CHAPTER I
INTRODUCTION

1.1 Motivations

The fifth generation new radio (5G-NR) mobile communications system is using millimeter wave (mm-wave) because the available channel bandwidth is greater than the bandwidth used by the previous generations. The mm-wave operating band candidate that will be used on 5G-NR is 28 GHz due to attenuation that can be tolerated compared to other mm-wave. It has been trialed measuring attenuation of 6 GHz - 400 GHz wavelength in Fig. 1.1 (Image: T. S. Rappaport *et al*, "Millimeter Wave Mobile Communications for 5G Cellular: It Will Work," 2013) [1]. Based on [2] – [3], smaller wavelengths will increase the sensitivity of the propagation model to the environmental scale and show some frequency dependence of the path loss and increase the occurrence of blockage and penetration loss is highly dependent on the material. It tends to increase along with the frequency, resulting in channel modeling between 5G-NR with previous technology, such as 4G-LTE, is not the same. The mm-wave on 5G-NR requires channel modeling in accordance with environmental conditions, whereas at present there is no channel modeling using the 28 GHz frequency mm-wave in Indonesia that 28 GHz will be used for 5G spectrum in Indonesia [4]. The use of mm-wave on 5G-NR has the biggest problem is easily disturbed by environmental obstacle conditions one of which is the influence of barometric pressure. Therefore, the authors propose 5G channel modeling on the influence of Telkom University barometric pressure.

Small scale fading technique for 5G channel modeling based on the real-field measurement and computer simulation methods. Real-field measurement were conducted directly at Telkom University and other location, which is has different environmental latitude that impact on different barometric pressures with validation by ITU-R reference standard atmosphere [5]. While for computer simulation is done with 5G channel modeling based on computer simulation software in order to approach the real condition by statistical approach using Cumulative Distribution Function (CDF). Based on [6], 5G channel modeling uses NYUSIM software to analyze channel conditions and spectral efficiency with mathematical propagation approaches as per the conditions in the United States. So that NYUSIM is an alternative channel model and more realistic than the 3^{rd} Generation Partnership

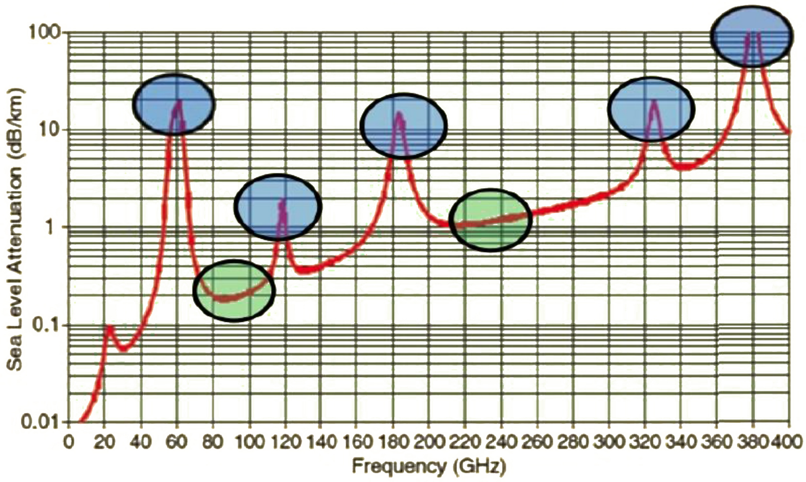

Fig. 1.1 Atmospheric absorption across mm-wave frequencies in dB/km.

Project (3GPP) channel model and other channel models, [7] – [10], for channel modeling in the mm-wave band.

Small scale fading channel modeling research that has been used in Indonesia is adopted from the calculation of channel model using channel modeling in European and American countries. That is not agree with Indonesia's tropical climate, rain rate, humidity, barometric pressure, and temperature, are different. To validate Indonesia's tropical climate, it will evaluate by environment conditions measurement causing computer simulation results in NYUSIM is still accurate when compared with Indonesia's tropical climate [11] – [14]. Thus, the results of the Power Delay Profile (PDP) and the delay time due to Non Line-of-Sight (NLOS) generated on other countries are not suitable to the conditions of the Indonesian tropical environment.

