CHAPTER 1
INTRODUCTION

1.1 Background

Indonesia, based on data released by the National Agency for Disaster Management (BNPB) [1], is the most vulnerable to disaster countries in the world. One of the biggest catastrophic events that occurred lately (28 September 2018) was the tsunami in Palu, Donggala, and Sigi that resulted in 2113 victims died, 1309 missing, and 4612 injured [2]. Proper post-disaster handling holds an important part in the recovery process of disaster-affected areas. One of the most important things that must be done immediately after a disaster is the search for victims in disaster-affected areas. Rescue of victims at the disaster site must not exceed the critical 72-hour period, after which the chances of rescuing victims become increasingly difficult [3]. In a disaster event, victims usually experience difficulty to get help and contact their relatives, due to the cellular network down. On the other hand, many victims might still have access to their mobile phone.

Traditional victims' positioning system includes an optical life detection system, infrared life detection system, and radar life detection system have been developed for a long time to accelerate the process of finding victims in the disaster-affected area [4]. The optical life detection system cannot observe into the ruins of the building construction, hence buried survivor cannot be detected by this system. The infrared life detection system cannot penetrate obstruction, which in many disaster-affected areas, victims are trapped under the building ruins. Life detection radar is one of the best equipment that can be used in a disaster event, this system has the ability to detect victim's physiological signals from dozens of meters away and can detect the signals from outside the ruins [5]. However, the coverage of life detection radar is limited, this system is not suitable for victim search in a large disaster-affected area.

The mobile phone transmits electromagnetic waves (cellular signals) to communicate with the Base Transceiver Station (BTS), and nowadays people always bring their mobile phones everywhere they go. This assumption can be used to detect the presence of victims in disaster areas. Hence, locating the victims by utilizing the cellular signals transmitted by the victim's mobile phone is one of the solutions that can be used to accelerate the process of victims finding in the disaster-affected area.

Open-source cellular network has been known as an alternative to recover telecommunication network in post-disaster situation. Some of the popular software that can be used to implement cellular networks are OpenBTS for 2G network, OpenBTS-UMTS for 3G network and srsLTE for 4G/5G network. Open-source cellular network, even though still not fully functional as a normal cellular network, but can perform major function of BTS in telecommunication network [6, 7].

Mobile phone auto registration [8] is one of the solutions that can be used to estimate the number of victims in disaster areas. Auto registration is a mechanism to force mobile stations (MS) within the coverage of the BTS to connect to the BTS (regardless of the the mobile stations operator). The previous study also shown that this technique can be used to detect victims with a maximum distance of 1.1 km by using a 20 W power amplifier [9] and provide better accuracy with using directional antenna. Mobile phone auto registration can only be applied for 2G network due to the difference security mechanisms in cellular network technology. In 2G network, BTS does not need to know the encryption key (Ki) of the MS to be able to connect with the BTS. In 3G and 4G network, BTS needs to know the Ki of the MS to connect to the BTS, this mechanism is known as mutual authentication [10]. Although the subscriber could not connect to the BTS in 3G, 4G, and 5G network, the BTS is able to record the International Mobile Subscriber Identity (IMSI) of the subscriber during the connection attempt.

In a normal condition, a mobile station will search and attempt to connect to the BTS with the strongest signal. In a disaster event, it is assumed that the cellular network is down and unable to serve the subscriber. This thesis proposes a technique to detect victim's location in a disaster area by using a victim finding system (VFS). The VFS is developed based on open-source cellular implementation software to provide a temporary cellular access network, which covers 2G, 3G, 4G, and 5G networks in a disaster-affected area with the main purpose to detect victims' mobile phones which assumed located close from the victim. When a VFS operates in the disaster-affected areas, the VFS is the only cellular network available in that area and automatically become a BTS with the strongest signal. The VFS records the identity of the victim's MS in the form of International Mobile Subscriber Identity (IMSI) in the VFS history log and furthermore, this data can be used to update the presence of victims in disaster-affected areas. Due to VFS's main purpose to perform victims' search, VFS will not provide BTS common functions such as call, SMS, and data services; therefore, it will eliminate the need for manual configuration at the rescuer side and minimize the configuration effort at victims' side.

