

Interference Effect of Adjacent IS-95 Network to LTE uplink Throughput

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1. Introduction

Cellular CDMA systems based on the IS-95 standard are commercialized and widely used in Korea. Recently, mobile broadband access providing outstanding user data rates gets reality within the next couple of years by the widespread deployment of OFDM based wireless technologies such as LTE and WiMAX [1, 2]. The interference between two WCDMA operators or WCDMA operator and IS-95 operator has been investigated [3,4]. In this paper, we are concentrating on the uplink throughput reduction of the LTE system when the LTE and IS-95 system are adjacent to each other and operated by different operators, assuming that the sites of two networks are independently located.

2. Interference Analysis Methodology

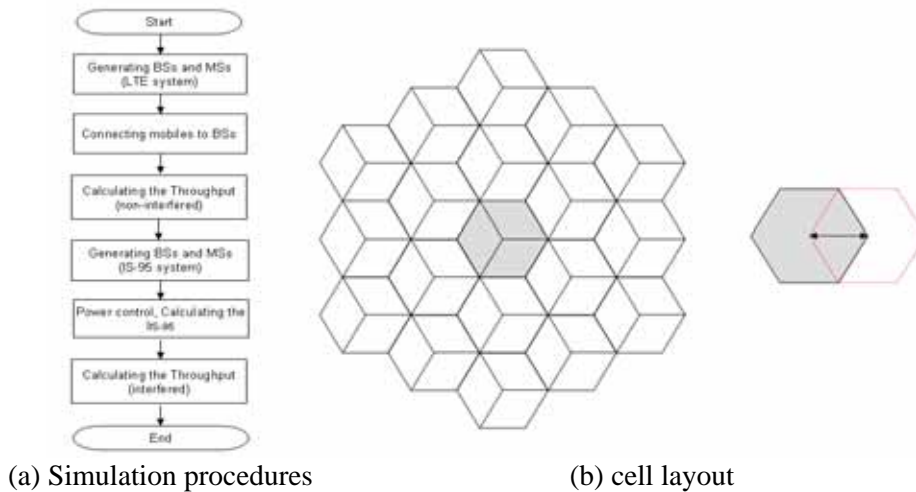


Figure 1: System level Monte-Carlo simulation procedures and cell layout

2.1 System Level Simulation

Figure1 illustrates the system level simulation procedures based on a Monte-Carlo for the interference analysis of the LTE uplink. In this simulation, we consider 2-tier deployment layout for both victim LTE system and interfering IS-95 system, with total of 57 sectors in 19 hexagonal cells[5]. Generate cluster of LTE 19 sites as like the cell layout in Figure1 and distribute mobiles uniformly throughout the entire cluster. Connect mobiles to base station having the smallest pathloss and assign the resource block to each user. And calculate SINR for mobile signal as receiving at its serving BS and the SINR value is defined as follows:

$$\begin{aligned}
 SINR(i) &= \frac{P_{TX_MS}(i) \cdot G_{MS}(i) \cdot G_{BS} \div PL(i)}{I_N + I_{INTRA/INTER} + I_{OTHER}} \\
 &= \frac{P_{TX_MS}(i) \cdot G_{MS}(i) \cdot G_{BS} \div PL(i)}{I_N + \sum_{k \neq i} P_{TX_MS}(k) \cdot ACIR(k) \cdot G_{MS}(k) \cdot G_{BS} \div PL(k) + \sum_{l} P_{TX_MS}(l) \cdot ACIR(l) \cdot G_{MS}(l) \cdot G_{BS} \div PL(l)}
 \end{aligned} \tag{1}$$

