IMPLEMENTING MULTI HOP TRANSMISSION IN WIRELESS LOW RATE IEEE 802.11 NETWORK

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Dedication to my beloved Husband and Daughter,

who has fulfilled my Heart with Love and Brightness

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ABSTRACT

An Ad Hoc networks are becoming more important in the daily lives. It can be used to instantly connect to local or remote networks such as the internet without the need of pre-existing infrastructure or centralized administration. The users of the network together will establish the infrastructure. The disadvantage of wireless communication is that it has limited range of radio transmission. Due to this, multiple network 'hops' may be needed for one node to exchange data with another across the network. In an ad hoc network, the nodes may not only operate as a host but also as a router to forwarding the packets to others nodes. There are variety of routing protocol targeted at this environment have been developed and most of them suffers from high overhead data traffic. The main purpose of this project is to develop a new routing strategy. The new routing is developed by using the existing network protocol that had been already used in network environments which is the Address Resolution Protocol (ARP). This new routing is used to maintain and establish routes in a vehicular ad hoc routing network. Many of the existing strategies nowadays are wasting these resources. By extending the ARP protocol with two new operation types, ARP Forward Request and ARP Forward Reply to allow the intermediate nodes to forward the request and reply, we have successfully manage to create a multi hop transmission in ad hoc network. The data can be sent through multi hop transmission until it reaches the destination. Measurement taken from a 3 nodes of 802.11b test bed demonstrate the new routing protocol for multi hop transmission can be used in an ad hoc network and it can perform well.

ABSTRAK

Rangkaian tanpa struktur tetap semakin menjadi kepentingan dalam kehidupan seharian manusia. Rangkainan tanpa struktur tetap ini boleh digunakan dalam menyediakan perhubungan diantara rangkaian tempatan atau rangkainan kawalan seperti laman sesawang tanpa memerlukan satu struktur rangkaian tetap. Pengguna didalam rangkaian perhubungan tersebut akan bergabung dengan sendirinya untuk membentuk satu rangkainan perhubungan yang tetap. Perhubungan tanpa wayar mempunyai keburukkan iaitu ia mempunyai kawasan rangkaian perhubungan yang terhad. Oleh itu, beberapa rangkaian untuk menghantar data dari satu nod to nod yang lain dalam rangkaian perhubungan yang sama di perlukan. Dalam rangkaian perhubungan tanpa struktur rangkaian tetap ini, setiap nod bukan hanya beroperasi sebagai penghantar tetapi juga nod yang digunakan sebagai pengantara untuk menjadi laluan penghantaran data dari mana-mana nod ke nod yang lain. Tujuan utama projek ini adalah untuk mencipta satu strategi penghantaran yang baru. Strategi penghantaran yang dicipta ini adalah dengan menggunakan strategi penghantran yang sedia ada dan digunakan dalam sistem perhubungan iaitu protocol ARP. Strategi yang dicipta ini adalah untuk menjaga selain membina satu jalan penghantaran di dalam aplikasi penghataran tanpa struktur tetap di antara kenderaan. Kebanyakkan strategi penghantaran yang sedia ada kini tidak menggunakan strategi protocol ARP yang sedia ada ini. Dengan menambah baik protocol ARP ini iaitu dengan membawa kehadapan pertanyaan dan membawa ke hadapan balasan untuk membenarkan pengantara nod menghantar pertanyaan dan membalas, pemprosesan data strategi ini berjaya dikurangkan. Selain itu data juga berjaya di hantar menerusi beberapa nod sehingga samapi ke destinasinya. 3 nod yang menggunakan 802.11b diaplikasikan dalam eksperimen dan keputusan menunjukkan bahawa strategi baru yang dicipta untuk penghantran data menerusi beberapa nod ini berjaya diaplikasikan dalam rangkain pehubungan tanpa struktur tetap

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LIST OF SYMBOLS

T	-	Average of round trip time in (ms)
i	-	No of packet transmission
T_i	-	Round Trip Time for each packet transmission
Th	-	Throughput (bps)

