Uplink Scheduling Technique for the LTE system to Improve the Performance of the NB-IoT System

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***Abstract*— Massive connectivity is one of the major goals of 5G mobile communications. NB-IoT systems are emerging as a way to achieve this goal. In this paper, we analyze the interferences of inband-mode NB-IoT system from the LTE system when they coexist. We propose an uplink scheduling method for the LTE system to improve the performance of the inband-mode NB-IoT system.**

***Keywords*— LTE, NB-IoT, Interference, Coexistence.**

I. INTRODUCTION

The NB-IoT technology defined in 3GPP release-13 is a standard developed for 20dB coverage expansion, long battery usage, easy installation, low device cost, and a significant increase in number of service devices [1, 2]. The NB-IoT system can operate in inband mode, guardband mode, and standalone mode. The subcarrier spacing of NB-IoT uplink channel (NPUSCH) can be 3.75 kHz for enlarging the coverage of the terminal, unlike the conventional LTE system using 15 kHz. In this case, the LTE system and the NB-IoT system may interfere with each other.

In this paper, we analyze the effect of LTE system on NB-IoT system when co-existence of LTE system and inband-mode NB-IoT system and subcarrier spacing of NB-IoT system uplink channel is 3.75 kHz. We propose an uplink scheduling method for the LTE system to improve the performance of the inband-mode NB-IoT system.

In section II, we describe LTE and NB-IoT coexistence. We also describe parameters and block diagram for simulation. In section III, we describe the analysis of the NB-IoT system received signal. Finally, we conclude this paper in Section IV.

II. LTE AND NB-IOT COEXISTENCE

To analyze the interference when the LTE system and the inband-mode NB-IoT system coexist and the subcarrier spacing of the uplink channel of the NB-IoT system is 3.75 kHz we assume that the bandwidth of LTE system is 20MHz so it has one hundred resource blocks (RB). NB-IoT system uplink channel is located at RB index 45. Table 1 shows simulation parameters for analysis the interferences between the LTE system and the NB-IoT system when they coexist. And figure 1 shows a block diagram for simulation.

Figure 2 shows the frequency domain characteristics when an LTE transmission signal without guard-RB is received by the NB-IoT receiver. At this time, the NB-IoT system receives about 7 dB of interference.

Figure 3 shows the frequency domain characteristics when the LTE transmission signal with guard-RB is received by the NB-IoT receiver. At this time, the NB-IoT system receives about 10 dB of interference.

TABLE I. SIMULATION PARAMETERS

Parameter	LTE	NB-IoT
NB-IoT mode	inband-mode	
Direction	uplink	
Subcarrier power ratio (NB-IoT/LTE)	1	
Subcarrier spacing	15 kHz	3.75 kHz
FFT size	2048	8192
Channel bandwidth	20 MHz	180 kHz (1-RB)
Assigned resource blocks (RB index)	0 ~ 43/44 46/47 ~ 99	45
Modulation	QPSK	QPSK

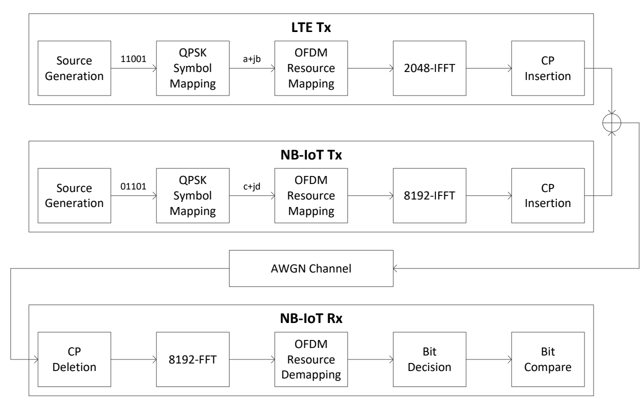

Figure 1. Block diagram for simulation

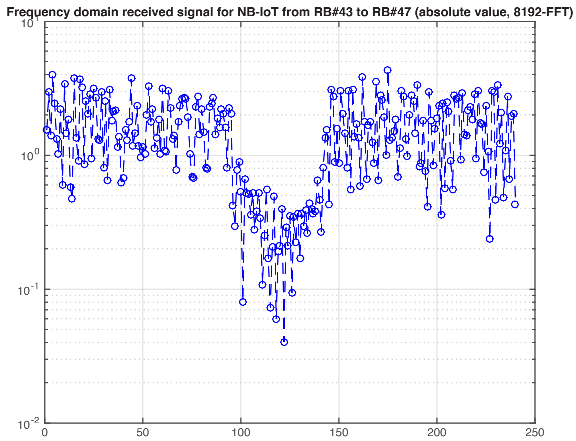

Figure 2. Analysis of LTE signal at NB-IoT receiver (without guard-RB)