Where I_N is the thermal noise power for the systems, including also the noise figure of the base station receiver. $I_{INTRA/INTER}$ is the interference levels from the LTE-mobiles of the inter-cell and intra-cell. I_{OTHER} is the interference levels of the LTE base station from the IS-95 mobiles. It expresses the adjacent channel interference caused by other systems and due to the imperfect RF performance of radio transceivers. $P_{TX_MS}(i)$ and $P_{TX_MS}(k)$ are the transmitting power of the i -th LTE mobile and k -th LTE mobile. $P_{TX_MS}(l)$ is the transmitting power of the l -th IS-95 mobile. $PL(i)$ and $PL(k)$ are the path loss between the i -th LTE mobile and base station and vice versa, $PL(l)$ is the path loss between the l -th IS-95 mobile and reference base station. $G_{MS}(i, k)$ is the antenna gain of the mobile station and G_{BS} is the antenna gain of the reference base station and $G_{MS}(l)$ is the antenna gain of the l -th IS-95 mobile station. The Adjacent Channel Interference Power Ratio (ACIR) is used to describe the interference level generated by interfering system to victim system. In 3GPP, ACIR is defined as [6][7]

$$ACIR = -10\log(10^{-ACLR/10} + 10^{-ACS/10})dB \quad (2)$$

where ACLR is Adjacent Channel Leakage Ratio and ACS is Adjacent Channel Selectivity. After calculating the actual SNIR for each mobile, determine the obtained throughput for the mobile according to throughput calculation method, and calculate the sum of all mobile throughputs for reference base station. It is noted as the non-interfered throughput. And then generate cluster of IS-95 19 sites and distribute mobiles uniformly throughout the entire cluster. Connect mobiles to base station having the smallest pathloss and apply the CDMA power control algorithm. Then notes the transmit powers and positions of relevant mobile station and calculate the interference power level at the LTE base station from the IS-95 mobiles. After calculating the I_{OTHER} value, LTE throughput is again calculated and this is noted as the interfered throughput. The effect of interference can be difference between the non-interfered throughput and the interfered throughput.

2.2 Throughput Calculation

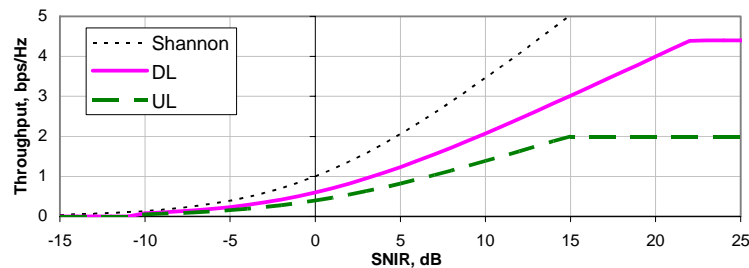


Figure 2: Throughput vs SNIR for LTE coexistence studies

In LTE co-existence studies, the system performance mainly concerns the throughput performance. Adaptive Modulation and Coding (AMC) is widely used in LTE system. In AMC technique, transmission data rate is decided among a data rate set, also called code set, according to the user's channel situations. Due to the employment of AMC technique, system throughput calculation is somewhat complicated. In current LTE co-existence studies, system throughput with AMC is approximated by an attenuated and truncated form of the Shannon bound [4]. Figure 2 demonstrates such approximating schemes. The throughput, which is the function of Signal to Noise plus Interference power Ratio (SNIR), is approximated by the following equation;

$$Throughput_{(bps/Hz)} = \begin{cases} Thr = 0 & SNIR < SNIR_{min} \\ Thr = \alpha S(SNIR) & SNIR_{min} < SNIR < SNIR_{max} \\ Thr = Thr_{max} & SNIR > SNIR_{max} \end{cases} \quad (3)$$

Where $S(SNIR) = \log_2(1 + SNIR)$ is the Shannon bound, α is the attenuation factor, which is approximated as slope to represent the implementation losses. $SNIR_{min}$ is the minimum target $SNIR$ corresponding to the chosen code set, Thr_{max} is the maximum throughput of the code set, $SNIR_{max}$ is the $SNIR$ value at which max throughput can be reached. Table 1 shows the parameters proposed for the baseline LTE DL and UL throughput calculation in co-existence studies.

