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**Intelligent Vertical Handover Model based on Neuro-
Fuzzy for LTE and WiFi networks
(IVH-NF LTE/WiFi)**

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Fuzzy for LTE and WiFi networks**

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Prepared by:

Niveen Omar Saleh Jaffal

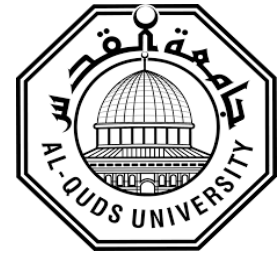
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Intelligent Vertical Handover Model based on Neuro-Fuzzy for LTE and WiFi networks (IVH-NF LTE/WiFi)

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Jerusalem – Palestine

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Dedication


Dedication To the sake of Allah, my creator and my master, To My great teacher and messenger, Mohammad (May Allah bless and grant him), To My parents, for their support and motivation throughout my life and career.

I dedicate my work also to my children (Ali, Omar, Abd Alrahman and Hala) who are the pleasure of my life and to my brothers and sisters (Saleh, Samer, Nisreen and Shireen), who always encouraged me to continue my way to achieve this degree. The work is dedicated also to my friends, family, work and my lovely city Jerusalem-Palestine.

Thank you all.

Declaration

I certify that this thesis submitted for the degree of Master, is the result of my own research, except where otherwise acknowledged, and that this thesis has not been submitted for higher degree to any other university or institution.

Signed: 

Niveen Omar Saleh Jaffal

Date: 15/ 05 / 2022

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Abstract

The rapid growth of the internet and the evolution of user equipment (UE) with multiple network interfaces contributed to provide more quality of services and enable the users a choice of connectivity to multiple access networks with different characteristics and transferring from one network to another. LTE from cellular networks and WiFi from IEEE802.x family networks are differ in coverage area, latency, data rate, signal strength, cost and bandwidth and each of these networks designed to support a different set of UE and specific services, so the limitation of these complementary wireless networks can overcome by integration of these different technologies into NGWN [1].

To make UE enjoy seamless connectivity and access to services anywhere at any time between these two heterogeneous networks, a vertical handover process is needed for achieving that, which is the switching between points of attachment or base stations within different network technologies. With development of technologies nowadays, the research of vertical handover algorithms in various mobility scenario networks today is still a challenging area for future research. In this thesis, we proposed an intelligent algorithm called IVH_NF which is compatible with UE for a vertical handover decision with four inputs parameters (RSS, PC, MS and D) gathering from the surrounding network for the UE between two heterogeneous integrated networks, WiFi and LTE using ANFIS technique which is based on Takagi–Sugeno Fuzzy Inference System (FIS) that combines both neural networks and Fuzzy logic principles, it takes the benefits of both in a single framework, it's working principle starts from allowing neural network to learn for tuning the parameters of a FIS using a collection of the training dataset to generate fuzzy membership rules which are responsible for selecting optimal network with achieving the best Quality of Service (QoS) in terms of enhanced Throughput, reducing the number of unnecessary handover and End to End Delay (EED).

The simulation results include first validating the accuracy of the mathematical IVH_NF design by MATLAB simulator through standard error measurement tools with statistical criteria such as RMSE, MAE and R^2 where these simulation results reveal that the mathematical design is achieve high level in accuracy, then many vertical handover scenarios were implemented from LTE to WiFi networks and extensive simulation experiments were carried out using Apache NetBeans simulator which reads the tuned rules as txt file which are responsible for VHO decision making and then study the effect

of UE speed and application Bitrate on the performance metric that affect the Quality of Service, such as Throughput, EED and Handover counts for vertical handover scenarios. The results obtained from the scenarios confirm that IVH_NF achieves better results in terms of enhanced the Throughput with acceptable values for speed and bitrates and with comparing our model with some previous VHO algorithms, we conclude that, it achieves improvement percentage in term of minimized EED by 58% from RSS [2] and reduced Handover counts by 33.3% from ANFIS [3] and 60% from Fuzzy Logic [4].

النموذج الذكي المعتمد على الشبكة العصبونية والمنطق الضبابي في التسليم العمودي بين شبكات

WiFi و LTE

اعداد : نيفين عمر صالح جفال

بإشراف : د. رشدي الحمامرة

الملخص

ساهم النمو السريع للإنترنت وتطور معدات المستخدم (UE) مع وجود الواجهات المتعددة للشبكات، في توفير المزيد من جودة الخدمات وتمكين المستخدمين من اختيار الاتصال بشبكات الوصول المتعددة، ذات الخصائص المختلفة، والانتقال من شبكة إلى أخرى. تختلف الشبكات ذات التطور طويل الأمد (LTE) من عائلة الشبكات الخلوية و الشبكة المحلية اللاسلكية (WiFi) من عائلة IEEE802.x في منطقة التغطية، ووقت الاستجابة، ومعدل البيانات، وقوة الإشارة، والتكلفة، وعرض النطاق الترددي، وكل واحدة من هذه الشبكات مصممة لدعم مجموعة مختلفة من UE وخدمات محددة، وبالتالي لتغلب على هذه الاختلافات في الشبكات اللاسلكية التكميلية من خلال دمج هذه التقنيات المختلفة في NGWN [1].

