UNIVERSITI PUTRA MALAYSIA

IMPROVED TREE ROUTING PROTOCOL IN ZIGBEE NETWORKS

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FK 2010 27

IMPROVED TREE ROUTING PROTOCOL IN ZIGBEE NETWORKS

By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

March 2010

This thesis is especially dedicated to my family: first and foremost, to my late dad, Kamil Abdulhusain, whose mentorship and encouragement led me to apply for admission into the master degree programme, but unfortunately did not live to witness my graduation. May his soul rest in perfect peace.

Special thanks to my dear mum, Munera Abdulwahab, and my only sister, Raghad, without whose continued moral and financial support, this work will not have been possible. The psychological disturbance of having to part with a dear son and brother for two solid years without seeing is in itself, in fact, a big sacrifice and hence deserves commendation.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Wireless Sensor Networks (WSNs) is becoming more important in various application areas. Many application scenarios require connectivity between WSN's nodes to transmit the collected data to a sink node. ZigBee is an industrial standard for wireless ad hoc networks based on IEEE 802.15.4. It has been developed for low cost, low data rate and low power consumption.

In the ZigBee standard, network layer defines two routing protocols namely Ad Hoc On-demand Distance Vector (AODV) and Tree Routing (TR). TR protocol follows the tree topology (parent-child) in forwarding the data to the sink node, However, the source node cannot know if the sink is located nearby to the source node or if it is not in the sub-tree. In this case it will follow the tree topology which will use a lot of hops to arrive to the sink node.

The objective of this thesis was to develop the TR protocol for ZigBee network and is called Improved Tree Routing (ImpTR) protocol which is computationally simple in finding the shortest path to transmit data packets to the sink node, and does not need any addition in hardware.

ImpTR protocol uses an approach to select next hope depending on new algorithm and uses the same tree topology construction for distributing address to all sensor nodes in the network. ImpTR determines the best path to the sink node depending on the tables of the neighbouring nodes, which is part of the existing ZigBee network specification. Packets are forwarded to neighbour node if the path to the sink through neighbour node is shorter than the path through personal area network (PAN) coordinator. The unreliability and inefficiency of the TR originates from the limited links for routes, i.e., parent-child links. If any ZigBee router loses its link to its parent the routing path is broken and the TR cannot recover the routing path by itself , for that the second main objective is overcome the link failure problem.

ImpTR algorithm reduces the average end-to-end delay by (10-31) % which is the time needs to transmit packets between source and sink node, decrease the energy consumption from the whole network by (8-40) % , reduce the number of hops need to transmit data packets to sink node by (3-32)%, and increases the average throughput by (4-65) % which is average number of bits receive in sink node per second.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

IMPROVED TREE ROUTING PROTOCOL IN ZIGBEE NETWORKS

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Wireless Sensor Networks (WSNs) menjadi semakin penting dalam pelbagai bidang aplikasi. Banyak senario aplikasi memerlukan perhubungan sesame nod-nod WSN untuk menghantar data yang dikumpul ke nod sink. ZigBee adalah piawaian industri untuk rangkaian ad hoc tanpa wayar berdasarkan IEEE 802.15.4. Ini telah dibangunkan untuk kos rendah, kadar data yang rendah dan penggunaan kuasa yang rendah.

Dalam piawaian ZigBee, lapisan rangkaian mentakrifkan dua protokol routing iaitu Ad Hoc On-Demand Distance Vector (AODV) dan Tree Routing (TR). protokol TR mengikuti topologi pohon (induk-anak) dalam memajukan data ke sink node, Sungguhpun begitu, nod sumber tidak dapat mengenalpasti jika sink itu terletak hampir dengan nod sumber atau ia tidak berada dalam sub-pokok. Dalam hal ini ia

akan mengikuti topologi pokok yang akan menggunakan banyak hops untuk sampai ke nod sink.

Objektif tesis ini adalah untuk membangunkan protokol TR untuk rangkaian ZigBee dan ini disebut protokol Improved Tree Routing (ImpTR) yang mudah secara perkomputeran dalam mencari jalan terpendek untuk menghantar paket ke nod sink, dan tidak memerlukan sebarang penambahan perkakasan.

Protokol ImpTR menggunakan pendekatan untuk memilih hop berikutnya bergantung pada algoritma baru dan menggunakan binaan topologi pokok yang sama untuk mengedarkan alamat untuk semua nod sensor dalam rangkaian. ImpTR menentukan laluan terbaik ke nod sink bergantung kepada table nod-nod bersebelahan, yang merupakan sebahagian daripada spesifikasi rangkaian ZigBee sedia ada. Paket dimajukan ke nod jiran jika laluan ke sink melalui nod jiran lebih pendek daripada laluan melalui koordinator personal area network (PAN). Ketidakbolehharapan dan ketidakcekapan TR berpunca daripada sambungan laluan yang terhad, iaitu, sambungan induk-anak. Jika ada router ZigBee hilang sambungan kepada induknya, laluan routing nya rosak dan TR tidak dapat mengembalikan laluan routing dengan sendirinya. Dengan itu, tujuan utama yang kedua adalah untuk mengatasi masalah kegagalan sambungan.

Algotirma ImpTR mengurangkan purata lengah akhir-ke-akhir sebanyak 10 hingga 31 peratus iaitu masa yang diperlukan untuk menghantar paket antara nod sumber dan nod sink, mengurangkan penggunaan tenaga daripada seluruh rangkaian sebanyak 8 hingga 40%, mengurangkan bilangan hops yang diperlukan untuk

menghantar paket data kepada nod sink sebanyak 3 hingga 32 peratus, dan meningkatkan purata throughput sebanyak 4 hingga 65 peratus yang merupakan purata bit diterima nod sink dalam setiap saat.

