CHAPTER I
INTRODUCTION

1.1 Background

The 3rd Generation Partnership Project (3GPP) predicts that the fifth telecommunication generation (5G) New Radio (NR) wireless systems, which is commercially available in 2020 [1], are likely to be different with today's technology with new service innovations driven by increasing data traffic demand, increasing processing power of smart devices, and new innovative applications [2]. International Telecommunications Union-Recommendation (ITU-R) defines the challenges to be addressed by 5G NR, i.e., supporting network speeds up to 20 Gbps, cell edge rate greater than 100 Mbps, and latency less than 1 ms [2]. ITU-R classified 5G services in the following groups: i) Enhanced Mobile Broadband (eMBB) requiring very high data rates and large bandwidths, ii) Ultra Reliable Low Latency Communications (uRLLC) requiring very low latency, very high reliability, and availability, iii) Massive Machine Type Communications (mMTC) requiring low bandwidth, high connection density, enhanced coverage, and low energy consumption at the user end [3].

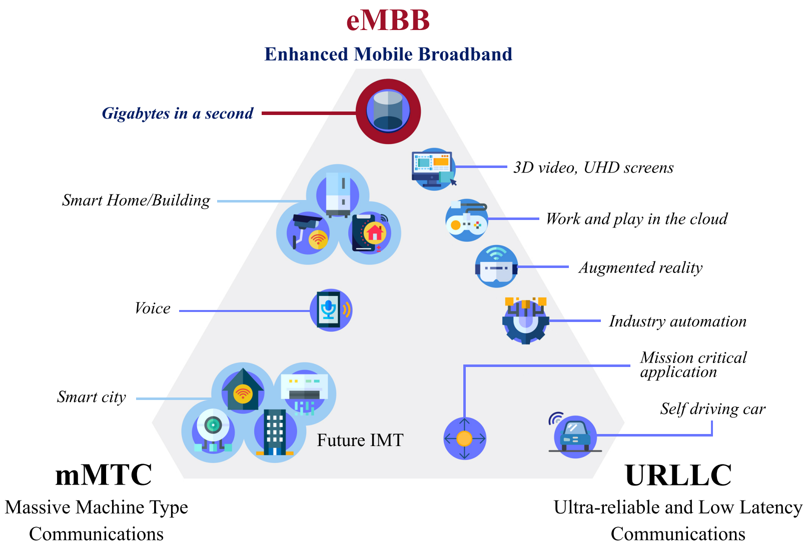

Fig. 1.1 5G services classified by ITU-R.

The difference between 5G NR and existing wireless communication is the usage of high frequency band, where the water (H_2O) molecules in the air highly affects the performances [4]. Since Indonesia is a tropical country having maximum and minimum temperature, which is affected by H_2O molecules in the air, understanding and calculating the temperature effects on propagation is required for future 5G communication system design [5]. When the channel model in a country is known, parameter for machine can be set to achieve capacity and system performance for the country. Therefore, channel modelling is very useful in order to design an optimal communication system [6].

Indonesia's weather conditions, temperature, environment, and soil structure are unique due to fluctuative changing of atmospheric conditions in the same place, then 5G channel models in Indonesia are different from channel models in other countries [7] and [8]. This thesis focuses on the effect of temperature changes occurring over the specified range and place, where Telkom University, Bandung, Indonesia, is chosen as a representative location for the 5G channel model. Since Indonesia is a tropical country having fluctuating temperature, which is extreme, understanding and calculating the temperature effects on propagation is needed for future 5G communication system design [5], especially in Indonesia. Some channel models for tropical countries, especially for Indonesia, have been derived in [9, 10].

Research on environment effect to the propagation channel has been widely practiced, 5G channel model considering humidity, temperature, and barometric pressure effects are evaluated in [11], [12], and [13], respectively. Furthermore, OFDM numerology effect to the channel model is evaluated in [14].

This thesis considers a frequency of 28 GHz, which is one of the frequencies uses on OFDM numerology $\mu = 3$, with bandwidth of 200–400 MHz [15]. This frequency is then appropriate frequency which is used in Indonesia, beacuse including available spectrum according to Perpem 33 is about "Perubahan Peraturan Menteri Komunikasi dan Informaitka Nomor 33 tahun 2015 Tentang Perencanaan Penggunaan Pita Frekuensi Radio Microwave Link Titik ke Titik (Point-to-Point) [16]".

