CHAPTER I
INTRODUCTION

1.1 Background

Indonesia consists of islands located between three large plate confluences, i.e., the Eurasian plate, the Indo-Australian plate, and the Pacific plate [1]. It causes a high tectonic activity that make Indonesia to be a country with a high potential for natural disasters. Indonesia has various natural disasters, i.e., earthquakes, tsunamis, floods, and landslides. The impact of natural disasters is unavoidable, causing damage to buildings and impacting network infrastructure causing high interference to cellular connectivity. The high-risk interference can occur when a base transceiver station (BTS) is damaged, causing the affected area to lose its connection. The impact of disasters requires technological innovation to restore the damaged network in a direct and integrated way.

The mobile cognitive Base station (MCRBS) is an alternative to replace the base station (BS) to recovery process during the post-disaster and help search and rescue (SAR) efforts in evacuating the victims [2] [3]. The authors in [4] are designed the antenna for MCRBS to serve mobile devices of the second telecommunication generation – the fifth telecommunication generation networks, where it can cover

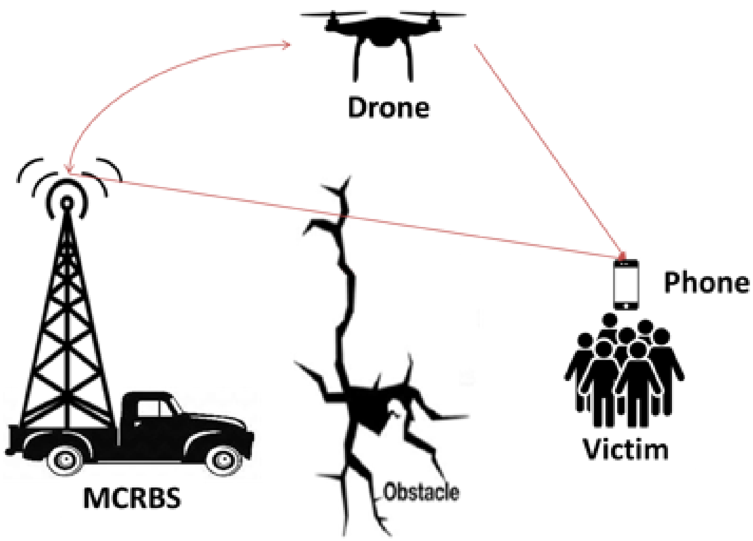

Fig 1.1 The illustration of extended communication between MCRBS between UAV linked to the victims due to the obstacles.

an area with a radius of 5 km with a return loss of less than -10 dB with an Omni-directional radiation pattern and minimum gain of 1 dB with frequency ranges are operated at 0.8 – 3.3 GHz. However, the MCRBS can potentially be stuck in the post-disaster area due to large obstacles that make it unable to reach the closer area to the victims. Thus, extended communications are needed to cover inaccessible disaster areas by air, i.e., through an unmanned aerial vehicle (UAV) [5]. Fig 1.1 shows a solution of deploying drones to extend the MCRBS communications when it is stuck.

The UAV, commonly known as a drone, is an aircraft flying without a human pilot or unmanned. The drone is becoming essential tools with advanced applications ranging from surveillance, search-and-rescue effort (SAR), agriculture, wildlife monitoring [6]. It is used as a relay node to forward communications from the MCRBS during the post-disaster. On the other hand, the UAV have advantageous characteristics, i.e., flying at low altitudes, flexibility in their deployment, quick mobility, hovering capability, and economic cost [7]. Since the MCRBS is blocked by obstacles, the drones are operated with a maximum altitude of 150 m [8] and flown with a global positioning system (GPS) to find out the node positions [9]. The hierarchy of communication networks for UAV is a backbone for broadband communications to reach rural areas. The authors in [2] are proposed the optimal routes by considering the remaining battery lifetime and number of nodes to help the MCRBS work with the number of available nodes to increase possible routes for successful communications.

The communication quality of the networks between MCRBS and UAV changes over time and makes the channel fluctuate, causing the communication to unstable. The Rayleigh fading channel could be the main reason for the propagation environment whose characteristics can differ significantly from conventional terrestrial channel models [7]. In addition, the UAV consume high power in both the transmitter and receiver applications making them difficult to apply in the field. One of the solutions to reduce the power consumption of battery lifetime is by introducing a simple channel coding scheme. This thesis focuses on the channel coding termed Polar codes for UAV communication, because the Polar codes have low computational complexity and simplicity of construction suitable for UAV.

Polar codes, introduced by Erdal Arikan, are the first family of error corrections proven to have reached channel capacity with efficient input, decoding, and construction algorithms [10]. The Polar codes were mathematically designed, where the performances are mathematically proven. The construction of Polar codes relies on the recursive application of reversible linear transformations while combined with an SC decoder, where effectively to divide the symmetrical channel into several polarized sub-channels [11]. The Polar codes have been shown to provide good error correction performances. However, the performance of Polar codes increased more slowly using long block lengths than many previously used codings, such as LDPC and Turbo codes.