لجعل خدمة الاتصال متوفرة دائماً ل UE بأفضل معايير الجودة بين هاتين الشبكتين غير المتجانستين، فإن عملية التسليم الرأسي ضرورية لتحقيق ذلك، وهو التبديل بين نقاط التعلق أو المحطات الأساسية ضمن تقنيات الشبكة. مع تطور التقنيات في الوقت الحاضر، لا يزال البحث عن خوارزميات التسليم العمودي في شبكات سيناريوهات التنقل المختلفة اليوم يمثل مجالاً صعباً للبحث في المستقبل. في هذه الدراسة، اقترحنا خوارزمية ذكية تسمى IVH_NF متوافقة مع UE لقرار التسليم العمودي مع أربعة متغيرات إدخال (قوة الإشارة المستلمة RSS، معدل استهلاك الطاقة PC، سرعة التنقل MS و المسافة D) التي تجمع من الشبكة المحيطة ل UE بين شبكتين غير متجانستين: WiFi و LTE باستخدام تقنية ANFIS التي تعتمد على Takagi – Sugeno FIS التي تجمع بين كل من الشبكات العصبية ومبادئ المنطق الضبابي، فهي تستفيد من كليهما في إطار واحد، ويبدأ مبدأ العمل من السماح للشبكة العصبية بالتعلم من أجل ضبط متغيرات نظام الاستدلال الضبابي (FIS) باستخدام مجموعة البيانات التدريب Data Set لإنشاء قواعد عضوية غامضة Membership Function Rules تكون مسؤولة عن اختيار الشبكة المثلى مع تحقيق أفضل جودة خدمة من حيث الإنتاجية المحسنة، وتقليل عدد عمليات التسليم غير الضرورية والتأخير النهائي.

تتضمن نتائج المحاكاة التحقق أولاً من دقة التصميم الرياضي IVH_NF باستخدام محاكي MATLAB من خلال أدوات قياس الخطأ القياسية مع معايير إحصائية مثل RMSE و MAE و R^2 حيث كشفت نتائج المحاكاة أن التصميم الرياضي يحقق مستوى عالٍ من الدقة، بعد ذلك تم العديد من تنفيذ سيناريوهات في عملية التسليم الرأسي من LTE إلى شبكات WiFi وتم إجراء تجارب محاكاة مكثفة باستخدام محاكي Apache NetBeans الذي يقرأ قواعد القرار لتسليم العمودي كملف txt من MATAB لدراسة تأثير سرعة UE ومعدل البت Bit Rate للتطبيق على مقياس الأداء الذي يؤثر على جودة الخدمة، مثل الإنتاجية و زمن التأخير EED وعدد عمليات التسليم لسيناريوهات التسليم العمودي. تؤكد النتائج التي تم الحصول عليها من السيناريوهات أن القيم مقبولة ومع مقارنة النموذج المقترح مع بعض الخوارزميات ذات الصلة، نستنتج أن النموذج المقترح يحقق نتائج أفضل من حيث تحسين الإنتاجية، تقليل EED بنسبة 58% من [2] RSS وخفضت عدد عمليات التسليم بنسبة 33.3% من [3] ANFIS و 60% من [4] FL.