This thesis proposes 5G channel model based on software simulation by considering the influence of temperature to calculate the power delay profile (PDP) with real-field environmental parameters including barometric pressure, humidity, and temperature parameters. There are thousand probabilities of PDP which is evaluate to have representative PDP in Telkom University with cumulative distribution function (CDF) method. Based on the representative PDP, this thesis calculates capacity and generate outage probability so it can be used to design the 5G channel model with temperature effect in Indonesia especially Telkom University. Outage performance validated using BER and FER performance of 5G Telkom University channel model with temperature effect which can be used as a reference to set the parameter of 5G system implementation in Bandung, Indonesia.

1.2 Problem Identification and Objective

The characteristics of wireless signal changes as the signal travels from the transmitter antenna to the receiver antenna. These characteristics depend on the distance between the the antennas of transmitter and receiver, the path(s) experienced by the signal, and the environment determining the strength of each path. The profile of the channel can be obtained from the transmitted signal and the received signals to estimate the theoretical outage performances. Implementation of 5G without knowing the channel model may causes high loss either in power or bit rate. The complexity and dynamic changes of the radio channel makes difficulties in obtaining an accurate representative channel model. Therefore, statistical models are often used. Furthermore, Indonesia does not have a channel model for 5G technologies leading to an unoptimal implementation of 5G in Indonesia. The thesis is aiming to obtain Telkom University 5G channel model considering temperature effects using the proposed framework, which is also applicable to other regions of Indonesia. As the result, many performances can be predicted as well as the optimal parameters setting for the 5G infrastructure.

1.3 Scope of Work

This thesis focuses on the derivation of 5G channel model by assuming several points as follows:

1. This thesis performs a simulation by considering Shannon limit theorem for capacity calculation and does not directly measure the channel model using tools that are equivalent to channel sounders.

2. The simulations is using frequency carrier of 28 GHz with bandwidth of 200 MHz and omnidirectional antenna.

3. This thesis focuses on temperature effect, while the other parameters (i.e., antenna height, rain rate, barometric pressure, and humidity) are set into a reasonable value.

4. To validate the outage results, this thesis presents BER and FER performance of CP-OFDM numerology $\mu = 3$ with 5G complex binary phase shift keying (C-BPSK), convolutional codes, and QC-LDPC codes.

1.4 Research Methodology

This thesis is divided into 4 work packages (WP) for high quality results.

1. WP1: Collect data about temperature, humidity, barometric pressure, and rain rate from real measurement and BMKG.

   This thesis takes real measurements using arduino microcontroller and BME 280 sensor including temperature, humidity, and barometric pressure parameters, where Telkom University, Bandung, Indonesia, is chosen as a representative location for the 5G channel model. The model is derived based on real-field environmental parameters including temperature, humidity, and barometric pressure.

2. WP2: Representative PDP calculation.

   Representative PDP with temperature effect are needed to produce the Telkom University 5G channel model with temperature effect.

3. WP3: Performance Evaluation.

   The performances evaluations of Telkom University 5G channel model with temperature effects are evaluated in terms of: (i) capacity and outage performances of 5G Telkom University channel model, and (ii) analysis of the temperature effect to the 5G Telkom University channel model.

4. WP4: Results Validation.

   The outage performance are then validated using BER and FER performance of CP-OFDM numerology $\mu = 3$ with 5G-NR C-BPSK modulation, convolutional codes and QC-LDPC codes.

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 PDP, channel capacity, outage probability, cyclic prefix-orthogonal frequency division multiplexing (CP-OFDM), channel coding, and environment effects.

Chapter III: System Model and Proposed Framework

This chapter discusses the system model of channel simulation and the proposed framework to obtain a Telkom University 5G channel model considering temperature effects.

Chapter IV: Results and Validations

This chapter provides results and validation of Telkom University 5G channel model considering temperature effects.

Chapter V: Conclusions

This chapter concludes the effects of Temperature to the Telkom University 5G channel model based on the results.