SCHEDULING OF ROUTING TABLE CALCULATION SCHEMES IN OPEN SHORTEST PATH FIRST USING ARTIFICIAL NEURAL NETWORK

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To my beloved family, thank you for their support and encouragement for me to finish my study.

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"In the name of Allah, the Entirely Merciful, the Especially Merciful. [All] praise is [due] to Allah , Lord of the worlds - The Entirely Merciful, the Especially Merciful, Sovereign of the Day of Recompense. It is You we worship and You we ask for help. Guide us to the straight path - The path of those upon whom You have bestowed favor, not of those who have evoked [Your] anger or of those who are astray." Al-Fatiha verse 1-7.

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ABSTRACT

Internet topology changes due to events such as router or link goes up and down. Topology changes trigger routing protocol to undergo convergence process which eventually prepares new shortest routes needed for packet delivery. Real-time applications (e.g. VoIP) are increasingly being deployed in internet nowadays and require the routing protocols to have quick convergence times in the range of milliseconds. To speed-up its convergence time and better serve real-time applications, a new routing table calculation scheduling schemes for Interior Gateway Routing Protocol called Open Shortest Path First (OSPF) is proposed in this research. The proposed scheme optimizes the scheduling of OSPF routing table calculations using Artificial Neural Network technique called Generalized Regression Neural Network. The scheme determines the suitable hold time based on three parameters: LSA-inter arrival time, the number of important control message in queue, and the computing utilization of the routers. The GRNN scheme is tested using Scalable Simulation Framework (SSFNet version 2.0) network simulator. Two kind of network topology with several link down scenarios used to test GRNN scheme and existing scheme (fixed hold time scheme). Results shows that GRNN provide faster convergence time compared to the existing scheme.

ABSTRAK

Topologi internet sering berubah kerana berlakunya kejadian di mana router atau talian komunikasi terputus atau talian komunikasi yang baru muncul. Perubahan topologi ini menyebabkan protocol *routing* mengalami proses pengiraan laluan terpendek yang diperlukan untuk penghantaran paket data. Aplikasi masa sebenar di gunakan secara meluas di dalam internet pada masa kini dimana ianya memerlukan masa *convergence* yang singkat iaitu di dalam julat mili saat. Tesis ini mencadangkan penggunaan skema penjadualan yang baru untuk pengiraan jadual *routing*. Algoritma penjadualan baru ini akan digunakan oleh *Interior Gateway Routing Protocol* bernama *Open Shortest Path First* (OSPF) untuk mempercepatkan lagi masa *convergence* bagi rangkaian yang menggunakan protocol *routing* ini. Algoritma yang dicadangkan ini akan menggunakan teknologi kepintaran buatan bernama *Generalized Regression Neural Network* (GRNN). Skema ini menentukan masa menunggu untuk penjadualan pengiraan jadual *routing* berdasarkan tiga parameter iaitu masa ketibaan antara paket LSA, bilangan paket penting semasa dan peratusan penggunaan semasa *CPU* bagi router. Algoritma GRNN ini akan di uji menggunakan simulator rangkaian bernama *Scalable Simulation Framework* (SSFNet versi 2.0). Dua jenis rangkaian topologi dengan beberapa scenario talian terputus digunakan untuk menguji keupayaan algoritma GRNN dan algoritma yang sedia ada di dalam simulator. Keputusan simulator menunjukkan algoritma GRNN menghasilkan masa *convergence* yang lebih cepat berbanding algoritma yang sedia ada.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xi
	LIST OF FIGURES	xii
	LIST OF SYMBOLS	xv
	LIST OF ABBREVIATION	xvi
	LIST OF APPENDICES	xviii
1	**INTRODUCTION**	1
	1.1. Introduction	1
	1.1.1. Router and Routing Protocol	1
	1.1.2. Convergences Process and Topology Changes	2
	1.1.3. Computational Intelligence	3
	1.2. Problem Background	4
	1.3. Problem Statement	5
	1.4. Dissertation Aim	6
	1.5. Dissertation Objectives	6
	1.6. Scope of the Study	7
	1.7. Significance of the Study	7