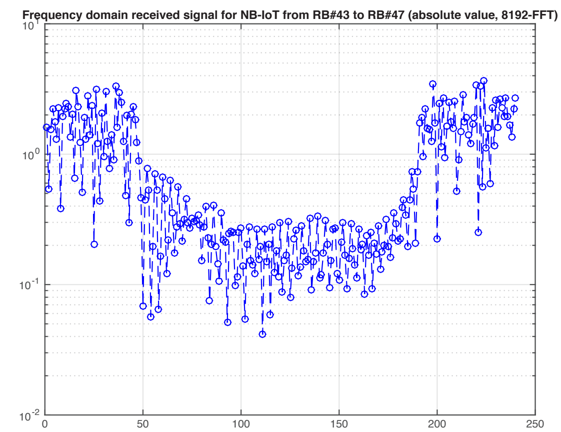

Figure 3. Analysis of LTE signal at NB-IoT receiver (with guard-RB)

III. ANALYSIS OF NB-IOT SYSTEM RECEIVED SIGNAL

A. Without Guard-RB

In this section, we did not use guard-RB. The NB-IoT signal is located in RB index 45 and the LTE signal is located in the remaining RBs except RB index 45.

Figure 4 shows the frequency domain signals received by NB-IoT receiver. If the LTE signal is not present, the frequency response of the NB-IoT received signal is flat, but the received signal is not flat because the LTE signal acts as an interference. Figure 5 shows the constellation received by NB-IoT receiver. If the LTE signal does not exist, the constellation of the NB-IoT signal will be located at a point in the same position as the transmitted signal, but the constellation points are spreaded around the transmitted signal position because the LTE signal acts as an interference.

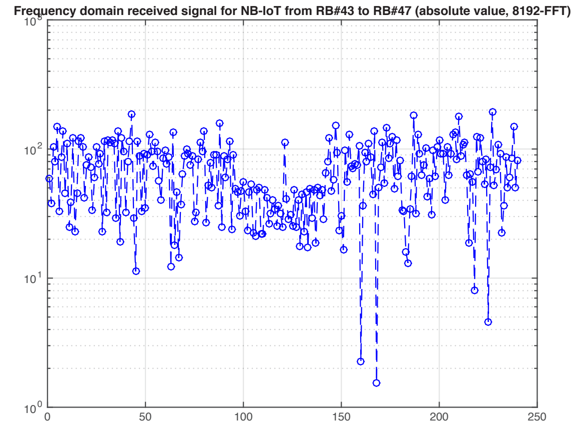

Figure 4. Frequency domain received signal for NB-IoT (without guard-RB)

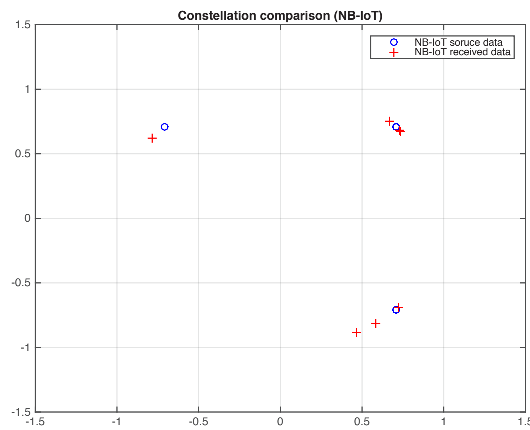

Figure 5. Constellation of NB-IoT system (without guard-RB)

B. Using Guard-RB

In this section, we used guard-RB. The NB-IoT signal is located at RB index 45, guard-RB is located at RB index 44 and 46 to the left and right of the NB-IoT signal and the LTE signal is located at the remaining RBs.

