CHAPTER I
INTRODUCTION

1.1 Background

The development of cellular telecommunications technology has begun to enter the 5G era. By looking at the development of technology in each generation, 5G will be implemented in 2020. 5G technology is high bandwidth usage of cellular phones. Every technological development requires preparation in implementation, such as a channel model. The steps taken to take the opportunity in the entry on 5G technology must look back at the definition of 5G technology based on the standards issued by ITU-R as shown in the Fig. 1.1. Enhanced mobile broadband (eMBB) is intended for user-centric scenarios to access multimedia content, services, and data rate is 20 Gbps. Ultra-reliable and low latency communications (URLLC) have more stringent requirements in terms of capabilities such as throughput, latency, availability already solved by massive multiple input and multiple output (MIMO), and millimetre-wave communications. Massive machine type communications (MMTC) is characterized by the large number of connected devices, especially devices that transmit data at low volume and are not sensitive to delay. This thesis focus on solving the problem of enhanced mobile broadband, where channel model is playing the most important point for the minimum signal-to-noise power ratio (SNR).

Channels are becoming the important part of the wireless communication system since the quality of transmitted signals depend on the channels. The candidates of frequency in 5G we divided into 3 bands, i.e., low band (below 1 GHz), mid band (between 1-6 GHz), and high bands (beyond 6 GHz). The usage of high frequencies of 1-100 GHz may lead to a big attenuation because of the environment (temperature, air pressure, foliage, humidity, etc) [1]. The channel model describes the amount of the received signal power and the inter symbol interference (ISI). Therefore, system performance can be evaluated based on the outage performances derived from the channel model.

Some countries have already conducted research on 5G channel models, which is influenced by the environment in their respective countries, for example, mobile and wireless communications enablers for twenty- twenty (2020) Information Society (METIS) 2020 [2], ETSI European telecommunications standards institute

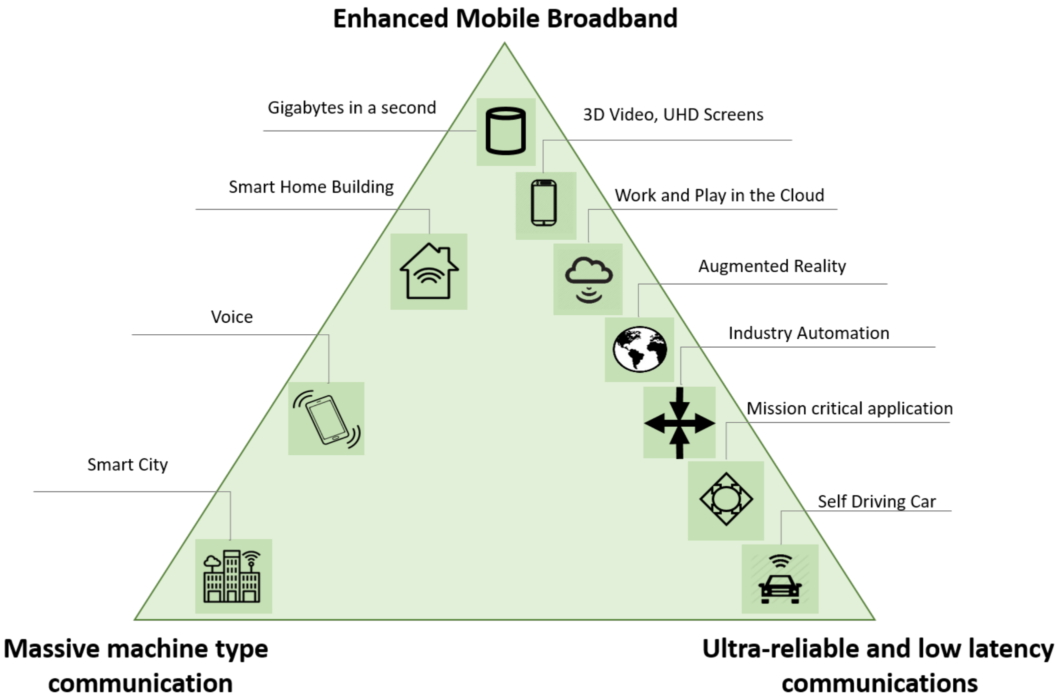

Fig 1.1 The usecases of 5G defined by the ITU.

