DEVELOPMENT OF AF RELAY USING USRP PLATFORM FOR INDOOR

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Specially dedicated to my beloved husband, *Mak* and *Ayah*

Thanks for all of your support.

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ABSTRACT

The increasing customer demand in broadband mobile wireless communication technology leads to the introduction of the relay. Relay is able to increase the capacity and coverage between base station and mobile user. There are a lot of benefits that motivate the usage of relay, including reducing the power used at base station and extending coverage area. Existing literature on relay focuses mainly on simulation, with no measurement validation. This research therefore aims to develop a prototype of Amplify-and-Forward (AF) relay using software defined radio. The proposed relay is developed using LabVIEW software and programmed on NI-USRP 2922 software defined radio platform. Measurement is performed indoor and the signal strength or receive power at the mobile user with and without relay is recorded. The result shows that the receive power performance and signal-to-noise ratio (SNR) at the user improve 23% when the AF relay is deployed, as compared to direct link point to point transmission without relay. As a future work, the proposed relay can be further studied in outdoor environment and MIMO antenna configuration to determine the receive power performance in line-of-sight area.

ABSTRAK

Permintaan pelanggan yang meningkat terhadap perkhidmatan jalur lebar untuk sistem komunikasi tanpa wayar telah memacu kepada pengenalan *relay*. *Relay* adalah satu teknik yang digunakan untuk meningkatkan penghantaran isyarat kapasiti antara Stesen Penghantar dan Penerima. Terdapat banyak faedah yang mempengaruhi penggunaan *relay* termasuk penghantaran kuasa yang kurang digunakan di Stesen Penghantar, lanjutan perlindungan yang tinggi dan lain-lain. Kajian ini dibuat untuk mengkaji pembangunan *Amplify and Forward* (AF) relay bermula dari Stesen Penghantar, *relay* AF dan akhirnya kepada Penerima. Ia dibangunkan dengan menggunakan perisian LabVIEW dan diprogramkan pada perkakas NI USRP-2922. Pengujian dilakukan di dalam bangunan Makmal WCC dan prestasi yang diukur adalah kekuatan isyarat atau Kuasa Penerima, Pr. Ia menunjukkan bahawa menerima prestasi kuasa dan SNR bagi *relay* AF adalah lebih baik berbanding dengan langsung titik pautan ke titik penghantaran dengan kenaikan sebanyak 23%. Pada masa hadapan, pengujian *Relay* ini boleh dibuat di luar bangunan serta menggunakan konfigurasi MIMO antenna untuk melihat prestasi kuasa Penerima pada kawasan Had Penglihatan.

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LIST OF ABBREVIATIONS

AF	-	Amplify and Forward
OFDM	-	Orthogonal Frequency Division Multiplexing
DF	-	Decode and Forward
CF	-	Compress and Forward
BS	-	Base Station
NAF	-	Non-orthogonal Amplify and Forward
SAF	-	Slotted Amplify and Forward
DMT	-	Discrete Multitone Modulation
SISO	-	Single Input Single Output
MIMO	-	Multiple Input Multiple Output
USRP	-	Universal Software Radio Peripheral
FGPA	-	Field Programmable Gate Array
FFT	-	Fast Fourier Transform
IFFT	-	Inverse Fast Fourier Transform
VI	-	Virtual Instrument
PC	-	Personal Computer
WCC	-	Wireless Communication Centre
IQ	-	Quadrature signals
LOS	-	Line of Sight
NLOS	-	Non-Line of Sight

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The demand for data rate in wireless mobile communication increases drastically in recent years [1]. The number of available data capacities and the customer demand is not synchronous. The growth of the demand surpasses the available capacity. In order to enhance the data rate and spectral efficiency [2], relay has been proposed as the alternative.

Relay is a concept taken from a repeater. The main function of relay to is to forward signals from base station to user and vice versa [3]. The relay is used to increase the system cell edge coverage effectively [4]. By using relay, the data transmission between Base Station and User at cell edge increases and the quality of the channel improves [4]. The other benefit of the implementing a relay is that it can reduce the power transmission consumption at the Base Station.

The relay can also be used to prevent the limitation of half duplex due to the incompetence of current modems to receive and transmit data at the same frequency and time. Another advantage of relay implementation is that it can avoid additional cost to build another Base Station in the network. Relay can be installed anywhere such as at the top of the lamp post or building because the relay hardware is of small

form factor. This will make the operation faster, flexible and cost effective for operators [5].

1.2 Problem Statement

The followings are the problem statements for this project:-

i. The conventional fabricated relay is realised using fixed hardware. If any changes or modifications are needed on the relay operation, the whole set of hardware needs to be changed. This makes the implementation of relay to become very costly.

ii. Previous studies are made in simulation environment rather than based on field study in real operating environment. In this situation, simulation result is an ideal case where it does not consider any kind of practical circumstances, such as the environment factors, weather and also the propagation conditions.

1.3 Research Objectives

The objectives of this project are:

i. to develop amplify-and-forward (AF) relay prototype using universal software radio peripheral (USRP) platform and LabVIEW software,

ii. to measure the receive power of relaying network in comparison with point-to-point direct transmission for indoor environment.

1.4 Scope of Work

The objectives of this project can be achieved within the scopes outlined. The project uses the off-the-shelf NI USRP 2922 software defined radio to implement the three-node network consists of the proposed AF relay, base station and mobile user. The programming of the USRP is made using NI LabVIEW software.