Table of Contents

Declaration	i
Acknowledgements	ii
Abstract	iii
المخلص	v
Table of Contents	vi
Table of Figures	viii
List of Tables	x
List of Equations	xi
Acronyms and Abbreviations.....	xiii
1. Chapter One: Introduction.....	1
1.1 Background information	2
1.2 Motivation	3
1.3 Statement of the Problem	3
1.4 Research objectives	4
1.5 Research questions	4
1.6 Thesis Contributions	5
1.7 Related works	5
1.8 Research methodology	8
1.9 Organization of thesis	9
2. Chapter Two: Handover Management in HWANs.....	10
2.1 Introduction	11
2.1.1 WLAN :WiFi (IEEE802.11)	12
2.1.2 WWAN : (Cellular networks : 3G , 4G)	14
2.2 Heterogeneous Wireless Access Network (HWANs)	17
2.3 Handover Management in Heterogeneous Access Network.....	18
2.3.1 Soft and Softer handover.....	18
2.3.2 Hard handover	19
2.3.3 Horizontal handover	20
2.3.4 Vertical handover	20
2.4 Ping-Pong effect	21
2.5 Classification of vertical handover algorithms	22
2.5.1 Received Signal Strength (RSS) based schemes	22
2.5.2 QoS based schemes	24
2.5.3 Decision Function based schemes.....	25
2.5.4 Intelligence based schemes	26
2.5.5 Context Aware based schemes.....	28
2.6 Summary	31
3.Chapter Three: An Intelligent Techniques Based HO Decision Algorithms.....	32
3.1 Introduction	33
3.2 Fuzzy logic system	33
3.2.1 Fuzzy set and it's characteristics	34
3.2.2 Membership Functions (MFs)	35
3.2.3 Fuzzy operators.....	37
3.2.4 Fuzzy models	37
3.2.5 Fuzzy Inference System (FIS)	38
3.2.5.1 Fuzzifier	38
3.2.5.2 Fuzzy Knowledge Base	39

3.2.5.3	Fuzzy Rule Base	40
3.2.5.4	Fuzzy Inference Engine	40
3.2.5.5	Defuzzifier	41
3.3	Artificial Neural Network (ANN)	42
3.3.1	Structural of Neural network	44
3.3.2	Artificial Neural Network layers.....	46
3.3.2.1	Input layers	46
3.3.2.2	Hidden layers	47
3.3.2.3	Output layer	48
3.3.3	Learning Process.....	48
3.3.4	Training Artificial Neural Network.....	49
3.4	Neuro-Fuzzy system	50
3.4.1	ANFIS.....	51
3.4.1.1	ANFIS Architecture.....	52
3.5	Summary	55
4.	Chapter Four : IVH_NF Proposed model between LTE and WiFi.....	56
4.1	Introduction	57
4.2	Message sequence diagram of IVH_NF procedure.....	85
4.3	IVH_NF Flow chart.....	60
4.4	The proposed Fuzzy Inference System	61
4.4.1	Identify the inputs/output parameters with their linguistic variables.....	62
4.4.2	Define a set of fuzzy MFs for each input and output variable.....	65
4.5	IVH_NF Rule Base	66
4.6	IVH_NF Structure	68
4.7	Steps for designing IVH_NF model	69
4.8	Summary	76
5.	Chapter Five: Simulation Results and Analysis.....	77
5.1	Introduction	78
5.2	Simulation Tool	78
5.3	Simulation Environment	79
5.4	Performance Metrics	79
5.4	Simulation Results	80
5.5.1	IVH_NF Mathematical design parameters in MATLAB simulator.....	81
5.5.1.1	IVH_NF Performance accuracy Evaluations.....	81
5.5.2	LTE and WiFi scenario parameters	84
5.5.2.1	Performance evaluation mechanism	86
5.6	IVH_NF performance Vs. previous models	93
5.7	Summary	95
6.	Chapter Six: Conclusion and Future Work.....	96
6.1	Conclusion	97
6.2	Future Work.....	99
	References.....	101

List of Tables

Table	Legend	page
2.1	WiFi standard evolution	13
2.2	Characteristics of LTE and WiFi	16
2.3	Analysis of QoS based handover decision schemes	29
3.1	Comparison between forward and backward pass	54
4.1	RSS membership function specifications	65
4.2	PC membership function specifications	66
4.3	D membership function specifications	66
4.4	MS membership function specifications	66
4.5	HO membership function specifications	66
4.6	IVH_NF 'IF-THEN' Rule Base	69
4.7	Comparison between MFs type based on RMSE and MAE	74
4.8	Comparison between hybrid and backpropagation	75
5.1	IVH_NF models analytical parameters	83
5.2	IVH_NF performance evaluation to determine the best fit structure type	85
5.3	Simulation parameters for LTE to WiFi scenario	88
5.4	Summary of evaluation performance metric for LTE to WiFi scenario	96
5.5	Performance comparison between IVH_NF and related VHO algorithms	98

List of Equations

Equation Number	page
2.1	22
2.2	23
2.3	23
2.4	24
2.5	24
2.6	24
2.7	25
2.8	25
2.9	26
2.10	26
2.11	28
2.12	28
3.1	33
3.2	33
3.3	34
3.4	34
3.5	35
3.6	35
3.7	35
3.8	36
3.9	36
3.10 – 3.12	38
3.13 – 3.14	40
3.15 – 3.16	41
3.17 – 3.20	43
3.21	47
3.22 – 3.23	55
3.24 – 3.27	56
4.1	65