ACKNOWLEDGEMENTS

First and foremost, Alhamdulillah for giving me the strength, patience, courage, and determination in completing this work. All grace and thanks belongs to Almighty Allah.

Many special thanks go to my supervisor Associate Professor Dr. Nor Kamariah bt. Noordin, for her incredible guidance, continuous support, and encouragement. She always having time for me and readily providing her technical expertise throughout the period of my study. I owe more than I can ever repay. Only has the successful completion of this work become possible due to her supervision. Her high stand of diplomatic power and professionalism set a great model for me to follow.

I would like to take this opportunity to express my sincere appreciation and thanks to Dr. Mohd. Fadlee b. A.Rasid, my committee member, for his invaluable technical assistance, moral support and motivation are the main reasons for timely completion of such a challenging thesis. His critical appraisals of my papers and presentations are extremely valuable for the improvement in my thinking also his kindness and willingness to help is unforgettable.

I want to thank my research collaborator and all my colleagues in the wireless laboratory, Dr. Michael, Ahmed M Muharib, Ali Amer Alwan, Bassam Mohammed Saeed, Bilel Nefzi, Aws, Alaa, Melad, Yassen, Bashar, Ayyoub, Sohail, Ali Zuhair, yaaqob, Hossein Fotouhi , Samer, Omar, M. Ben Mubarak, Abdullnaser, Sabah and

Farhad Mesri for the illuminating discussions and invaluable help in the development of this research.

Thanks also are due to other members of the academic, and the technical staff in the faculty of engineering for their help. Also I would like to thank many people I have met during my stay in Malaysia for their help, enjoyable discussions and good times.

I am grateful for the emotional and financial of my family. Without their continuous prayers and support, this work would not have been accomplished. Mum, thank you for directing me in my academic and professional life. I would also to express my deepest gratitude to my sister for providing me with guidance and supporting all my decisions. I ask ALLAH to keep my family safe, and support them with good health.

I certify that a Thesis Examination Committee has met on 24 March 2010 to conduct the final examination of Mostafa Kamil Abdulhusain Al-Harbawi on his master of science thesis entitled "IMPROVED TREE ROUTING PROTOCOL IN ZIGBEE NETWORKS" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P. U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

_____

MOSTAFA KAMIL ABDULHUSAIN AL-HARBAWI

Date: 24 March 2010

TABLE OF CONTENTS

		Page
ABSTRACT		iii
ABSTRAK		v
ACKNOWLEDGEMENTS		viii
DECLARATION		xii
LIST OF TABLES		xv
LIST OF FIGURES		xvi
LIST OF ABBREVIATIONS		xviii
CHAPTER		
1	**INTRODUCTION**	1
	1.1 Overview	1
	1.2 Problem statement	2
	1.3 Objective	4
	1.4 Research Scope	5
	1.5 Contribution	6
	1.6 Study Module	6
	1.7 Thesis Organization	7
2	**LITERATURE REVIEW**	9
	2.1 Wireless Sensor Network	9
	2.2 Overview of the ZigBee Network	11
	2.2.1 ZigBee Device Types	13
	2.2.2 Network Topology	14
	2.3 ZigBee Network Layer	17
	2.3.1 Network Formation	17
	2.3.2 Address Assignment Scheme	18
	2.4 Routing protocol for WSN	21
	2.4.1 Routing Challenges	22
	2.4.2 Classification of Routing Protocol	24
	2.4.2.1 Routing Path	24
	2.4.2.2 Network Structure	25
	2.4.2.3 The Initiator of Communication	25
	2.4.3 Routing protocol Types in WSN	26
	2.4.3.1 Data-centric Protocol	26
	2.4.3.2 Hierarchical Protocol	27
	2.4.3.3 Location-based Protocol	28
	2.4.3.4 Network flow and QoS-aware Protocol	29
	2.5 Routing Protocol in ZigBee Network	29
	2.5.1 Ad-hoc On Demand Distance Vector (AODV)	29
	2.5.2 Tree Routing (TR) Protocol	31
	2.6 Related Work of the Tree Routing Protocol	32
	2.7 Summary	40
3	**METHODOLOGY**	41
	3.1 The aim of System	41

3.2 Tree Routing Protocol Issues 42
3.2.1 Inefficient Routing 43
3.2.2 The Issue of Link Failure 44
3.3 Preprocessing of the Network 45
3.4 Preliminary Work 47
3.4.1 Assumptions 47
3.4.2 System Design Algorithm 48
3.5 Link Failure 59
3.6 Summary 62

4 RESULTS AND DISCUSSIONS 63
4.1 Introduction 63
4.2 Simulation Experimental Setup 63
4.3 Performance Parameters 65
4.3.1 Average End-to-End Delay 66
4.3.2 Energy Consumption 66
4.3.3 Average Number of hops 67
4.3.4 Average Throughput 67
4.4 Performance Evaluation 67
4.4.1 Scenario One - Different Size of Network 68
4.4.2 Scenario Two - Fixed Network 73
4.4.3 Scenario Three - Different Number of Sources 79
4.5 Summary 86

5 CONCLUSION AND FUTURE WORK 87
5.1 Conclusion 87
5.2 Future Work 88

REFERENCES 89
APPENDIX A 94
APPENDIX B 95
BIODATA OF STUDENT 104
LIST OF PUBLICATIONS 105