	1.8.	Dissertation Organization	8
2	**LITERATURE REVIEW**		9
	2.1.	Introduction	9
	2.2.	Routing Protocol	9
	2.3.	Open Shortest Path First Routing Protocol	11
		2.3.1. OSPF Operation	11
		2.3.2. Topology Changes	12
		2.3.3. Routing Table Calculation	13
		2.3.4. The OSPF Scheduling Scheme	14
	2.4.	Stability Issues in OSPF and Enhancement to Improve It	17
	2.5.	Related Works on Improving OSPF Convergences Time	19
		2.5.1. Fast Link Failure Detection	19
		2.5.2. Faster and Fewer Adjacency Establishment	21
		2.5.3. Optimization of LSA Generation and Flooding	22
		2.5.4. Optimization of Routing Table Calculation	23
	2.6.	Other Applications of AI in OSPF	24
	2.7.	Artificial Intelligence	25
		2.7.1. Artificial Neural Network	26
		2.7.1.1. General Regression Neural Network	28
		2.7.1.2. Back Propagation Neural Network	30
	2.8.	Summary	33
3	**RESEARCH METHODOLOGY**		34
	3.1.	Introduction	34
	3.2.	Research General Framework	35
	3.3.	Information Gathering	37
	3.4.	Development of ANN Hold Time Based Scheme	37
	3.5.	Preparation of Data	38
	3.6.	Conducting Experiments	39
	3.7.	Schemes Implementation	41
	3.8.	Network Simulator	42

		3.8.1. Scalable Simulation Framework Network Simulatior (SSFNet)	43
		3.8.1.1. Domain Modelling Language (DML)	45
	3.9.	Simulation for Performance Evaluation	48
	3.10.	Result Analysis	52
	3.11.	Research Documentation	53
	3.12.	Summary	53
4	**THE DESIGN OF INTELLIGENT HOLD TIME BASED SCHEME**		54
	4.1.	Introduction	54
	4.2.	Proposed Scheme: ANN Hold Time Based Scheme	54
		4.2.1. Generalized Regression Neural Network Technique	57
		4.2.2. GRNN Framework	59
		4.2.2.1. Data Processing	59
		4.2.2.2. Output Computation	63
	4.3	Comparison of Intelligent and Existing Hold Time Based Scheme	66
	4.4	Summary	67
5	**EXPERIMENTAL RESULT**		68
	5.1.	Introduction	68
	5.2.	ANN Data Training and Testing	69
	5.3.	Summary of Result Analysis on Data Training	79
	5.4.	Network Simulation	80
		5.4.1. Mesh Topology (10 Routers: Link Down at Isolated Times)	81
		5.4.2. Mesh Topology (10 Routers: Link Down at Simultaneous Times)	86
		5.4.3. Ring Topology (50 Routers: Link Down at Isolated Times)	91
		5.4.4. Ring Topology (50 Routers: Link Down at Simultaneous Times)	93
	5.5.	Summary of Network Simulation Result	95

	5.6.	Summary	96
6	**CONCLUSION AND FUTURE WORKS**		97
	6.1.	Introduction	97
	6.2.	Summary of Achievements	97
	6.3.	Advantages and Contributions	99
	6.4.	Future Works	100
REFERENCES			101
Appendices A-D			105- 183

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	OSPF RTC Scheduling Scheme Release Date	17
3.1	Input Values range	41
3.2	Simulation Scenarios Table	51
4.1	Difference between existing and intelligent hold time based scheme	67
5.1	MSE of GRNN and BP model	80
5.2	Average Convergence Time for Routers in Mesh Topology Isolated	81
5.3	Average Convergence Time for Routers in Mesh Topology Simult	86
5.4	Average Convergence Time for Routers in Ring Topology Isolated	91
5.5	Average Convergence Time for Routers in Ring Topology Simult	94
5.6	Overall Average Convergence Time for Simulation	95
5.7	The percentage of convergence times improvement	96

LIST OF FIGURES

TABLE NO.	TITLE	PAGE
2.1	Fixed hold time scheme	15
2.2	Exponential back-off hold time scheme	16
2.3	Basic structure of ANN model	27
2.4	Basic structures of GRNN	29
2.5	Basic structures of BP	31
3.1	Flowchart of the research	36
3.2	SSFNet Basic Architectures	44
3.3	DML Hierarchy	46
3.4	Basic DML examples	47
3.5	Mesh topology used for simulation	49
3.6	Ring topology used for simulation	50
4.1	State diagram of ANN hold time based scheme	55
4.2	GRNN structure of the scheme	57
4.3	Code Fragment for GRNN input layer	59
4.4	GRNN pattern layer workflow	61

