Throughput Effects of the LTE DL due to LTE UE

[#] Ho-Kyung Son[1]
[1] Radio Technology Research Division, Electronics and Telecommunications Research Institute
138 Gajeongno, Yuseong-gu, Daejeon, 305-700, KOREA, hgson@etri.re.kr

1. Introduction

In Korea, SK Telecom (SKT) operator has been serviced Cellular CDMA systems by using the frequency of 824~849MHz/869~894MHz. But the Korea Communications Commission (KCC) announced recently that they collected partial frequency band and allocated it to new service operator. Also KCC allocated the frequency of 905~915MHz/950~960MHz to new operator for mobile communication service. Candidate technology which will be serviced at these frequency bands can be LTE, etc. The 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].

An example of such a band plan is illustrated in Figure 1 and we can expect the interference scenarios including base station to base station interference and user equipment to user equipment interference. In other words, we can consider an interference path from the LTE B user equipment (UE) into an LTE A downlink, where user equipment (UE) of LTE A would be interfered. We can also consider an interference path from the LTE A base station into an LTE B uplink, where base station (BS) of LTE B would be interfered.

In this paper, we are only concentrating on the downlink throughput reduction of the LTE system when the LTE uplink is adjacent to each other and operated by different operators. In order to determine the UE-UE interference, it has been assumed normally that the users are uniformly located over the network area. In this case, the impact of UE-UE interference can be difficult to ascertain, due to the strong influence of the terminal distribution [3]. Also this is not real situation and the users in the radio cell located inside clusters. The indoor users are mainly located inside offices, shopping malls, restaurants etc. And the outdoor users are typically located in the squares, pedestrian streets or in the parking areas [4]. To determine levels of interference that will be experienced within a real system, analysis would need to include realistic assumptions such as appropriate user distribution. So we evaluated the impact of UE-UE interference considering real user distribution and also recommend the proper technical criteria for use without adjacent interference between other operators.

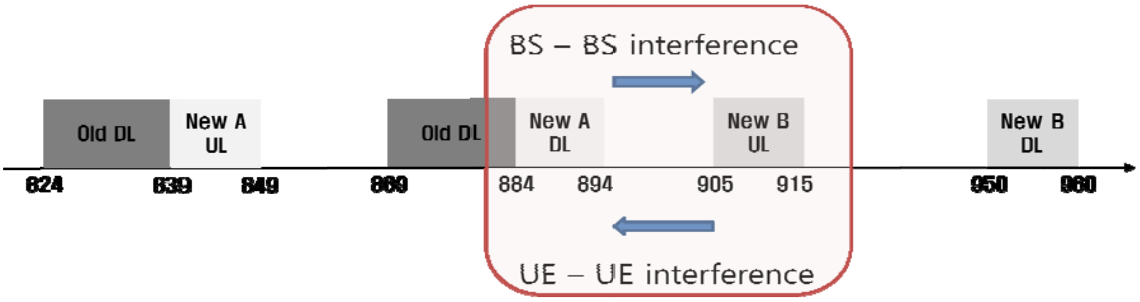

Figure 1: 800MHz/900MHz frequency band for mobile communication in Korea.

2. Interference Model

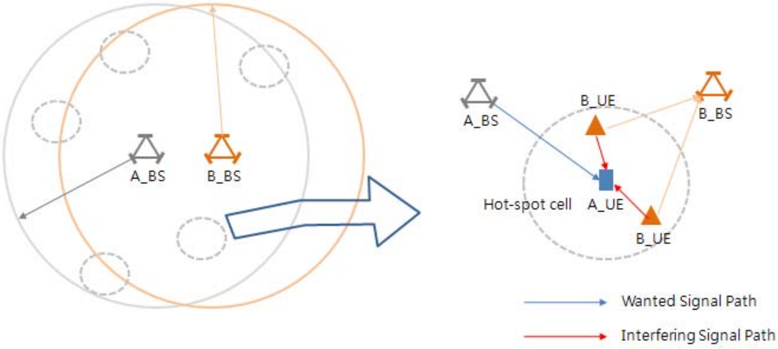

Figure 2: Interference scenario between the LTE UL and LTE DL.

