Study on OFDM Numerology 4 of 5G New Radio (NR) under Indonesia 5G Channel Model

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***Abstract*—With data transfer speed expected around 20 Gbps, the fifth generation of cellular communication (5G) New Radio (NR) is estimated to serve services interconnected to all heterogeneous wireless networks. However, several optimal parameters are not yet known, such as Fast Fourier Transform (FFT) size, cyclic prefix (CP) length, block length, coding rate, and bandwidth that suitable for Indonesia. This paper proposes study on 5G NR technology performances using Orthogonal Frequency Division Multiplexing (OFDM) Numerology 4 under Indonesia 5G Channel Model to serve various applications of 5G technology in future. This paper investigates the characteristics of bandwidth distribution and parameters for the application of 5G NR for OFDM Numerology 4. The results show that with parameters of OFDM Numerology 4, the 5G channel model has 13 paths which the outage performances are derived for coding rates $R = 1/2$ and $R = 1$.**

***Index Terms*—Cellular Communication, 5G New Radio (NR), OFDM Numerology, Indonesia 5G Channel Model.**

I. Introduction

Cellular communication is currently evolving to support world community needs for communication services, e.g., wireless broadband access, video chat, and mobile TV requiring large capacity bandwidth [1]. The fifth generation of cellular communication (5G) New Radio (NR) are developed with the goals of increasing existing system capacity and data rates, reducing latency, and accommodating the application of Internet of Things (IoT) concepts [2]. All the missions carried by 5G NR technology are still constrained regarding optimal performances that have not been found using the parameters of Orthogonal Frequency Division Multiplexing (OFDM) Numerology for each 5G NR user.

OFDM is used for cellular communication systems due to ability of OFDM to resolve multipath fading effect that causes the occurrence of Inter-symbol interference (ISI) and Inter-carrier interference (ICI) during transmission [3]. However, the optimal performances of sharing concept for each 5G NR user has not found. Performance in sharing bandwidth is important because it predicts how much bandwidth is needed, such that requests from users can be fulfilled maximally and fairly [4].

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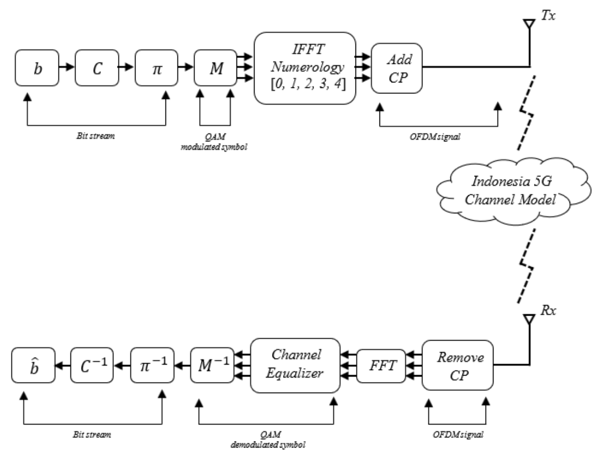

Fig. 1. Proposed transmitter and receiver block diagram.

This paper investigates solution to resolves optimization problems in 5G NR technology applied for Indonesia with Numerology 4 due to significant natural differences for each region in Indonesia. The similar results have been presented in [5] and [6] for other numerologies. The results are expected to be a reference to determine the performances of 5G NR in Indonesia for various Numerology.

II. System Model

Fig. 1. shows the configuration between transmitter and receiver systems to evaluate the system performances of Indonesia 5G Channel Model. We begin with collecting data sources in the bit form, i.e., 0 and 1. After data has been collected, data is encoded using the Forward Error Correction (FEC) encoder. Data are mapped into Quadrature Amplitude Modulation (QAM) symbols. Then, data is sent and evaluated for several channel coding rates under Indonesia 5G Channel Model.

Output of the channel is mixed with noise. Then, data are returned into bits using QAM demapper and decoded using FEC decoder to produce data information. Evaluation of the system performances are based on outage probability, Bit Error Rate (BER), and Block Error Rate (BLER) during the test for OFDM Numerologies 0, 1, 2, 3, and 4 under Indonesia 5G Channel Model.