(ETSI) mmWave SIG [3], 5G mmWave Channel Model Alliance [4], millimetre-wave evolution for backhaul and access (MiWEBA) [5], millimetre-wave based mobile radio access network for fifth- generation integrated communications (mm-Magic) [6], New York University (NYU) Wireless [7]. These researches produce different PDPs for each country, due to the different the environmental conditions of each country. different channel models recommended for different weather conditions [8] and [9]. Countries have a tropical climate, which is geographically located below the equator, having two seasons (rainy and dry). Therefore, the 5G channel models in Indonesia should be derived became they are for different from the existing channel model. The similar model has been presented in [10], [11], [12], and [13], where the models do not assume humidity effect.

This thesis considers the 5G channel model operating at 3.3 GHz, because for Indonesia the frequency is still empty [14], with 99 MHz bandwidth based on the specification of Orthogonal Frequency Division Multiplexing (OFDM) numerology $\mu = 1$ in 5G NR standard representing Telkom University under humidity effects. This thesis also compare the PDP, outage performances, bit-error rate (BER), and frame error rate (FER) to confirm the validity of the calculation.

1.2 Problem Identification and Objective

Channel models are the important part of communication systems to predict system performances, from which the outage performances can be derived. With the absence of a channel model in Indonesia, performances of mobile communication systems in Indonesia are evaluated under channel model of other countries, for example, Stanford University channel model. However, the current existing channel models cannot be used in Indonesia, because Indonesia has different environments, where big effects of different environment is expected at high frequency as used in 5G systems. The use of other channels, except 5G Indonesia channels, may cause unoptimal performances of 5G implementation in Indonesia.

Indonesia is a tropical country with two seasons (dry and rainy), where the analysis of humidity becomes important. This thesis provides 5G channel model derived from environmental conditions at Telkom University, Bandung, Indonesia. The objectives of this thesis are (i) to obtain a channel model represented by the Power Delay Profile (PDP) and theoretical outage performances used for 5G implementation at Telkom University, Bandung, Indonesia, and (ii) to propose a framework such that the model can be derived and measured in other cities of Indonesia.

1.3 Scope of Work

To simplify the description, this thesis assumes several points as follows:

1. This thesis creates 5G channel model of Telkom University with the humidity effects based on computer simulations for thousands of generated data using NYUSIM.

3. This thesis considers the frequency of 3.3 GHz with bandwidth of 99 MHz based on 5G NR specification of OFDM numerology $\mu = 1$.

3. Receiver moves around Telkom University area while the transmitter does not move.

4. Real–field measurements are made during morning, noon, afternoon, and evening at Telkom University Campus area.

1.4 Research Methodology

This thesis is divided into four work packages (WPs) to produce high-quality results.

1. WP1: Data processing from BMKG and real–field measurement
   In this WP, this thesis collects data based on temperature, humidity, and air pressure in Bandung for a year. The data are then processed, to measure maximum and minimum values (temperature, humidity, and air pressure) in a year which are then used as input to NYUSIM.

2. WP2: Obtaining PDP using NYUSIM
   The data from WP1 are used to obtain PDP representing Telkom University. This WP also formulates a framework in 5G channel modeling such that 5G channel modeling in other cities is possible.

3. WP3: Performance evaluations
   This thesis calculates the outage performances of all WP2 results to predict the quality of 5G system implementation at Telkom University, Bandung, Indonesia.

4. WP4: Result validation
   The outage performances which is obtained from Shannon limit are then validated using FER and BER performances of practical cyclic prefix (CP)–OFDM numerology $\mu = 1$ as in 5G NR standard.

1.5 Stucture of Thesis

The rest of this thesis is organized as follows:

Chapter II: Basic Concept

This chapter describes the basic concept of the wireless channel, including the general description of power delay profile (PDP), channel capacity, outage performances, and orthogonal frequency division multiplexing (OFDM).

Chapter III: System Model and Proposed Framework

This chapter discusses the system model of channel simulation and the proposed framework to obtain Telkom University 5G Channel Model Considering Humidity Effects.

Chapter IV: Results and Validations

This chapter shows the obtained power delay profile, outage performance, BER, and FER of Telkom University 5G Channel Model Considering Humidity Effects.

Chapter V: Conclusions

This chapter concludes all the discussion and analysis of this thesis, so that it can provide significant contribution to the future development of 5G channel modeling in Indonesia.