9] J. H. Pablo, J. C. Muniesa, I. A. Benede, M. G. Martin, B. M. Cuezva, R. Giuliano, "End-to-End Coexistence Tests in an Interworking UWB-UMTS Platform", 16th IST Mobile and Wireless Communications Summit, 2007, pp. 1-5.

[10] V. Rodriguez, F. Jondral, "Technical-Economic Impact of UWB Personal Area Networks on a UMTS Cell: Market-Driven Dynamic Spectrum Allocation Revisited", 2nd IEEE International Symposium on New Frontiers in Dynamic Spectrum Access Networks, 2007, pp. 585-596.

[11] B. T. Ahmed, M. C. Ramon, "On the Impact of Ultra-Wideband (UWB) on Macrocell Downlink of UMTS and CDMA-450 Systems", IEEE Transactions on Electromagnetic Compatibility, Vol. 50, Issue 2, 2008, pp. 406-412.

[12] Zeng Guang, F. A. Cassara, P. Voltz, "UWB interference on 3G UMTS terminals", IEEE International Conference on Ultra-Wideband, Vol. 3, 2008, pp. 197-200.

[13] Yong-Xin Guo, Viet Hung Pham, Ming-Li Yee, Ling Chuen Ong, " MB-OFDM UWB signal co-transmission with WCDMA, WLAN and GSM over multi-mode radio-over-fiber", IEEE MTT-S International Microwave Symposium Digest, 2009, pp. 209-212.