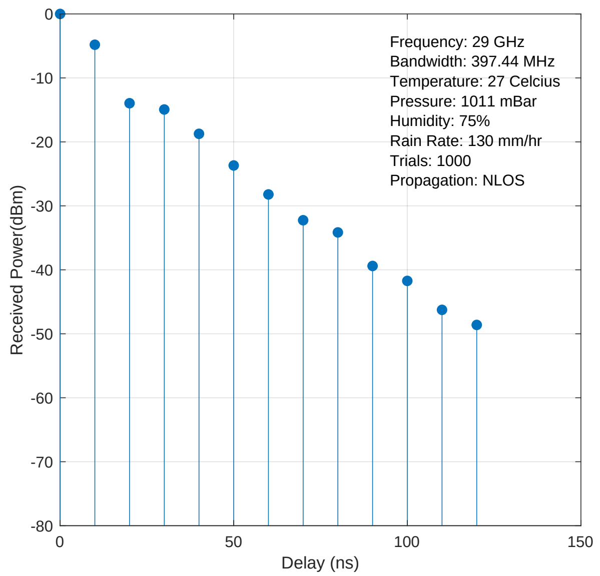

Fig. 2. Representative PDP with Numerology 4 for Indonesia 5G Channel Model.

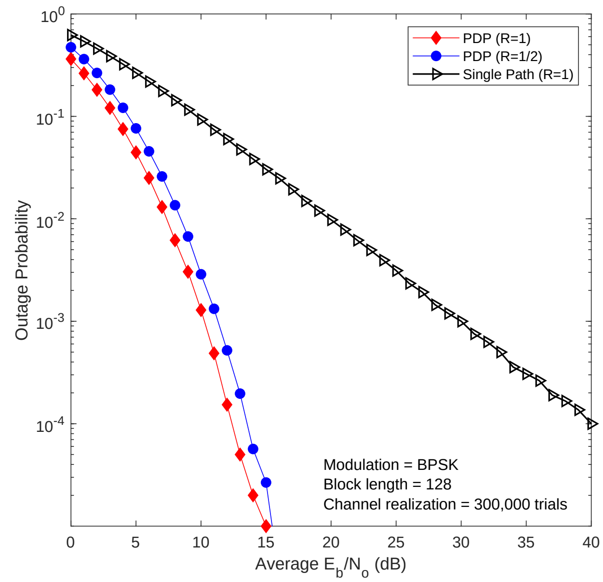

Fig. 3. Outage performance for Numerology 4 of Indonesia 5G Channel Model.

III. Outage Performance Analysis

The Indonesia 5G Channel Model is built based on representative PDP that calculated from thousand instantaneous PDP, where the power of minimum path is $-150\ dB$ [5], [6]. Representative PDP of Indonesia 5G Channel Model for Numerology 4 is shown in Fig. 2. following specification in 5G NR standards, i.e., frequency and bandwidth. The characteristics of Indonesia 5G Channel Model are temperature of 27 ^oC, average barometric pressure of 1011 $mBar$, average humidity of 75%, and average rain rate of 130 mm/h. Representative PDP with Numerology 4 has 13 paths.

The outage performance of Indonesia 5G Channel Model for Numerology 4 is shown in Fig. 3. The outage probability curve of Indonesia 5G Channel Model has a better performance than that of single path. This good result is caused by diversity effects as the impact of multipath. The outage probability of 10^{-5} from the system can be obtained with E_b/N_o of 15.7 dB in $R = 1/2$. Then, the outage probability of 10^{-5} from the system can be obtained with E_b/N_o of 14.9 dB in $R = 1$. The outage performance and value of E_b/N_o are still satisfying the existing theory.

IV. Conclusion

This paper has proposed 5G NR performances of Indonesia for Numerology 4 under Indonesia 5G Channel Model. The reference of capacity for maximum performances is the Shannon limit for Indonesia 5G Channel Model. The outage performances are expected to become a reference for 5G NR implementation in Indonesia, especially for Numerology 4.

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