Downlink link-level Simulator designs for 3GPP Rel. 16 NR Non-Terrestrial Networks

Gyeongrae Im
Satellite wide area infrastructure
Radio and Satellite Research Division
Electronics and Telecommunications Research Institute, ETRI
Daejeon
imgrae@etri.re.kr

Jung Bin Kim
Satellite wide area infrastructure
Radio and Satellite Research Division
Electronics and Telecommunications Research Institute, ETRI
Daejeon
jbkim777@etri.re.kr

Joon Gyu Ryu
Satellite wide area infrastructure
Radio and Satellite Research Division
Electronics and Telecommunications Research Institute, ETRI
Daejeon
jgryurt@etri.re.kr

Seung Keun Park
Radio and Satellite Research Division
Electronics and Telecommunications Research Institute, ETRI
Daejeon
seungkp@etri.re.kr

***Abstract*—Standardization for non-terrestrial network (NTN) including satellite is in progress in 3GPP, the International Organization for Standardization of Wireless Communications. Currently, in RAN 1, various companies contributing to standardization are submitting simulation results to calibrate the results of link level simulation, which requires simulator design for transmitters and NTN channels that meet the 3GPP NR standard. In this paper, the block diagram of the transmitter and the NTN channel is created, and a configuration for this is described. Then simple simulation result will be shown.**

Keywords—non-terrestrial network, NTN, NR simulator, Leo satellite

I. INTRODUCTION

Satellites are expected to play a major role in future mobile communication, and various research is being actively conducted at large corporations, national research institutes or universities. Wireless communication systems using low-orbit satellites are being actively developed to enable communication anytime, anywhere and achieve coverage without shaded areas. It is expected that applications for low data rates such as satellite IoT and applications for high-speed data transmission of 500MBits/s will be possible.

3GPP, an international mobile communication standardization organization, is also conducting international standardization for non-terrestrial base stations including satellites, and many companies are contributing to this [1]. Basic studies or standards for NTN were completed in rel. 17, and standardization for performance improvement will be carried out from Rel. 18. In RAN1, coverage expansion, network positioning, and standardization for IoT will be carried out [2]. In order to expand coverage, each company will submit a link-level simulation, and the results of the link-level simulation will determine the physical channels to be improved.

In order to calibrate the link-level simulation results, the simulator must be designed to meet the standard specifications. In this paper, we will design the structure of NR simulator and channel based on 3GPP standard specifications. A simple simulation result will be shown.

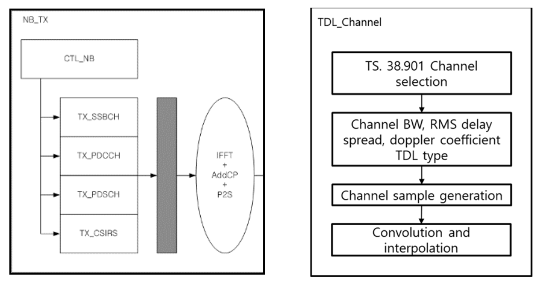

Figure 1. TX block diagram and TDL channel generation block diagram

II. TRANSMITTER

The simulator used in this paper uses subcarrier spacing 30khz and is written based on 4096FFT and CP-OFDM. Therefore, the sampling rate is 122.88 MHz and the length of one slot is 0.5ms. The overall structure of the transmitter is shown in the left side of Figure 1.

A. Syncrhonization channel

In the NR standard, a synchronization signal block (SSB) is transmitted to a specified synchronization raster, and the terminal receives the synchronization signal block (SSB) to obtain cell information for initial access. The SSB consists of 20 resource blocks, transmitted at Layer 0, and the structure of the PSS, SSS, DMRS, and PBCH follows TS 38.211 [3].

B. Control channel

The control channel delivers information that is essential to know when transmitting data. It is transmitted to Layer 1, and representative parameters are as follows [4]. DMRS configuration, TCI state, VRB to PRB interleaver, RBG size, PRB bundling size, MCS table, etc. are transmitted. The downlink control channel is called DCI, and if it is not properly decoded, it will attempt to retransmit.

C. Shared channel

The shared channel is a channel for transmitting data, and the LDPC code rate and late matching size are determined by the MCS table generated based on the channel information between the transmitter and the receiver [5]. The LDPC base graph varies according to the data rate to be transmitted.

D. CSI-RS

Through the CSI-RS channel [3], the receiver predicts the base station and its own channel information. The predicted information is transmitted to the base station through the uplink channel, and based on this information, the base station selects MCS information used for data transmission from the MCS table.