The authors in [12] conducted a study on the development of Polar code decoding, named List decoding. The Polar codes with List decoding can have good performances and approximate the ideal decoding of maximum-a posteriori probability with the number of list size. A study of List decoding also has been done in other papers [13] and [14]. The principle of List decoding is dividing the node into two paths with estimated bits of 0 or 1. The List decoding keeps the several paths at each stage with calculated probabilities of paths in the list and compared to get the most likely paths.

The construction of single kernel Polar codes is limited to the block length power of 2. It can be expanded using the recursive Kronecker product from matrix 2×2. In [10], Arikan had suspected that the polarization phenomenon is not limited to the power of kernel T_2 and allowed some researchers to conduct the structure from the construction of Polar codes to improve the polarization performance based on a larger kernel. The authors in [15] have proposed an alternative kernel dimension concept, called multikernel constructions, where it offers increased block length flexibility. The studies of [16] [17] have proposed numerical illustrations on a multikernel matrix of 3×3 compared with the Polar codes using puncturing and shortening based on the minimum-distance spectrum to determine information bits and frozen bits with reliability distances.

A new study on kernel construction has been developed, called Hybrid multikernel. The authors in [18] proposed the hybrid multikernel codes with different matrix constituents. The constructions designed on different virtual channels performed using Bhattacharyya parameters, where the measure polarization is used to characterize the polarization performances. The other studies also conducted the Polar codes using additive white Gaussian noise (AWGN) channels and Rayleigh fading channels for Polar codes with short blocklength effects [19] [20].

In this thesis, the hybrid multikernel construction is designed for the communications between MCRBS and UAV with different matrix constituents by selecting the optimal matrices for the construction. This thesis proposes the decoding technique for hybrid multikernel codes to obtain the accurate error performances. The BER performance is evaluated based on the decoding techniques under additive white Gaussian noise (AWGN) and block Rayleigh fading channels with binary phase shift keying (BPSK) as the modulation.

1.2 Problem Identification

The communication quality of the networks between MCRBS and UAV changes time-by-time, making the communications unstable. The UAV have higher power consumption that should be simply applied in the field and consumes less power while being a transmitter or receiver. However, The conventional coding are complex to be applied to the UAV flying base station.

1.3 Objective

One of the solutions to reduce the power consumption or extend battery lifetime is by introducing a simple channel coding scheme. This thesis uses Polar codes as a channel coding, where the Polar codes have a simple construction code and have low complexity. The hybrid multikernel construction is needed with a decoding algorithm to reduce error in systems with a flexible design to achieve low computational complexity.

The main goal of this thesis is to propose the decoding schemes for the hybrid multikernel constructed Polar codes as suitable coding for devices requiring low power consumption. This thesis also provides performance analysis in terms of BER under AWGN and block Rayleigh fading channels.

1.4 Scope of Work

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

1. This thesis uses hybrid multikernel-constructed Polar codes with different matrices 3×3 and 2×2 for short blocklengths.
2. This thesis uses Bhattacharyya parameters and Polar Weight to find the location of frozen and information bits.
3. These channels are assumed to be AWGN and block Rayleigh fading channels with BPSK as the modulation.
4. The thesis evaluates the hybrid multikernel-constructed Polar codes with the proposed decoding performances in terms of bit-error rate (BER) via a series of computer simulations.

1.5 Research Methods

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

1. WP1: Study literature
   In this WP, this thesis studies the basic theory related to Polar codes papers, journals, and textbooks. This study of literature is intended to explain the basic concepts and theories to support the understanding of channel coding, proposed systems, and the results analysis.

2. WP2: Design Hybrid multikernel-constructed Polar codes
   This thesis designs hybrid multikernel-constructed Polar codes using mixed kernel size of 3 and combined with single kernel size of 2 in both encoding and decoding. The successive cancellation (SC) decoding and List decoding are used as the decoding technique in the system.

3. WP3: Performance evaluations
   This thesis evaluates the performances of hybrid multikernel-constructed Polar codes consisting of BER. This WP works on proving the BER performances under AWGN and block Rayleigh fading channels. In this step, this thesis performs simulation and analysis using a computer simulation.

4. WP4: Result validation
   In this WP, this thesis evaluates all results of the performances of proposed Polar codes.

1.6 Structure of Thesis

The rest of this thesis is organized as follows:

CHAPTER II: CHANNEL CODING THEORIES

This chapter describes the channel coding theories, especially Polar codes. This chapter also introduces the general description of multikernel, hybrid multikernel, including encoding and decoding process.

CHAPTER III: SYSTEM MODEL AND PROPOSED CODING

This chapter describes the system model and the hybrid multikernel-constructed Polar codes with the proposed decoding.

CHAPTER IV: PERFORMANCE EVALUATIONS

This chapter discusses the BER performances of the proposed decoding schemes for hybrid multikernel with several decoding techniques, (i) SC decoding, (ii) List decoding under AWGN and block Rayleigh fading channels.

CHAPTER V: CONCLUSIONS

This chapter concludes the thesis and notifies the future work.