Figure 6 shows the frequency domain signals received by NB-IoT receiver. The frequency response of the NB-IoT received signal is flatter than Figure 4. Figure 7 shows the constellation received by NB-IoT receiver. As you can see in the picture, the points of constellation are gathered at transmitted signal point than Figure 5. Through Figure 6 and Figure 7, we can predict that the use of guard-RB reduces the interference of the LTE system on the NB-IoT system.

C. Ber Performance

Figure 8 shows the BER performance. When the guard band is not used (the red dashed line) an SNR loss of 2dB compared to the theoretical performance curve (the green dashed line) occurs at BER 10^{-3}. When the guard band is used (the blue dashed line) the BER performance curve is almost identical to the theoretical BER performance curve.

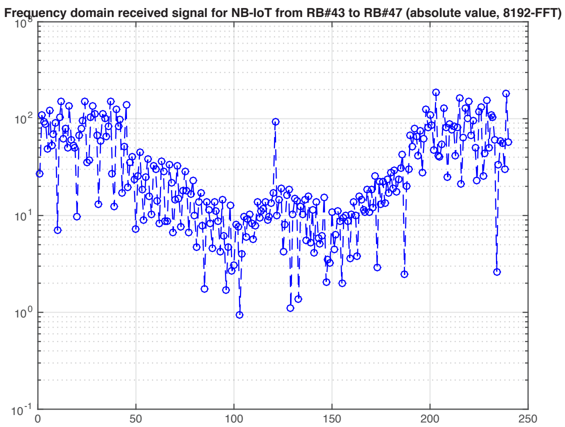

Figure 6. Frequency domain received signal for NB-IoT (with guard-RB)

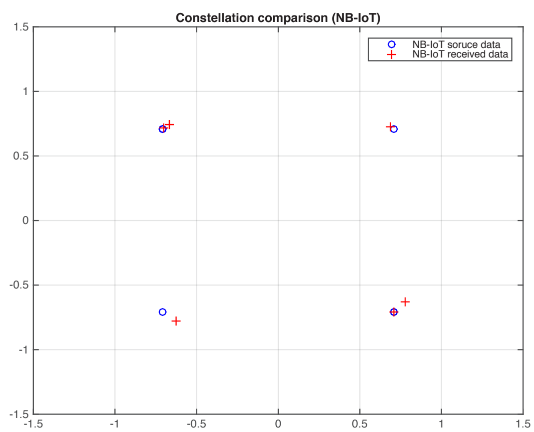

Figure 7. Constellation of NB-IoT system (with guard-RB)

IV. Conclusion and Further Study

The LTE uplink signal with 15 kHz subcarrier spacing and in-band mode NB-IoT uplink signal with 3.75 kHz subcarrier spacing are interfering each other. Therefore, it is desirable that the scheduler of the LTE system empties the neighboring RBs of the NB-IoT system and allocates resources if possible. Our work focused primarily on coexistence of LTE and NB-IoT. More simulations in a diverse environment are required to compare the reception performance.

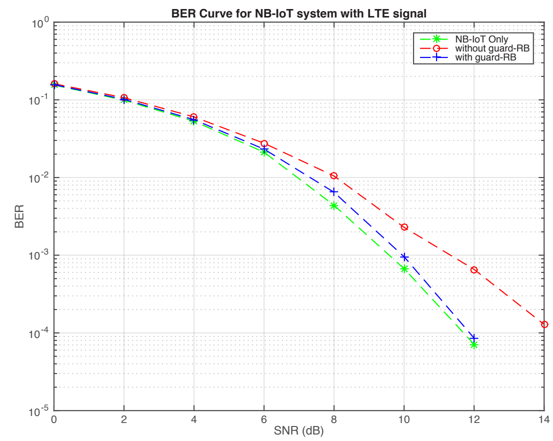

Figure 8. BER curve for NB-IoT system with LTE signal

Acknowledgment

This work was supported by Institute for Information & communications Technology Promotion(IITP) grant funded by the Korea government(MSIT) (No. 2017-0-00724, Development of Beyond 5G Mobile Communication Technologies (Ultra-Reliable, Low-Latency, and Massive Connectivity) and Combined Access Technologies for Cellular-based Industrial Automation Systems)

References

[1] 3GPP TS 36.211 V13.5.0 (2017-03) Physical channels and modulation.

[2] 3GPP TS 36.213 V13.5.0 (2017-03) Physical layer procedures.