Table 1: Link Level Performance for Co-existence Simulation

	DL	UL	Notes
α	0.6	0.4	attenuation
SNR_{min}	-10	-10	QPSK 1/8 rate (DL) & 1/5 rate(UL)

3. Simulation and Result

3.1 Simulation scenario and parameters

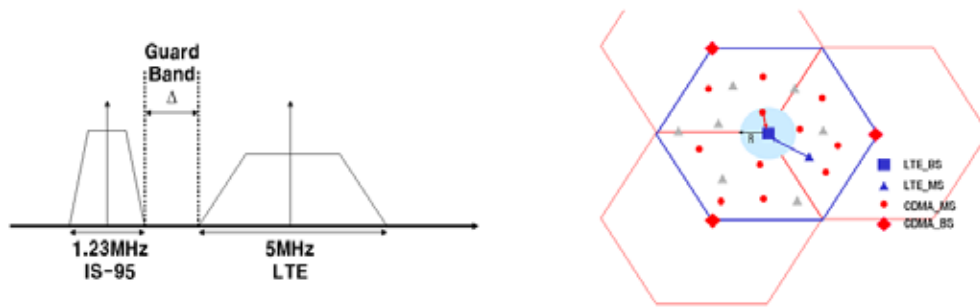


Figure 3: Scenario of interference analysis between LTE and IS-95 operated at adjacent frequency bands

Figure3 depicts the assumed frequency allocation and the basic interference scenario. The LTE throughput effect by the IS-95 uplink will be shown as a function of guard band. The detailed parameters for the system-level Monte-Carlo simulation are shown in Table 2.

Table 2: Simulation parameter

parameter	value	parameter	value		
			CDMA	LTE	
environment	urban, macro, outdoor	Channel Bandwidth	1.23MHz	5MHz	
Path loss model	Extended Hata	Link level data	900MHz, Qualcomm, 1%FER	Fig.2	
Cell radius	1km	TX	BS Mask	-	
BS height	40m		MS mask	-	3GPP
BS antenna gain	15dBi, 3GPP	RX	BS ACS	-	3GPP
MS height	1.5m		MS ACS	- 90dB @ +/- 900kHz	-
MS antenna gain	0dBi				

3.2 Result

Figure4 presents the CDF of SINR value at the LTE base station as a function of guard band. We observe that the CDF curve of SINR has good value as guard band is larger. It is due to the fact that as the guard band is larger, the adjacent channel interference becomes smaller. The throughput reduction due to adjacent IS-95 system at a certain channel separation is dependent on

the adjacent channel interference and we can observe the throughput reduction result by the SINR value. If the throughput reduction is attempted to compare, on average, the users can obtain the 9Mbps throughput in case there is no interference signal except the LTE mobile station. About 5Mbps can be gotten in case the guard band is 0MHz and about 8Mbps can be obtained in case the guard band is 1MHz. From the result, the guard band need more than 1MHz to guarantee the throughput less 10% reduction.

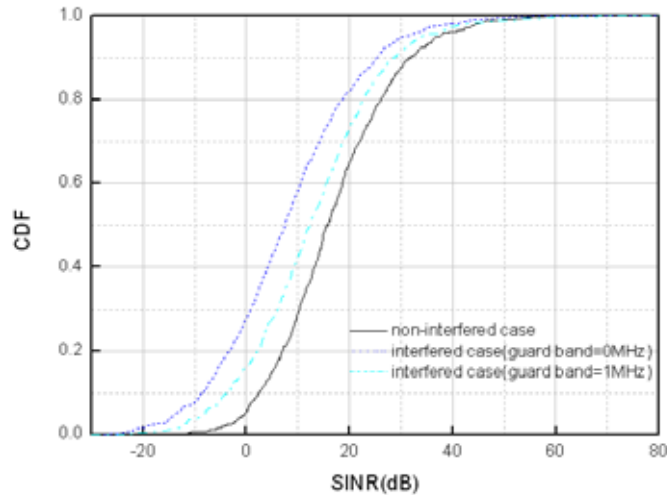


Figure4: SINR CDF value of LTE base station as a function of guard band

4. Conclusion

The effect of the adjacent IS-95 network on the uplink throughput of the LTE is studied in this paper. A method for the system level Monte-Carlo simulation and calculating the throughput at the base stations also has been presented. We look for the CDF curve of SINR value at the LTE base station as a function of guard band and assessing the throughput reduction by the interfering signal. We confirm that the guard band needs more than 1MHz to guarantee the uplink throughput of the LTE less 10% reduction by the IS-95 network.

Acknowledgments

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References

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