E. FFT and cyclic prefix

After putting data desired to be transmitted into 3300 subcarriers, 4096 FFT is performed. The 4096 FFT is performed on a symbol-by-symbol basis, where the SCS uses 30KHz, the size of the CP is 288 samples per symbol, and 320 samples are used for the first symbol of the slot. Therefore, the number of samples per slot is (4096+288)*6+(4096+320) = 30720.

III. Channel Modelling

The channel model is designed based on 3GPP standard TS 38.811 [6]. The overall structure of the channel model is shown in the right side of Figure 1.

A. TDL model configuration

NTN-TDL-A and NTN-TDL-B are the environments where LOS paths do not exist. NTN-TDL-C and NTN-TDL-D are the environments where LOS paths exist. The specific parameters are shown in Table 1.

Table 1. NTN-TDL parameters

NTN-TDL	Tab #	Normalized Delay	Power in dB	Fading distribution
A	1	0	0	Rayleigh
	2	1.0811	-4.675	Rayleigh
	3	2.8416	-6.482	Rayleigh
B	1	0	0	Rayleigh
	2	0.7249	-1.973	Rayleigh
	3	0.7410	-4.332	Rayleigh
	4	5.7392	-11.914	Rayleigh
C	1	0	-0.394	LOS path
		0	-10.618	Rayleigh
	2	14.8124	-23.373	Rayleigh
D	1	0	-0.284	LOS path
		0	-11.991	Rayleigh
	2	0.5596	-9.887	Rayleigh
	3	7.3340	-16.771	Rayleigh

For Rayleigh distribution, we adopt Jake's channel model. For delay calculation, we use rms delay spread.

B. Channel coefficient selection

To determine the interval and constant value of the channel tab, the value of the desired delay spread, channel bandwidth, and Doppler values must be determined. The delay spread is for multipath and should be less than the CP length. If this value exceeds the length of the CP, problems may occur at the receiver side, and solutions need to be presented accordingly. In the case of the channel bandwidth, the reciprocal value of the channel bandwidth is the time between channel tabs. In addition, it is designed to enable the use of Doppler values that occur when the satellite moves at high speed in consideration of the case where the LEO satellite is a base station.

IV. Simulation Results

In this section, we show the simulation result of the SSB channel, especially for the PBCH block error rate. For the simulation, we use NTN-TDL-C, subcarrier spacing 30kHz, delay spread 300ns. SSB is located at the third symbol of the first subframe. The path length between the target satellite and the receiver is 1000km and path loss exponent

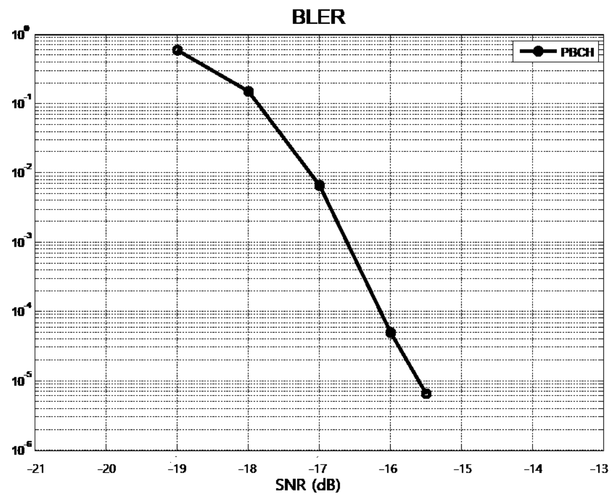

Figure 2. PBCH block error probability versus received SNR

Figure 2 shows the PBCH BLER. It is shown that the BLER curve achieves 10^{-3} at -17~-16dB. Due to the path loss and multipath, the BLER performance is very poor compared to AWGN.

Acknowledgment

This work was supported by Institute of Information & communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (No.2021-0-00847, Development of 3D Spatial Satellite Communications Technology).

Reference

[1] Munira Jaffar and Nicolas Chuberre "NTN & Satellite in Rel-17 & 18." https://www.3gpp.org/news-events/partners-news/2254-ntn_rel17 (accessed Aug 15, 2022).

[2] RP-220953, NR NTN (Non-Terrestrial Networks) enhancements, 3GPP TSG RAN Meeting #95e, Electronic Meeting, March 17 - 23, 2022.

[3] Physical channels and modulation, TS 38.211, 3GPP, version 17.2.0, June 23, 2022.

[4] Physical layer procedures for control, TS 38.213, 3GPP, version 17.2.0, June 23, 2022.

[5] Physical layer procedures for data, TS 38.214, 3GPP, version 17.2.0, June 23, 2022.

[6] Study on New Radio (NR) to support non-terrestrial networks., TR 38.811, 3GPP, version 15.4.0, Oct 08, 2022.