The measurement is done indoor where the parameter considered is the received power at the user. The measurement is done only for downlink transmission and for single-input and single-output (SISO) antenna configuration only.

1.5 Thesis Outline

This thesis consists of five chapters. Chapter 1 gives an overview and the introduction of the project.

Chapter 2 discusses the literature review on the concept of AF relay techniques. The characteristics of AF and the purpose of choosing these techniques are explained in details by comparing with previous studies. Other than that, the concept of software defined radio (SDR) and the use of USRP is also discussed in this chapter. In addition, the benefits of using AF relay are specified. Finally, the concept of OFDM is also explained.

Chapter 3 contains the design methodology of the project. The design is illustrated using flow charts to show the development of three main nodes which are base station, AF relay and mobile user. Then, the measurement setup of the USRP with a LabVIEW implementation is be discussed in this chapter.

In Chapter 4, the result and analysis of the point-to-point direct transmission and AF relay assisted transmission are elaborated with the support of previous study and also the theory of indoor propagation model.

Finally, Chapter 5 presents the conclusion of this project. The future work is also elaborated in this chapter.

1.6 Summary of Work

The project flow illustrated in Figure 1.1. The project begins with the literature review, followed by the simulation of the ergodic capacity versus SNR using Matlab, for AF relay associated network in comparison with point-to-point direct transmission. Next, the LabVIEW coding of a source, AF relay and destination will be developed using basic transmission and receiver block diagram with the aid of OFDM, Multiplexer, QAM Modulation, Matched Filter and some other coding's. The coding will be programmed onto the NI-USRP2922 FPGA system and the downlink transmission will be tested. At first, the test runs on the equipment rack in the laboratory. After the system is working as specified, it runs in real indoor and environment. The parameter measured is the receiving power versus distance. The final step is presentation and thesis writing.

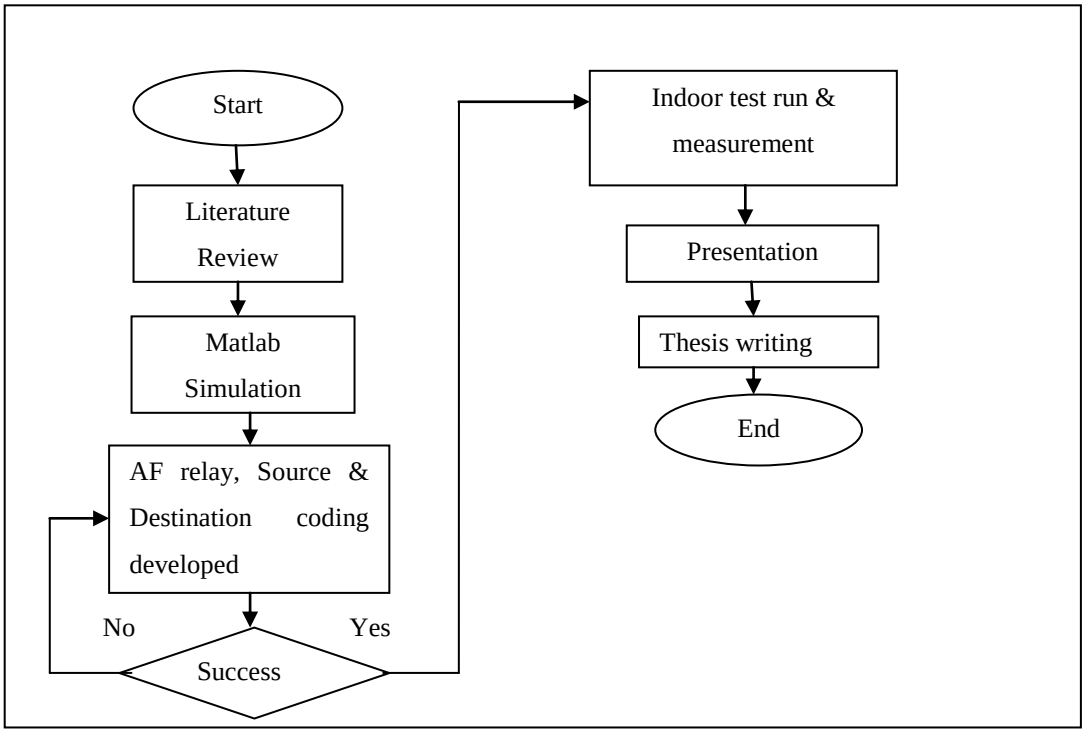

Figure 1.1: Project overview

Figure 1.2 shows the Gantt chart of the project schedules for phase one and phase two. The implementation of phase one was in semester one which covers studying and understanding of literature review and also the determining the project specification. Previous research related to this project and various types of relay techniques is studied, including AF relay technique**.**

For phase two, the development of AF relay and also the Base Station (source) and user (destination) coding using LabVIEW and NI-USRP 2922 are performed. Then, indoor measurement of the receive power for relay assisted network and point-to-point direct transmission are accomplished. Finally, presentation and thesis writing are made after the development and measurement of relay is completed.

PHASE ONE															
MONTH	FEBRUARY			MARCH				APRIL				MAY			
WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Research on related topic															
Literature review															
Methodology study															
Presentation															
Report writing															

(a)

PHASE TWO																
MONTH	SEPTEMBER				OCTOBER				NOVEMBER				DECEMBER			
WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Development of AF relay, BS and User																
Indoor measurement																
Presentation																
Thesis writing																

(b)

Figure 1.2: Project schedule for (a) phase one (b) phase two

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