DEVELOPMENT OF COOPERATIVE RELAY USING UNIVERSAL SOFTWARE RADIO PERIPHERAL

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Specially dedicated to *my mother Siti Aishah Omar* and *my father Sabirin Ikhsan* also my brothers *Mohammad Rashid, Mohammad Ridhuan* and *Mohammad Radzi* who have encourage, guide and inspired me throughout my entire life.

Hopefully, all the contributions are blessed by Allah S.W.T, The Mighty Creator.

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ABSTRACT

To meet the demand for high speed data, wireless cellular system technology has grown in a steady pace. However, the wireless signals are still vulnerable to the multipath fading, shadowing and path loss, making the communication less reliable. Cooperative relay is a techniques to improve signal reliability by introducing a an additional node between source terminal and destination terminal to provide redundant path for data transmission. However, existing work of cooperative relay investigate performance through theoretically simulation only. The real world performance remains unknown because the lack of prototype for field testing and measurement. The focus of this work is therefore to implement the cooperative relay prototype using Universal Software Radio Peripheral (USRP) and LabVIEW platform. The relay prototype based on Amplify-and-Forward (AF) protocol has been developed. The performance in terms of bit error rate (BER) of the cooperative relay link is compared with the direct link without relay. The measurement is carried out in the indoor environment. Measurement results show that the cooperative relay significantly improves the signal reliability and extends the coverage distance if compared to direct communication without relay.

ABSTRAK

Dalam usaha untuk memenuhi tuntutan untuk data berkelajuan tinggi telah menyebabkan perkembangan pesat dalam teknologi wayarles sistem selular akan tetapi isyarat wayarles masih terdedah kepada kesan pelbagai arah yang pudar , membayangi dan rendah kekuatan isyarat yang menyebabkan isyarat kurang diperolehi. Geganti Koperasi adalah teknik yang mampu meningkatkan kebolehpercayaan isyarat dengan memperkenalkan geganti pautan sebagai nod tambahan antara terminal sumber dan terminal destinasi. Walau bagaimanapun, kerja-kerja yang telah dibuat oleh penyelidik ,dengan menyiasat prestasi relay koperasi melalui teori atau prototaip simulasi akan tetapi bahawa prototaip adalah penting dimana ia boleh diuji prestasinya sebelum dilaksanakan dalam persekitaran sebenar.Fokus dalam kerja ini adalah untuk melaksanakan komunikasi koperasi berdasarkan Universal Perisian Radio Persisian (USRP) dan platform LabVIEW dalam persekitaran yang sebenar. Teknik relay berdasarkan Amplift-dan-Forward (AF) diimplikasikan pelaksanaanya. Prestasi perbandingan kadar ralat bit (BER) antara pautan geganti kerjasama dengan pautan langsung telah dinilai. Persediaan eksperimen dijalankan dengan senario yang berbeza dan dijalankan dalam kawasan persekitaran tertutup. Hasil keputusan menunjukkan pautan geganti koperasi dapat meningkatkan prestasi dari segi kebolehpercayaan isyarat dan liputan jarak lanjutan.

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LIST OF ABBREVIATIONS

1G	-	First Generation
4G	-	Fourth Generations
MIMO	-	Multiple Input and Multiple Output
SDR	-	Software Defined Radio
NI	-	National Instrument
USRP	-	Universal Software Radio Peripheral
BER	-	Bit Error Rate
AF	-	Amplify & Forward
OFDM	-	Orthogonal Frequency-Division Multiplexing
SISO	-	Single Input Single Output
LOS	-	Line of Sight
N-LOS	-	Non Line of Sight
eNB	-	enhanced Node B
UE	-	User Equipment
DF	-	Decode & Forward
QAM	-	Quadrature Amplitude Modulation
PSK	-	Phase Shift Keying
ADC	-	Analog to Digital Converter
DAC	-	Digital to Analog Converter
DSP	-	Digital Signal Process
FPGA	-	Field Programmable Device Array