LIST OF ABBREVIATIONS

ARP	-	Address resolution Protocol
AES	-	Advance Encryption Standard
API	-	Application Programming Interface
AODV	-	Ad Hoc On Demand Distance Vector
CCK	-	Complementary Code Keying
CSMA/CA	-	Carrier Sense Multiple Access/Collision Avoidance
DSDV	-	Destination Sequenced Distance Vector
DSSS	-	Direct Sequence Spectrum
DSR	-	Dynamic Source Routing
DPSK	-	Differential Phase Keying
DQPSK	-	Differential Quaternary Phase Keying
EEPROM	-	Electrically Erasable Programmable Read Only Memory
IP	-	Internet Protocol
IPX	-	Internetwork Packet Exchange
IEFT	-	Internet Engineering Task Force
ICD	-	In Circuit Debugger
ISM	-	Industrial, Scientific and Medical
IPv4	-	Internet Protocol Version 4
LAN	-	Local Area Network
LLC	-	Logical Link Control
LED	-	Light Emitting Diode
MANET	-	Mobile Ad Hoc Network
MAC	-	Media Access Control

MPR	-	Multipoint Relays
OFDM	-	Orthogonal Frequency Division Modulation
OSI	-	International Organization for Standardization
OSLR	-	Optimized Link Rate Routing
PCB	-	Printed Circuit Board
PIC	-	Programmable Interface Controller
PHY	-	Physical
RF	-	Radio Frequency
RFC	-	Request for Comments
RTCC	-	Real Time Clock and Calender
RTT	-	Round Trip Time
RREQ	-	Route request
RREP	-	Route Reply
RERR	-	Route Error
SRAM	-	Static Random Access Memory
SSID	-	Service Set Identifier
TP	-	Topology Local message
TCP	-	Transmission Control Protocol
TCP/IP	-	Transmission Control Protocol/Internet Protocol
TKIP	-	Temporal Key Integrity Protocol
UART	-	Universal Asynchronous Receiver/Transmitter
UDP	-	User Datagram Protocol
USB	-	Universal Serial Bus
UTM	-	Universiti Teknologi Malaysia
VANET	-	Vehicular Ad Hoc Networks
V2V	-	Vehicle to vehicle
VRC	-	Vehicle to Roadside
V2I	-	Vehicle To Infrastructure
WEP	-	Wired Equivalent Privacy
WPA	-	Work Project Administration
WSN	-	Wireless Sensor Network
WLAN	-	Wireless Local Area Network
ZRP	-	Zone Routing Protocol

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CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, the technology for wireless communications has made tremendous advantages where it allows a very high mobility, efficient working and almost extreme economical. Moreover the Wireless Sensor Network (WSN) has become more crucial for mankind. The WSN is built of nodes from a few node to several hundreds or even thousands nodes, where each node is connected to a sensor. Each of the sensor network nodes consists of a radio transceiver with an internal antenna, a microcontroller, an electronic circuit for interfacing and an energy source. Devices such as cellular phone have now become necessity to everyone which allows people to communicate with each other with the urban coverage nearly everywhere around the world. Bluetooth and Wireless Local Area Network (WLAN) technologies have now become available and it facilitates easier living and creating the wireless environment.

Ad hoc is one of the communication technologies which provide the possibility for wireless devices to communicate directly with each other. Ad hoc mode allows all wireless devices to operate within the range of each other to discover and communicate in peer-to-peer fashion without using central access points. Ad hoc network is a network that makes pre-existing infrastructure obsolete and it provides

dynamic topology. Ad hoc network has the ability of self healing structure that makes the communication less vulnerable for failing links. This means that, even the communicating devices may be removed or added in the network, the information still can make its way through the networks to its final destination.

Due to the limited transmission range of the wireless network interfaces, sometimes the exchange data from one node to another may not be successful across the network. So, multiple networks "hops" may be needed to exchange data between the nodes across the network. In such a network, each of the nodes will not only operate as a host but also as a router where the forwarding packets from one node to another in the network may not be within direct wireless transmission range of each other. Each node that participates in an ad hoc routing protocol will allows it to discover 'multi-hop' path through the network to any other node. The ad hoc networking is also called infrastructure less networking, since the node in the network will dynamically establish routing among themselves to form their own network.

The existence of ad hoc technology and the 'multi-hop' network are useful for the Vehicular Ad Hoc Network (VANET) application. The VANET technology used vehicle as mobile nodes in the network to create a network. Every participating car in the network is turned by VANET into a wireless router or node. This allows car approximately 100 to 300 metres of each other to communicate and this creates a network with wide range. The cars may fall out of the signal and drop out of the network and other cars may join in, connecting vehicles to one another.

For the safety purpose, the system that integrated with this technology is beneficial to the police and fire vehicles where the communication of Vehicle to vehicle (V2V) application can be done even the nodes or vehicles can move around with no boundaries on their direction.