4.5	The code fragment of GRNN training data stored in SSFNet	62
4.6	The GRNN summation and output layer calculation	63
4.7	The GRNN hold time calculation	64
4.8	Code Fragment for GRNN summation and output layer	65
5.1	The values of hold time over *alsa* when both of *ncm* and *cut* is low	70
5.2	The values of hold time over *alsa* when the value of *ncm* is medium and *cut* is low	71
5.3	The values of hold time over *alsa* when the value of *ncm* is high and *cut* is low	72
5.4	The values of hold time over *alsa* when the value of *ncm* is low and *cut* is medium	73
5.5	The values of hold time over *alsa* when both of *ncm* and *cut* is medium	74
5.6	The values of hold time over *alsa* when the value of *ncm* is high and *cut* is medium	75
5.7	The values of hold time over *alsa* when the value of *ncm* is low and *cut* is high	76
5.8	The values of hold time over *alsa* when the value of *ncm* is medium and *cut* is high	77
5.9	The values of hold time over *alsa* when both of *ncm* and *cut* is high	78
5.10	The average convergences time by Routers in Mesh Topology (10 Routers Link Down at Isolated Times)	82
5.11	Example of high occurrence of LSA arrivals	83
5.12	Example of low occurrence of LSA arrivals	84
5.13	Example of hold time timeline	85
5.14	The average convergences time Routers in Mesh Topology (10 Routers Link Down at Simultaneous Times)	87
5.15	LSA arrival pattern for 5 and 10 links down	88

5.16	LSA arrival pattern for 15 and 50 links down	89
5.17	LSA arrival pattern for 15 and 45 links down using Intelligent Hold Time scheme	90
5.18	LSA arrival pattern for 50 links down using Intelligent Hold Time scheme	90
5.19	The average convergences time by Routers in Ring Topology (50 Routers Link Down at Isolated Times)	92
5.20	The average convergences time by Routers in Ring Topology (50 Routers Link Down at Simultaneous Times)	94

LIST OF SYMBOLS

$\sum$	-	Summation of
exp	-	Exponential Function
τ	-	Spread Factor
y	-	Output
x	-	Input vector
n	-	Number of training patterns
p	-	Number of elements of an input vector
net_j	-	Summation of the weighted input added with bias
W_{ij}	-	Weight associated to connection link
O_i	-	Input at the nodes in layer$_i$
θ_i	-	Bias associated at each connection link
O_j	-	Output of activation function at hidden layer j
$\hat{y}$	-	Predicted hold time value
$f(Y_{net})$	-	Nonlinear activation function
Y_{net}	-	Summation of weighted inputs
J_r	-	Error between observed value and network response
N	-	Numerator
D	-	Denominator

LIST OF ABBREVIATION

OSPF	-	Open Shortest Path First
IP	-	Internet Protocol
VoIP	-	Voice over Internet Protocol
ISP	-	Internet Service Providers
LSA	-	Link State Advertisement
ANN	-	Artificial Neural Network
SPF	-	Shortest Path First
SPT	-	Shortest Path Tree
LSDB	-	Link-State Database
IGP	-	Interior Gateway Protocol
EGP	-	Exterior Gateway Protocol
RIP	-	Routing Information Protocol
IGRP	-	Interior Gateway Routing Protocol
EIGRP	-	Enhanced Interior Gateway Routing Protocol
BGP	-	Border Gateway Protocol
AS	-	Autonomous Systems

TE	-	Traffic Engineering
BFD	-	Bidirectional Forwarding Detection
DD	-	Database Description
DR	-	Designated Router
BDR	-	Backup Designated Router
MLE	-	Machine Learning Engine
SRG	-	Shared Risk Group
ACO	-	Ant Colony Optimization
GRNN	-	Generalized Regression Neural Network
BP	-	Backpropagation
ICMP	-	Internet Control Message Protocol
WAN	-	Wide Area Network
LAN	-	Local Area Network
WLAN	-	Wireless Local Area Network
UDP	-	User Datagram Protocol
GUI	-	Graphical User Interface
SSFNet	-	Scalable Simulation Framework Network Simulator
DML	-	Domain Modelling Language
CM	-	Control Messages
CPU	-	Central Processing Unit
CUT	-	CPU Utilization
MSE	-	Mean Square Error