Since the barometric pressure is of our interest to observed on environment conditions measurement and computer simulation, this thesis is paying attention to the changes of the PDP given the different barometric pressure measured at different location between Telkom University and other location having different latitudes. This thesis also have been published with validated using convolutional codes [15]. Furthermore, this thesis has successful measurement of the proposed 5G-NR channel model, which is confirmed by the agreement in gradients of outage performance FER and BER using 5G-NR OFDM and channel coding 5G-NR QC-LDPC BG2 and Convolutional codes. Therefore, provide some benefits, e.g., optimal parameters such as channel coding rate, modulation, required power of 5G-NR equipment planned to be deployed in Indonesia.

1.2 Problem Identifications

The mm-wave has an impact on the ability to penetrate smaller objects. An existing 5G-NR channel model (i.e. 3GPP, METIS, etc, [7] – [10],) is not relevant to Indonesia, resulting in the PDP and the delay time due to Non Line-of-Sight (NLOS) generated are not suitable to the conditions of the Indonesian tropical environment. The mm-wave for 5G-NR requires channel model in accordance with environmental conditions, whereas at present there is no channel model using the 28 GHz cause 5G implementation in Indonesia not optimal. Thus, 5G-NR requires channel model for optimal deployments especially between 5G-NR implementation and channel capacity theory in the Indonesia.

1.3 Objectives

To obtain the PDP of 5G-NR channel model is given the different pressure measured at Telkom University and the other location having different latitudes represent the conditions of major cities in Indonesia, which are located on the coast, lowlands and highlands, this thesis consider two methods, i.e., (i) environment conditions measurement of 5G-NR channel model in order to adapt the real Indonesia's tropical climate, and (ii) computer simulations, New York University Simulation Model (NYUSIM) is used to estimate the channel model. Also, this thesis analyzes 5G-NR channel model by outage performance, FER and BER validation.

1.4 Scope of Works

PDP of the 5G channel model will be generated by measuring the environment condition especially the barometric pressure in order to adjust the real Indonesia's tropical climate in Bandung and Palembang. The PDP simulated by New York University Simulation Model (NYUSIM) is used to estimate the channel model with bandwidth maximum and minimum of 5G-NR CP-OFDM in 28 GHz. We assume PDP with CDF of 90th percentile as representative PDP of Indonesia 5G channel model. To validate the performance evaluation of 5G channel model, Outage Probability vs the signal-to-noise power ratio (SNR) compared by the practical 5G-NR OFDM and channel coding, 5G-NR QC-LDPC BG2 and Convolutional codes, in terms of BER and FER.

1.5 Expected Results

The proposed thesis is focused on the changes of the PDP given the different barometric pressure measured at different location between Telkom University and other location having different latitudes, represent the conditions of major cities in Indonesia, which are located on the coast, lowlands and highlands. With the result that can be generalized to Indonesia 5G channel model. The successful measurement of the 5G-NR channel model is validated by the agreement in gradients of outage performance and FER of practical 5G-NR OFDM and channel coding, 5G-NR QC-LDPC BG2 and Convolutional codes. The obtained 5G-NR channel model also provide some benefits for industries to set optimal parameters such as channel coding rate, modulation, and required power of 5G-NR equipment planned to be deployed in Indonesia.

1.6 Research Methodology

To obtain good 5G Telkom University channel models, the work of this thesis is divided into work packages (WP) as:

1. WP1: Study of 5G-NR channel modeling literature.
2. WP2: The environment conditions measurement of channel modeling using microcontroller and sensor in Telkom University and other location.
3. WP3: Computer simulation using NYUSIM channel modeling simulator with barometric pressure factor in Telkom University and other location environment.
4. WP4: Performance evaluation among the terms of Power Delay Profile (PDP); Cumulative Distribution Function (CDF); channel capacity; outage performance vs SNR; channel coding, 5G-NR QC-LDPC BG2 and Convolutional codes, and 5G-NR OFDM in terms of FER and BER for performance validation with bandwidth 50 MHz and 200 MHz.