A VFS use Software Defined Radio (SDR) to perform the radio function, and the coverage of the VFS is limited by the capability of the Software Defined Radio. Due to the above limitation and to use VFS effectively, the coverage of the VFS in a practical condition needs to be evaluated. To obtain a result that similar to a post-disaster condition, the experiment is conducted in an open environment with minimum obstacle and it is assumed that the condition between the VFS and victims' mobile phone is Line of Sight (LOS). The performance of the proposed system is evaluated by comparing the result of the simulation and experiment.

1.2 Problem Identification

Detecting victims in the disaster area is critical during post-disaster evacuation. In most disaster events, telecommunication infrastructures are paralyzed, due to the following two reasons:

(i) Service of base stations is off with common reasons of:

1. Broken base station due to the destruction by strong earthquakes or flood;
2. Power outage since the backup batteries can last only 1 to 2 hours , where 70% of the 3300 disconnected base stations during 88 flood were out of power [3];
3. Destroyed backhaul links.

(ii) Victims cannot be reached although they have enough battery of mobile phone. The victim's mobile phone can receive signals from the base station if the service is available.

1.3 Objective

The objective of this thesis is to develop a VFS system to find mobile devices within the coverage of the VFS and lead the rescuer to the victim. The proposed technique is designed to find victims in a disaster area by utilizing cellular signals of 2G, 3G, 4G, and 5G transmitted from the victim's mobile phone by observing power transmitted by the VFS, coverage of the VFS, identity of victim's MS, and received signal strength indicator (RSSI) level at victim's MS. In addition, this thesis identifies the users based on mobile device identity to update the list of victims with the detection success rate above 75%.

1.4 Scope of Work

This thesis considers the following conditions:

1. VFS only provides location estimation of a victim in the coverage area and does not provide a detail location of the victim.

2. All devices are using an open-source software, where all process and synchronizations are performed by the USRP and the software.

3. This thesis does not change modulation and coding rate, therefore main parameters are not changed, except the most related point to the detection of victims.

4. This thesis uses USRP to represent 5G User Equipment (UE), because currently (2020) the legal 5G mobile is not available yet in the Indonesia market.

1.5 Research Methodology

This thesis is divided into four work packages (WP) as follows:

1. WP1: A series of computer simulations to determine the percentage of the success rate compared to the received signal strength indicator (RSSI) threshold to estimate the theoretical coverage of the proposed VFS system.

2. WP2: 2G cellular network implementation and RSSI real-field measurement. 2G cellular network is implemented using OpenBTS software and USRP B210. The RSSI measurement is performed with android phone and net-monitor application.

3. WP3: 3G and 4G cellular networks implementation and RSSI real-field measurement. 3G cellular network is implemented with OpenBTS-UMTS and 4G cellular network is implemented with srsLTE software and USRP B210. The RSSI real-field measurement is performed with an android phone and net-monitor application.

4. WP4: 5G cellular network implementation and RSSI real-field measurement. 5G cellular network is implemented with srsLTE software and USRP B210 operates at 5G frequency.

The results obtained from the computer simulations are to be confirmed with the real-field measurement results from the cellular network experiment to evaluate the effectiveness of the proposed VFS system.

1.6 Structure of Thesis Proposal

The rest of this thesis is organized as follows:

CHAPTER 2: Basic Concept

This chapter describes the basic concepts of SDR, mobile cognitive radio base station (MCRBS), and cellular communications technologies which cover 2G, 3G, 4G, and 5G.

CHAPTER 3: System Model and The Proposed Victim Finding Technique

This chapter discusses the main components of the VFS to be used in this thesis, system model and proposed VFS.

CHAPTER 4: Performance Analysis

This chapter discusses the simulation and experiment results and provides an analysis of the results.

CHAPTER 5: Conclusion

This chapter discusses the conclusion of this thesis obtained from the analysis of simulation and experiment results.