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	The input and target of the ANN model	105
B	Domain Modeling Language sample (10 Routers Mesh Topology 50 Link down Isolated)	132
C1	Example of Link down Scenarios Table (Ring Topology Isolated Link Down)	155
C2	Example of Link down Scenarios Table (Ring Topology Simultaneous Link Down)	162
C3	Example of Link down Scenarios Table (Mesh Topology Isolated Link Down)	169
C4	Example of Link down Scenarios Table (Mesh Topology Simultaneous Link Down)	173
D	Java Pseudo Code for Proposed Scheme	176

CHAPTER 1

INTRODUCTION

1.1 Introduction

Internet has become essential to human nowadays. People can communicate easily using internet from almost any places in the world. The internet has rapidly grows over 10 years. Statistic shows estimated that there were 1.8 billion internet users compared to 360 million users in year 2000. The percentage of internet users has growth over 399.3% over these ten years. As the internet keep expanding and growing rapidly in terms of size and traffic load, the number of routers in a routing domain is also become larger. This situation eventually leads to frequent topological changes because of link failures, recoveries and changes.

1.1.1 Router and Routing Protocol

Router can be defined as a device that determines the next network point to which a packet should be forwarded towards its destination. The routing protocol use in the routers specifies how the routers communicate with each others. They are two major classes of routing protocol which are the interior gateway routing protocol (IGP) and the exterior gateway routing protocol (EGP). In this research we will be focusing on a particular interior gateway routing protocol called Open Shortest Path First (OSPF).

The interior gateway routing protocol operates within an autonomous system and can be divide into two categories which is distance vector routing protocol and link-state routing protocol. Distance vector routing protocol informs their neighbors about topology changes periodically. In the distance vector routing protocols, routers discover the best path to the destination from their each neighbors. Unlike the distance vector routing protocol, the link-state routing protocol require routers to inform all the nodes in an area about topology changes.

Basically node maintains a map of connectivity each for the area it resides. When topology change occurs, the affected nodes will have to recompute the best path to destinations. The collection of the best path will form the node's routing table. Once the entire node's routing table has been updated, convergence is complete.

1.1.2 Convergence Process and Topology Changes

Convergence is the process of routers agreeing on optimal routers for forwarding packets and thereby completing the updating of their routing tables [3].It is important for routing protocol to have a quick convergence nowadays because of real time applications for example video-conferencing and VoIP (Voice over Internet Protocol). The link-state routing protocol provide greater flexibility and sophistication compared to the distance vector routing protocol. In term of speed of convergence, distance vector routing protocol can converge slowly and have routing loops while converging and also suffers from count to infinity problems [4].

This research will be focusing on the one of the link-state routing protocol which is Open Shortest Path First (OSPF). OSPF has become famous routing protocol and most of Internet Service Providers (ISP) use OSPF as their interior gateway routing protocol. OSPF used Link State Advertisement (LSA) to describe the local state of a router or network and for a router, LSA also describing the current state of the router's interfaces and adjacencies. At the event of topology changes, the nodes will sent the LSA to the all nodes within autonomous system. The nodes than will calculate the new routing table.

There were two routing table calculation scheduling schemes in OSPF which is hold time based scheme and LSA Correlation. The Hold-time based scheme uses value of delay parameters that configured by the network administrator. For LSA Correlation, it assumes that new LSA does not trigger new routing table calculation but assume that it was symptom of a topology changes. So, the routers should a router should correlate the information in individual new LSA to identify the topology change itself and then perform a routing table calculation.

This scheme has just been proposed and the topology change identification is not straight-forward. The Hold-time based and LSA Correlation has not used computational intelligence techniques. In this research, we propose the use of computational intelligence in the new scheduling of routing table for optimizing the frequency of routing table calculation

1.1.3 Computational Intelligence

Fuzzy Logic and Artificial Neural Network are examples of computational intelligence techniques. For this research, we will be using artificial neural network to optimize the scheduling of routing table calculation schemes. Artificial Neural Network (ANN) is a computational model that tries to simulate biological process of the human brain. Basically ANN consist 3 types of layer which is input layer, hidden layer and output layer. The function of ANN is to process information, and it suitable to process the scheduling of routing table information to determine the suitable frequency of routing table calculations.