FM	-	Frequency Modulation
AM	-	Amplitude Modulation
PM	-	Phase Modulation
ASK	-	Amplitude Shift Keying
FSK	-	Frequency Shift Keying
PAM	-	Pulse-Amplitude Modulation
QPSK	-	Quadrature Phase Shift Keying
GMSK	-	Gaussian Minimum-Shift Keying
MSK	-	Minimum-Shift Keying
2D	-	Two Dimensions
3D	-	Three Dimensions
WARP	-	Wireless Open-Access Research Platform
LTE	-	Long-Term Evolution
PC	-	Personal Computer
IP	-	Internet Protocol
FFT	-	Fast Fourier transforms
VI	-	Virtual Instrument
SNR	-	Signal to Noise Ratio

LIST OF SYMBOLS

dB	-	Decibel
m	-	meter
Hz	-	Hertz

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CHAPTER 1

INTRODUCTION

1.1 Project Background

The growing demand of data applications has led significant development in wireless communications. The development of cellular networks from first generation, 1G until the latest fourth generation, 4G is due to the demand in high speed data rate among the users. However, to provide an improvement of signal reliability and enhanced system capacity remains a challenge. This is due to various propagation effects like path loss, shadowing, multipath fading and interference.

Multiple Input and Multiple Output (MIMO) is one of the approaches to improve the data rate and reliability. In MIMO, the receiver receives the combined signals from individual paths which are independently distributed in frequency, time and space. This technique is known as spatial diversity which can enhance the system performance. However, a higher cost is required to upgrade an existing base station with the multiple antennas for MIMO.

On the other hand, wireless relay terminal offers improvement of signal reliability and cost efficiency whereby its deployment is not relying on wired backhaul. A relay is introduced in between source terminal, and destination terminal to provide redundant path known as the cooperative relay link for transmission. The conventional wireless system used a point-to-point link from the base station to the user equipment. This link is also known as a direct link. A relay can boost the signal reliability by combining the cooperative relay link and direct link.

1.2 Problem Statement

The following are the problem statements for this project:

(a) Most of the existing works on cooperative relay investigate the performance through theoretically simulation. The real world performance remains unknown because the lack of relay prototype for field testing and measurement.

(b) The simulations usually fail to realistically capture the real world wireless signal propagation effects, which motivates the need of a testbed of practical relay to access the performance in actual environment.

1.3 Research Objectives

The objectives of the project are:

(a) to develop a cooperative relay testbed using Universal Software Radio Peripheral (USRP) and LabView platform software.

(b) to measure the performance bit error rate (BER) performance of cooperative and direct communication in indoor environment.

1.4 Scope

The scope of work is outlined in this section.This project covers the development of three-node network consists of source, destination and a relay. The cooperative relay technique used is amplify-and-forward (AF).

Besides that, the modulation will be accessed using orthogonal frequency-division multiplexing (OFDM) mode. Scenarios consists of source, destination and relay like single input single output (SISO) configuration, single relay network, the

line of sight (LOS) and non line of sight (N-LOS) environments are considered. Lastly, all the measurements perform on the downlink transmission.

1.5 Thesis Outline

The structure of the report consists of five chapters. In Chapter 1, the introduction and overview of this project is stated.

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In Chapter 2, the literature review on cooperative relay and AF relay and also the benefits of using SDR in developing of wireless system is highlighted. The hardware and software tools used in this project are discussed as well. The Related work about the cooperative relay based either on theoretical simulations and testbed measurements are reviewed in order to identify the research gaps.

The methodology of the project is covered in the Chapter 3. In this chapter, the overview of the development USRP relay testbed is discussed. There are two phases in developing the testbed. The first phase of development starts with the direct link communication between the source and the destination. The second phase covers the cooperative relay development, where the relay node is introduced between the source and destination. The experimental setup and the configuration parameters of the project is explained and the measurements of BER performance is conducted in the indoor environment.

In Chapter 4, the results of BER performance measurement of the direct link versus cooperative relay link communication is analysed. Discussion on whether the relay prototype meets the requirements of the project is made.

Finally, in Chapter 5 a conclusion is drawn to summarise the main findings of this project. Potential future works is also suggested.

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