1.2 Motivation

Nowadays the IEEE 802.11 standard dominates the market and the implementing hardware is well developed. Ad Hoc protocol can be used for robustness and it can be deployed anywhere. This is useful for Vehicular Ad Hoc Network (VANET) which has grown out of the need to support the growing number of wireless products that can be used in vehicles. Moreover, as the mobile wireless devices and networks become increasingly important, the demand for Vehicle-to-Vehicle (V2V), Vehicle to Roadside (VRC) and Vehicle-to-infrastructure (V2I) communication will continue to grow where the nodes can move around with no boundaries on their direction. To support the communication in VANET network, a multi-hop concept is needed. Hence a new strategy for multi-hop transmission in wireless low rate ad hoc network with less overhead network traffic compared to existing protocols is developed.

1.3 Objective

The objectives of the project are:

1. To configure the low rate IEEE 802.11b platforms using Microchip WiFi Development Board.
2. To develop a multi hop routing protocol in C language.
3. To implement multi hop routing protocol on wireless Ad Hoc network.

Performances of the routing protocol will be evaluated base on the packet receives, packet loss, average time required for successful transmission and the throughput.

1.4 Scope of Work

The scope of this project includes developing software for the low rate 802.11b platforms in C language. The routing protocol of multi hop transmission using the existing network protocol, Address Resolution Protocol (ARP) on wireless Ad Hoc network is developed to send packets to the destination. This software will be embedded in the low rate 802.11b radio. The node will acts as a transmitter, receiver and a router.

The proposed routing protocol used the existing network protocol which is the Address Resolution Protocol (ARP). The ARP protocol utilizes to define the route or the path to the destination nodes. The query packet which is the ARP request will be broadcast to all nodes in the network in order to find the location of the destination. The forwarding nodes are implemented to find the routes to the destination. This new protocol comprises of two phases which are route discovery and data forwarding. In route discovery, if the nodes are in the same network, the ARP request or the query will be broadcasted. Nodes that hear the request will decide to broadcast the packet by replacing the source IP with its own IP. Therefore, at the destination node that receive this packet will then send a reply to the intermediate node and it will be forwarded via the route that have been established.

The development of this new routing began with the development of the state diagrams of the algorithm that illustrates the essential sequence of events. This eases the real test bed implementation. This project did not involve with the simulation but are developed in a real working implementation of a test bed that runs the routing protocol. The performance metrics such as packet receive, packet loss, the round trip time and also the throughput are analyzed. The test bed developed consists of three 802.11b and a laptop that can run a Wireshark.

1.5 Significant of the Project

This project is to develop a new routing protocol that can works in an ad hoc network. The development of the new routing protocol is based on the literature review on the existing routing protocol in the current communication network. The performance of this new routing protocol is verified with the implementation on a test bed in a two different environment. Depends on these outcomes, the feasibility of using this new protocol can be determined.

1.6 Organization of the Project

This report consists of five chapters. Chapter 1 contains the introduction to the project, the motivation, objectives, scope of work and the significant study of the project. Chapter 2 contains the literature review of the ad hoc network, the existing routing protocol and the concept of the Address resolution Protocol (ARP). In chapter 3, the methodology of the project is illustrated. This chapter details the hardware and software tools used. Besides, the testing method is also discussed here. In addition, the flow chart of the methodology and the flow chart of the programming are also explained here. Chapter 4 explains the result and the analysis of the experiments. The result of the different location of the experiment is also illustrated. Finally, chapter 5 concludes the report and suggests the future works.

REFERENCES

1. Microchip Technology Inc. (2010). *MRF24WB0MA/MRF24WB0MB Data Sheet 2.4 GHz, IEEE Std. 802.11b™ RF Transceiver Module*. USA.
2. IEEE Computer Society, (2000). *PART 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher-Speed Physical Layer Extension in the 2.4 GHz Band*. New York USA.
3. http://www.radio-electronics.com/info/wireless/wi-fi/ieee-802-11b.php
4. Liza Bt. Abdul Latiff (2007). *Quadrant Based Directional Routing Protocol For Mobile Ad Hoc Network*. PHD Thesis. Universiti Teknologi Malaysia.
5. Microchip Technology Inc.(2005). *Explorer 16 Development Board User's Guide.* USA.
6. The Story of the PING Program, May 2006. URL http://ftp.arl.mil/~mike/ping.html.
7. http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1406&dDocName=en019469&part=SW007002
8. Saurabh Rastogi (2006). *Optimizing Routing Protocol for Ad Hoc Network*. Mobile AdHoc and Sensor System (MASS), 2006 IEEE International Conference.
9. Mark Wright (2010).*MRF24WB0M Indoor and Outdoor Antenna Range Testing*. Microchip Technology Inc.
10. Ping Chung Ng, and Soung Chang Liew (2005). *Throughput Analysis of IEEE802.11 Multi-hop Ad hoc Networks*. IEEE/ACM Transactions on Networking.
11. Douglas S. J. De Couto Daniel Aguayo John Bicket and Robert Morris (2003). *A High-Throughput Path Metric for Multi-Hop Wireless Routing*.ACM.