As illustrated in Figure 2, a scenario is considered where a B LTE network is deployed in the same geographical area as an A LTE network. It is assumed that the B LTE network operates at 11MHz frequency separation that are neighbouring those used by the A network in the downlink direction, thereby giving rise to the possibility of UE-to-UE interference from the B network to the A network. The victim LTE A_UE is dropped at a random uniformly distributed location within the LTE A macro-cell and then LTE B_UE interferers are located at random locations within a hot-spot surrounding the LTE A_UE. LTE UE's locations are different at each Monte Carlo trial. In here we evaluate B_UE interferer's out-of-block EIRP subject to the requirement that, across the ensemble of all realisations considered, the victim A_UE does not experience interference that is greater than a defined tolerable level. The tolerable interference power level, $\mathrm{P_{tolerable\_I}}$ in dBm/MHz, at the victim A LTE UE receiver caused by a non-co-channel UE interferer may be written as [5]

$$\mathrm{P_{tolerable\_I} = P_N + G_{I,A\_OP} + G_{D,A\_OP} - G_{A,A\_OP}} \tag{1}$$

where $\mathrm{P_N}$ is the thermal noise floor at the receiver in dBm/MHz, $\mathrm{G_{I,A\_OP}}$ is the noise rise in dB due to the presence of intra-system interference power in the down link of the A LTE network, $\mathrm{G_{D,A\_OP}}$ is the tolerable increase in dB of the interference-plus-noise power level at the cell edge, and $\mathrm{G_{A,A\_OP}}$ represents the increase in dB of the tolerable interference due to proximity of the victim to its serving base station. The interference allowance, $\mathrm{G_{A,A\_OP}}$, accounts for the fact that, as a victim UE moves in from the cell-edge and approaches its serving base station, the wanted down-link signal increases, and so for a fixed signal-to-interference-plus-noise ratio, the victim receiver can tolerate a proportionally greater amount of interference.

$$\mathrm{G_{A,A\_OP} = G_{1,A\_OP} - G_{0,A\_OP}} \leq 0 \tag{2}$$

where $\mathrm{G_{1,A\_OP}}$ and $\mathrm{G_{0,A\_OP}}$ are the BS to UE mean path-gains in dB at the victim UE's location and the cell edge respectively. For a non-co-channel B_UE interferer radiating with an out-of-block EIRP level of $\mathrm{P_{OOB,B\_OP}}$ dBm/MHz in the vicinity of a victim A LTE UE, one may write

$$\mathrm{P_{OOB,B\_OP} - G_{PL,UE\_UE} - G_{PC,B\_OP} + G_{Coll} \leq P_{tolerable\_I}} \tag{3}$$

where $\mathrm{G_{PL,UE\_UE}}$ is the UE-UE propagation path loss in dB, $\mathrm{G_{PC,B\_OP}}$ is a power control factor in dB, and $\mathrm{G_{Coll}}$ accounts for the extent of collision in time between a packet transmitted by the interferer and a wanted packet received by the victim. The term $\mathrm{G_{PC,B\_OP}}$ accounts for the fact that, as the interferer UE moves in from the cell-edge and approaches its serving base station, the interferer may transmit at a proportionally reduced in-block EIRP, implying a corresponding reduced out-of-band EIRP.

3. Simulation and results

As depicted in Figure 2, a scenario is considered where a B LTE network and an A LTE network are deployed in the same geographical area. We also consider the separate distance between A operator BS and B operator BS is 0m, 100m. The interference analysis between the LTE UEs will be performed as a function of UE's out-of-block EIRP level. The table 1 presents the operational system parameters for Monte Carlo system level simulation.

Table 1: Simulation Parameter value for simulation

	Parameter	Value
General	Operating frequency	900MHz
	Number of Monte Carlo trials	5000
	MS-MS separation	1m ~ 25 or 50m
	MS-MS path loss model	IEEE 802.11 Model C
	Separation between A_BS and B_BS	Fixed
	MS antenna height	1.5m
	Boltzmann's constant, k	$1.3804 \times 10^{-23}(\mathrm{W} \iddots \mathrm{K} \iddots \mathrm{Hz})$
	Ambient temperature, T	290 Kelvin
A operator	Cell radius	1000m
	BS antenna height	30m
	Minimum BS-MS separation	50m
	BS-MS path loss model	Extended Urban Hata
	MS antenna gain	0dBi
	Noise-equivalent bandwidth, B	10MHz
	MS noise figure	9dB
	Desensitization	3dB
	Intra-system noise rise	6dB
B operator	Cell radius	1000m
	Hot-spot radius	25 or 50m
	BS antenna height	30m
	Minimum BS-MS separation	50m
	BS-MS path loss model	Extended Urban Hata
	Number of interferers in hot-spot	2 or 1

Figure 3 shows the simulation result of interferer UE out-of-band EIRP for using without adjacent band interference as a function of BS-BS separate distance. The results are also for a hot-spot radius of 25m and number of interferers are 2. The results show that LTE UE out-of-band EIRP curves coincide almost with each other.