1.2 Problem Background

The hold-time based scheme is divided into two types which is fixed hold-time and exponential back-off hold time schemes. In this scheme, routers not in the convergence process are in initial state. When the routers that in initial state received LSA, the routers will change state to the SPF (Shortest Path First) state where the routing table calculation were initiated immediately and hold timer is started. It assumed that the time needed for a routing table calculation is less than the hold time. In the SPF state, the routers will wait for the hold time to expire or the arrival of the new LSA. When the hold time is expiring, it will cause the routers to return to the initial state. However the router that in SPF state received new LSA, that router will change state to the SPF hold state. In the SPF hold state, the router has one or more pending LSA and is waiting for the hold time to expire so that the router can return to the SPF state and perform a routing table calculation. This is when all the received LSA will be process while the hold timer is running.

In the exponential back-off hold time scheme, the transition state from the SPF state to the SPF Hold state causes the hold time to double in value up to maximum. The scheme starts with a small value for hold time. If the LSA received frequently, the hold time will quickly reach its maximum value therefore limiting the frequency of routing table calculation. However, it is possible that no LSA is received during hold time duration and the hold time will be reset to its small initial value.

The both schemes depend on the values of several delay parameters. The main problems of the both method is to determine the values for the parameter that will result in fast convergence time for all possible topology change scenarios that happen to a network.

The other schemes for routing table calculation scheduling are LSA Correlation. A router randomly receives new LSA at one or more of its interface because of topology changes in network. Each new LSA will be update to Link-State Database (LSDB) that stores the map of the routers is OSPF by the routers. The content of the new LSA will be examined, correlated and compared to the previous LSA when necessary to decide whether a topology changes can be determine. If a topology change has been identified and determine, then the new routing table calculation needs to be scheduled. In LSA Correlation, many scenarios need to be handled and extra memory space is needed for the new and older LSA for the topology identification process.

This research will propose scheduling schemes that is less complicated than LSA Correlation but still offered minimum frequency of routing table calculation and fast convergence time. To the best of our knowledge, no scheduling schemes for routing table calculation that used computational intelligence so far. This research will explore the possibility of using computational intelligence to solve the research problems.

1.3 Problem Statement

Many real time applications such as VoIP are widely deployed in the internet nowadays. This real-time application requires the routing protocol to have a quick convergence time. Many efforts have been done to improve OSPF convergence times but none of them are using computational intelligence or artificial intelligence. This research wants to study the use of computational intelligence or artificial intelligence to improve OSPF convergence times.

The proposed scheme takes several factors for determination of suitable hold time values intelligently. This intelligent hold time based scheme use three factors to determine suitable hold time which is LSA inter-arrival time, number of important control message is queue and CPU utilization of the routers. The proposed scheme will address the limitations of previous scheme and provide faster convergence times to cater the needs of real time applications.

1.4 Dissertation Aim

This research aimed to speeding up OSPF convergence time by minimizing the frequency of routing table calculation. In this research, we propose a new scheduling scheme that use Artificial Neural Network model to optimize the scheduling of routing table calculation.

1.5 Dissertation Objectives

The objectives for this research are stated as below:

1. To design Artificial Neural Network model for intelligent hold time scheme to overcome the previous scheme shortcomings.
2. To develop Artificial Neural Network Model for intelligent hold time based

scheme.

3. To evaluate the performance of the intelligent hold time based scheme by comparing the results with existing schemes.

1.6 Scope of the Study

To achieve research objectives, it is important to determine research scope and the limits to the research. The scopes of this research are:

1. This study will focus on convergence process within an area and inter area convergence process will not be include in this research.
2. To speed up convergence time, the proposed intelligent hold time scheme are applied to optimize the scheduling of routing table calculation
3. The proposed intelligent hold time scheme use Artificial Neural Network technique.
4. SSFNet network simulator is used to evaluate performance of intelligent hold time based scheme.

1.7 Significance of the Study

This project will study on scheduling of routing table calculations using artificial neural network. This was the first time the artificial intelligence implemented to schedule the routing table. If this research become success, it can be implemented to the commercial routers and it will benefits the users of the internet. When the time taken by OSPF to convergence is decreases, the network performance will increase thus satisfies the demand of fast failure recovery applications such as

Voice over Internet Protocol and live video streaming.

1.8 Dissertation Organization

There are 6 chapters in this dissertation report. The first chapter provides the introduction of the study, problem background and statement, aim, objectives, scope of the studies and the significance of this research. Chapter 2 will gives the literature review about topics related to the research. Methodology use in the research will be discussed in the chapter 3. Chapter 4 will explained about the proposed method of the research while chapter 5 will present research results. Chapter 6 is where the conclusion and suggestion for future works is stated.

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