REPUBLIC OF SUDAN

MINISTERY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

RED SEA UNIVERSITY

FACULTY OF GRADUATE STUDIES

IMPROVED CAODV ROUTING PROTOCOL FOR COGNITIVE RADIO ADHOC NETWORK

A thesis

Submitted to the faculty of graduate studies in Fulfillment of requirements for the M.Sc. degree in electrical engineering (communication).

Submitted by

Rasha Eltayeb Abd Ellatif Altom

Supervised By

Dr. Adel Gaafar Abd Elrahim

APRIL 2018

Abstract

Cognitive Radio Network (CRN) introduced to solve the problem of spectrum scarcity by taking advantage of the unused spectrum. Cognitive Radio Ad-hoc Networks (CRAHNs) considered as one kind of different types of cognitive radio networks it operates without infrastructure and this lead to various challenge in data routing like frequent topology change, spectrum availability and intermittent connectivity caused by the Primary User (PU).The new routing protocols in cognitive radio network can solve that challenges but they introduced various shortage like the resource consumption and route complicity procedure.

In this thesis a new node model with a new routing protocol for (CRAHNs) referred as Cognitive Improved Ad-hoc On Demand Distance Vector (CIAODV) has been proposed with an aim to eliminate the overhead, resource consumption and taking advantage of conventional Ad-hoc On demand Distance Vector (AODV) protocol which considered as the most suitable protocol to dynamic and infrastructure less networks.

We evaluate the performance of CIAODV against AODV, the proposed protocol find out a stable route with the property of working coexist with the AODV nodes. Our simulation results indicate that the proposed algorithm achieves better performance in terms of throughput, end to end delay, packet delivery ratio and overhead. The performance evaluation has been conducted using OMNET++ simulator.

المستخلص

شبكة الراديو الأدراكي قدمت حل لمشكلة ندرة الطيف من خلال الاستفادة من الطيف الغير مستخدم. الشبكات الادراكية المؤقتة تعتبر واحدة من اشكال شبكات الراديو الادراكي المختلفة التي تعمل بدون بنية تحتية وهذا يؤدي الى تحديات مختلفة في مجال توجيه البيانات مثل كثرة تغييرشكل الشبكة، وتوافر الطيف والاتصال المتقطع الناجم عن وجود المستخدم الأساسي. بروتوكولات التوجيه الجديدة في شبكة الراديوية الإدراكية يمكن أن تحل تلك التحديات ولكنها أدخلت نقص اخر مثل استهلاك الموارد وتعقيد اجراءات ايجاد المسار المناسب.

في هذه الاطروحة تم اقتراح بروتوكول توجيه جديد بهدف القضاء على التاخير واستهلاك الموارد مع الاستفادة من البروتوكول التقليدي AODV الذي يعتبر اكثر البروتوكولات مناسبة للشبكات الديناميكية منعدمة البنية التحتية

في شبكة الراديو الادراكية يحدث التاخير نتيجة لوجود عدد كبير من الأجهزة المتحركة اثناء اختيار المسار المناسب مما يؤدي الى خروج بعض منها من مدى المستخدم الأساسي البروتوكول المقترح يقوم بكشف المسار واستخدام الاجهزة الاقل حركة لضمان مسار مستقر وتقليل التاخير بالاضافة الى تقليل استهلاك المصدر .

تم اجراء تقييم الأداء باستخدام برنامج المحاكاة OMNET++. اثبتت نتائج المحاكاة أن البروتوكول الجديد يحقق أداء أفضل في فترة الإنتاجية والتأخير بالمقارنة مع البروتوكول التقليدي.

TABLE OF CONTENTS

LIST OF FIGURES.....	**VII**
LIST OF ABBREVIATIONS.....	**IX**

CHAPTER ONE: INTRODUCTION.....	**1**
1.1 INTRODUCTION.....	1
1.2 MOTIVATION.....	2
1.3 RESEARCH CONTRIBUTIONS.....	2
1.4 THESIS ORGANIZATION.....	3
CHAPTER TWO: COGNITIVE RADIO PAR ADIGM.....	**4**
2.1 INTRODUCTION.....	4
2.2 Spectrum Scarcity…….……..	4
2.3 Cognitive Radio Technology…….…….	8
2.4 Cognitive Radio Networks……..……..	13
2.5 Cognitive Radio Ad-hoc Networks…….…….……	17
2.5.1 Classical Ad-hoc Networks vs. CRAHNs…….	17
2.5.2 Spectrum Management Framework……	18
CHAPTER THREE: Routing in Cognitive Radio Ad-Hoc Networks……	**24**

3.1 Introduction…….…….	24
3.2 Network layer for CRAHNs…….	25
3.2.1 Basic framework……	25
3.3 Routing in CRAHNs…….	27
3.3.1Routing challenges in CRAHNs……..…..…….	27
3.3.2 Design challenges of routing in this network…….	29
3.4 Solutions for the Three Main Challenges…….……...…..	31
3.4.1 Routing schemes based on full spectrum knowledge: ……	31
3.4.2 Routing schemes based on local spectrum knowledge: …….	32
CHAPTER FOUR: ROUTING PROTOCOL IN COGNITIVE RADIO ADHOC NETWORK……	**38**
4.1 Introduction……..	38
4.2 CLASSIFICATION OF ROUTING PROTOCOLS FOR CRAHNS…….	40
4.2.1 Based on Channel Switching ……	41
4.2.1.1C-DSDV Protocol …….....	41

4.2.2 Based in Link Modeling……	42
Based on Geographic forwarding…….…… 4.2.3	44
SEARCH Protocol - Spectrum Aware Routing protocol ……...…… 4.2.3.1	47
4.2.4 Based on Spectrum Awareness: ……..	48
4.2.4.1 SER - Spectrum and Energy Aware Routing Protocol…….……..	48
4.2.5 Based on Connectivity: …….……	49
GYMKHANA Protocol…….……. 4.2.5.1	49
4.3 Adaptation of on-demand routing to CRAHNs……	50
**CHAPTER FIVE: COGNITIVE IMPROVED AODV ROUTING PROTOCOL FOR COGNITIVE ADHOC NETWORK……..…….. **	**59**
5.1 Introduction …….	59
5.2 The Node Model of Cognitive Radio Capability ……...	60
5.2.1 Physical module: (PHY layer)…….	60
5.2.2Cross layer aware MAC protocol (C-AMAC)……	61

AODV Routing Protocol …… **5.3**	63
5.3.1 Method of transmission in AODV protocol……..	65
The Cognitive Improved AODV (CIAODV) protocol……. **5.4**	66
5.5 Simulation set up parameter…….…..…….	69
5.6 Conclusion……	75
CHAPTER SIX: CONCLUSION & FUTURE WORK.....	**76**
6.1 CONCLUSION.....	76
6.2 FUTURE WORK.....	77
REFERENCES.....	**78**

Finally we evaluate the performance of the new protocol and compare the results with the old one by discussing the advantage and disadvantage for both .From simulations we found that the new protocol has better performance in the terms of throughput, PDR, End To End delay and overhead.

6.2 Future Work

Various improvements can be addressed in future projects concerning network topology, node description and spectrum utility. In the same area an improved work can be done as below:

- Taking into account the availability of primary user by adding spectrum aware capability to avoid interference with it.
- Adding mobility aware channel to ensure the best selection of the node has the minimum movement to get the minimum hop count and improve the network stability.
- An enhancement in CIAODV protocol in the routing schemes like route selection and maintenance to cover their limitation can be carried out.

The protocol performance can be evaluated by using more performance metrics to cover larger area of studies.