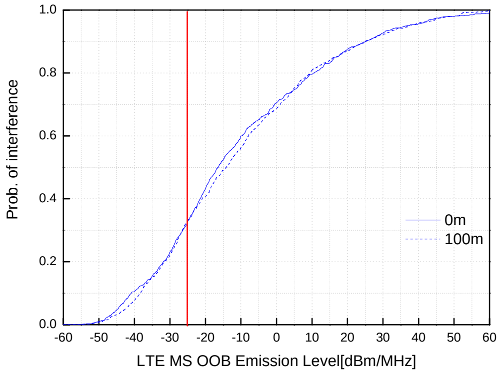

Figure 3: CDFs of interferer UE out-of-EIRP for the distance BS-BS.

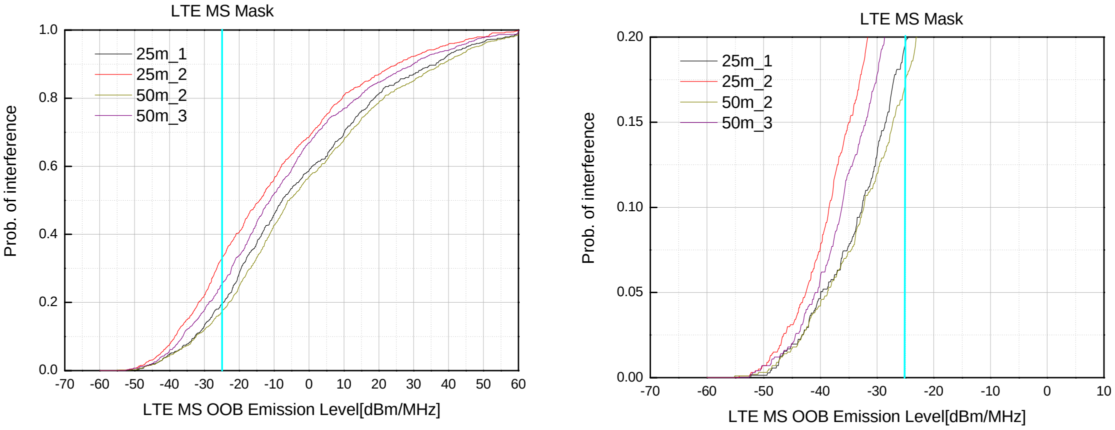

Figure 4: CDFs of interferer UE out-of-EIRP for different hot-spot radius.

The results presented in Figure 4 are the CDFs of the LTE UE out-of-band EIRP that the victim LTE UE does not experience interference as a function of hot-spot cell radius and number of interferers. It should be pointed out that these curve values are sensitive to the number of interferer UEs within the examined hot-spot. From the result, we suggest that the corresponding LTE UE out-of-band EIRP limits for a 5% probability of the victim LTE UE is -40dBm/MHz. This value is tighter about 15dB than transmitting mask of LTE UEs.

4. Conclusion

In this paper, we evaluated the impact of UE-UE interference between a LTE systems operated by different operators at adjacent frequency band, also taking into account real user distribution and investigated the proper technical criteria for use without adjacent interference between other operators. For this, a Monte Carlo approach for the computation of the UE EIRP limits are used and hot-spot cell is introduced to consider the real user distribution.

The simulations indicate that the LTE UE out-of-band EIRP limits of -40dBm/MHz can be justified for a 5% probability of the victim LTE UE. The proposed value can be applied to evaluate the interference between a LTE system for frequency assignment and planning each system deployment without an unacceptable interference impact each other.

Acknowledgments

This work was supported by the IT R&D program of MKE/KEIT. [2008-F-013-1, Development of Spectrum Engineering and Millimeterwave Utilizing Technology].

References

[1] 3GPP TS 36.300, “Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRA),” Overall description Release 8.

[2] IEEE Standard for local and metropolitan area networks, IEEE P802.16-REVd/D5-2004, “Air Interface for Fixed Broadband Wireless Access Systems,” 2004

[3] ECC report 119, “Coexistence between mobile systems in the 2.6GHz frequency band at the FDD/TDD boundary”, 2008.

[4] Kari Heiska, Kari Rikkinen, Peter Muszynski, Uwe Schwarz, “Modeling of UE-UE Interference at 2.5GHz WCDMA”, PIMRC, pp. 69-73, 2003.

[5] ECC report 131, “Derivation of a block edge mask (BEM) for terminal stations in the 2.6GHz frequency band (2500~2690MHz), 2009