12. Furqan Haq and Thomas Kunz (2009). *Simulation vs. Emulation:Evaluating Mobile Ad Hoc Network Routing Protocols* . In Proceedings of the International Workshop on Wireless Ad-hoc Networks (IWWAN'05).
13. S. S. Jadhav, T. X Brown, S. Doshi, D. Henkel, R. G. Thekkekunnel (2005). *Lessons Learned Constructing a Wireless Ad Hoc Network Test Bed.* Proceedings of the First Workshop on *Wireless Network* Measurements WiNMee.
14. T. X. Brown,S. Doshi, S. Jadhav, J. Himmelstein (2004). *Test Bed for a Wireless Network on Small UAVs*. proceedings of AIAA 3rd Unmanned Unlimited Technical Conference, September 2004, pp. 20-23.
15. P. Hu,A. A. Pirzada and M. Portmann (2006). *Experimental Evaluation of AODV in a Hybrid Wireless Mesh Network.* The 5th Workshop on the Internet, Telecommunications and Signal Processing (WITSP'06)
16. Anders Lundström and Magnus Westbergh (2004). *A New Routing Strategy for Mobile Ad Hoc Communication.* Master Thesis. University of Kalmar Sweden.
17. Josh Broth, David A. Maltz, David B. Johnson and Yih-Chun Hu.(1998) *A Performance Comparison of Multi-Hop Wireless Ad Hoc NeWork Routing Protocols.* Published by ACM 1998.
18. Liza Abdul Latiff, Norsheila Fisal, (2003) *Routing Protocol in Wireless Mobile Ad Hoc Network – A Review.* Communication 2003, APCC 2003. The 9th Asia-Pacific Conference on 2003.
19. Sandhaya Kohli, Bandanjot Kaur and, Sabina Bindra (2010). *A comparative study of Routing Protocols in VANET.* Proceeding of ISCET 2010.
20. Kevin C. Lee, Uichin Lee and Mario Gerla. (*2009Survey of Routing Protocols in Vehicular Ad Hoc Networks*. Book Chapter, Advances in Vehicular Ad-Hoc Networks: Developments and Challenges, IGI Global, Oct, 2009
21. L. A Latiff, A. Ali, Chia-Ching Ooi, N.Faisal, M. Ismail (2006) *Network Performance of a Multi-hop Quadrant-based Directional Routing Protocol (Q-Dir) in Wireless Mobile Ad-Hoc Network.* Computing & Informatics, 2006. ICOCI'06, International Conference on June 2006.
22. Anne Aaron and Jie Weng (2001). *Performance Comparison of Ad-hoc Routing Protocols for Networks with Node Energy Constraints*. EE 360 Class Project. Spring 2000-2001 Stanford.edu.

23. C. E. Perkins and E. M. Royer (1999) *Ad-hoc On-Demand Distance Vector Routing*. Proceeding WMCSA '99 Proceedings of the Second IEEE Workshop on Mobile Computer Systems and Applications.
24. Frederick Ducatelle. (2007) *Adaptive Routing in Ad Hoc Wireless Multi-hop Networks.* PHD Thesis. Universita Della Svizzera Italiana.
25. Aaron Balchunas (2007). *OSI Reference Model*. aaron@routeralley.com
26. Rainer Baumann (2004). *Vehicular Ad hoc Networks (VANET).* Master Thesis. Swiss Federal Institute of Technology Zurich.
27. Stallings (2005), W. *Wireless Communications and Networks*. Second Edition. USA.Pearson Prentice Hall. 2005.
28. IEEE 802.11. http://en.wikipedia.org/wiki/IEEE_802.11
29. Leif Axelsson, Anders Lundstorm, and Magnus Westbergh (2010). *Method, Communication Device and System For Address Resolution Mapping in a Wireless Multihop Ad Hoc Network.* United States Patent (US 7,660,287 B2)
30. http://www.linuxchix.org/content/courses/security/icmp