Sudan University of Science and Technology

College of Engineering

School of Electronics Engineering

COOPERATIVE COMMUNICATION WITH RELAY NETWORK

الاتصالات التعاونية مع شبكة محطة اعادة الارسال

A research submitted in partial fulfillment for the requirements of the degree of B.Sc. (Honors) in Electronics Engineering

Prepared By:

1. Lana Hassan Sharif Ahmed.
2. Sanaa Aboul-fotouh Zahir Surour.
3. Sogod Abdelmotalab Fadl-elmola.

Supervised By:

Dr. Jacqueline John George.

October 2015

قال تعالي :

{ وَقُلِ اعْمَلُواْ فَسَيَرَى اللّهُ عَمَلَكُمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ وَسَتُرَدُّونَ إِلَى عَالِمِ الْغَيْبِ وَالشَّهَادَةِ فَيُنَبِّئُكُم بِمَا كُنتُمْ تَعْمَلُون }

التوبة 105

To our great parents….

Acknowledgements

First and foremost we must thank Allah, the Ever-Magnificent; the Ever-Thankful, for his help and blessings.

We thank our supervisor **Dr. Jacqueline John George** who has been always generous during all phases of the research and we are totally sure that this work would have never been, without her guidance.

We are grateful to some people, who worked hard with us from the beginning till the completion of this research; in particular we thank **Dr. Idreas E. B. Adam**, **Mayada Abdelgadir Mohamed**. We extend our sincere thanks to our colleague **Mubarak Mohammed** for his great efforts with us and his continuous support.

We would like to take this opportunity to thank all our beloved friends, who have been so supportive along the way of doing this thesis.

ABSTRACT

Wireless channels suffer severely from the effect of multi-path and fading. To mitigate these effects cooperative diversity protocols are used. In cooperative diversity, two or more users share their antennas to create a virtual MIMO system. Hence in cooperative communication several single antenna relays assist the transmission between a source and a destination.

In this thesis Matlab program was used to simulate the performance of the cooperative communication protocols; Amplify and Forward (AF), Decode and Forward (DF) and Quantize and Forward (QF). The received signals at the destination were combined using the Maximal Ratio Combining (MRC) technique. The performance of the cooperative communication protocols was simulated for a single relay and multi relay in Rayleigh fading channel, using M-ary Phase Shift Keying (M-PSK). The results showed that the Quantize and Forward (QF) had the best performance in one relay and two relay compared to the Amplify and Forward (AF) and Decode and Forward (DF) when using BPSK, QPSK and 8PSK.

المستخلص

القنوات اللاسلكية تعانى من تأثير تعدد المسارات والتلاشي الذى يحدث للاشارة . للحد من هذا التأثير نستخدم بروتوكولات التنوع التعاونية . في التنوع التعاوني يقوم اثنين او اكثر من المستخدمين بتبادل الهوائيات لأنشاء نظام ظاهر لنظام المداخل المتعددة والمخارج المتعددة التالي في نظام الاتصالات التعاونية نستخدم هوائي واحد في محطة اعادة الارسال لنقل البيانات بين المرسل و المستقبل.

في هذه الأطروحة استخدمنا بعض البروتوكولات : تكبير الاشارة و ارسالها، فك تشفير الاشارة ثم اعادة تشفيرها و اعادة ارسالها ، تكميم الاشارة ثم ارسالها و يتم عمل محاكاة لهذه البروتوكولات بإستخدام الماتلاب. في المستقبل يتم استقبال الاشارات و تجميعها بخوارزمية تجميع الاشارات للوصول الى اشارة ذات نسبة اشارة عالية بالنسبة الى الضجيج.

و يتم قياس أداء النظام بإستخدام نسبة الخطأ لكل ثمانية بت ثم عمل محاكاة لها باستخدام محطة واحدة وعدة محطات اعادة ارسال وذلك في قناة رايلى للتلاشي باستخدام ازاحة الطور الثنائي والرباعي والثماني.

Table of Contents

List of Tables

Table **Page**

List of Figures

Figure **Page**

List of Symbols

$\eta_{s,d}$	Additive White Gaussian Noise from source to destination
η_{s,r_i}	Additive White Gaussian Noise from source to relay$_i$
$\eta_{r_i,d}$	Additive White Gaussian Noise from relay$_i$ to destination
$\eta'_{r_i,d}$	Equivalent Additive White Gaussian Noise
ψ_{PSK}	SER formulations for an un-coded system with *M*-PSK
δ	Variance that came with channel coefficients
ρ	Signal to Noise Ratio (SNR)
γ	Total instantaneous SNR of the MRC output
γ_1	Total instantaneous SNR of the MRC output from source to destination
γ_2	Total instantaneous SNR of the MRC output from source to relay$_i$
a_1, a_2	Factors that maximized the SNR of the MRC output
$h_{s,d}$	Channel coefficients from source to destination
h_{s,r_i}	Channel coefficients from source to relay$_i$
$h_{r_i,d}$	Channel coefficients from relay$_i$ to destination
h^*_{s,r_i}	Conjugate channel coefficients from source to relay$_i$
$h^*_{r_i,d}$	Conjugate channel coefficients from relay$_i$ to destination
K	Number of bits
M	Number of modulation levels
$\mathcal{N}_0$	Variance that came with Additive White Gaussian Noise
P	Parameter changes depend on the function of the protocol
P_1	The transmitted power at the source
P_2	The transmitted power at the relay$_i$

$\tilde{P_2} = P_2$	If relay decode the transmitted symbol correctly, otherwise $\tilde{p}2=0$
q	Uniform quantization bits
$y_{s,d}$	Transmitted signal from source to the destination
y_{s,r_i}	Transmitted signal from source to relay$_i$
$y_{r_i,d}$	Transmitted signal from relay$_i$ to the destination
x	Transmitted information symbol
x_{r_i}	Transmitted information symbol from relay

Abbreviations

8PSK	8 Phase Shift Keying
AF	Amplify and Forward
AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
CF	Compress and Forward
DF	Decode and Forward
EGC	Equal Gain Combining
FEC	Forward Error Correction
MIMO	Multiple Input Multiple Output
MRC	Maximal Ratio Combining
M-PSK	M-ary Phase Shift Keying
M-QAM	M-ary Quadrature Amplitude Modulation
P/N_0	Average Signal to Noise Ratio (SNR) per Bit
QBSK	Quadrature Phase Shift Keying
QF	Quantize and Forward

SC	Selection combining
SER	Symbol Error Rate
SNR	Signal to Noise Ratio