UNIVERSITI PUTRA MALAYSIA

PERFORMANCE OF AD-HOC ON-DEMAND DISTANCE VECTOR DISCOVERY ALGORITHMS BASED ON PACKET LIFETIME

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By

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Ad hoc On-Demand Distance Vector (AODV) routing protocol is a reactive protocol in Mobile Ad hoc Network (MANET). AODV uses a distance or hop count for determining the best forwarding path and store the sequence number at table entry to ensure the path information is up-to-date. Although the AODV is a better performance compare to other proactive and reactive routing protocol in MANET, this routing still has a limitation and can to be improved.

In this research, two algorithms that enhanced the original AODV are proposed. The first algorithm focuses on the AODV route table update management. The combination metrics of the lifetime and the sequence number in the table entry is used to solve the problem of the discarded active path information when the lifetime is expired. From the performance analysis, the proposed algorithm is successful to

enhance the original AODV based on the performance of delay, overhead, packet delivery ratio and packet loss ratio.

The second proposed algorithm is focused on the AODV route discovery. On the original AODV, packets will be allowed to rebroadcast the packet with a minimal lifetime. This will cause an unnecessary packets are discarded from the broadcasting. To solve this problem, Lifetime Ratio (LR) is proposed to reduce the unnecessary packets rebroadcast until it reaches the destination nodes. Based on the performance analysis, LR algorithm enhances the performance of the overhead, packet delivery ratio and packet loss ratio.

The performance analysis of the proposed algorithms was conducted by using the discrete-event simulator, OMNeT++. The simulator was used to simulate the mobility environment and the Open System Interconnections (OSI) layers utilized in wireless simulation. To compare the performance between the original AODV and the proposed algorithms, the performance metrics are based on delay, overhead, packet delivery ratio, packet loss ratio and throughput.

From the extensive simulations based on the performance metrics, the two proposed algorithms have shown distinct improvement and subsequently enhancing the performance of AODV.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
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ALGORITMA PENEMUAN AD HOC ON-DEMAND DISTANCE VECTOR BERPANDUKAN KEPADA HAYAT PEKET

Oleh

NOOR AZLAN BIN AHMAD

Ogos 2008

Pengerusi: **Shamala K. Subramaniam, PhD**

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Penyaluran protokol Ad hoc On-Demand Distance Vector (AODV) ialah protokol reaktif di dalam rangkaian Ad hoc bergerak. AODV menggunakan jarak atau bilangan lompatan untuk menentukan laluan penghantar dan menyimpan nombor jujukan pada jadual kemasukan bagi memastikan informasi laluan dikemaskini. Walaupun AODV adalah prestasi terbaik berbanding penyaluran protokol proaktif dan reaktif yang lain di dalam MANET, tetapi penyaluran ini masih mempunyai batasan dan masih boleh diperbaiki.

Di dalam penyelidikan ini, dua algoritma untuk memperbaiki AODV asal dicadangkan. Algoritma pertama fokus kepada pengurusan kemaskini jadual kemasukan AODV. Kombinasi metrik jangka hayat dan jujukan nombor di dalam jadual kemasukan digunakan untuk mengatasi masalah pembuangan informasi laluan aktif apabila jangka hayat telah tamat. Berdasarkan kepada analisis prestasi, algoritma

yang dicadangkan berjaya untuk memperbaiki AODV asal berpandukan kepada prestasi kelengahan, overhed, nisbah penghantaran peket dan nisbah kehilangan peket.

Algoritma kedua yang dicadangkan ialah fokus kepada penemuan jalan AODV. Pada AODV asal, peket akan dibenarkan untuk melakukan penyebaran semula peket dengan jangka hayat yang sedikit. Ia akan menyebabkan peket yang tidak diperlukan dibuang daripada penyebaran. Untuk mengatasi masalah ini, Nisbah Jangka Hayat (LR) diperkenalkan untuk mengurangkan peket yang tidak diperlukan disebar semula sehingga tiba ke nod-nod destinasi. Berpandukan kepada analisis prestasi, algoritma LR memperbaiki prestasi metrik bagi overhed, nisbah penghantaran peket dan nisbah kehilangan peket.

Analisis prestasi bagi algoritma-algoritma yang dicadangkan dikendalikan dengan menggunakan pensimulasi peristiwa diskrit iaitu OMNeT++. Pensimulasi ini digunakan untuk mensimulasi persekitaran mobiliti dan lapisan Saling Sambungan sistem Buka (OSI) dalam simulasi wayarles. Untuk membandingkan prestasi antara AODV asal dan algoritma dicadangkan, prestasi metrik adalah berpandukan kepada kelengahan, overhed, nisbah penghantaran peket, nisbah kehilangan peket dan daya pemprosesan.

Daripada simulasi yang meluas berpandukan kepada prestasi metrik, dua algoritma yang dicadangkan menunjukkan peningkatan ketara dan kemudiannya memperbaiki prestasi AODV yang dikehendaki.

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I certify that an Examination Committee has met on **date of viva** to conduct the final examination of **Noor Azlan Bin Ahmad** on his **Master of Science** thesis entitled **"Performance of AD-HOC On-Demand Distance Vector Discovery Algorithms Based on Packet Lifetime"** in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declared that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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NOOR AZLAN BIN AHMAD

Date: 3 March 2009

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LIST OF ABBREVIATIONS

Abbreviation	Term
AODV	Ad hoc On-Demand Distance Vector
AODV-AP	AODV Accessibility Prediction
AODV-CF	AODV-Controlled Flooding
AODV-SB	AODV Compatible Stability Based Routing Protocol
DARPA	Defense Advanced Research Projects Agency
DSDV	Destination Sequenced Distance Vector
DSR	Dynamic Source Routing
D-LAOR	Delay-based Load-Aware On-demand Routing
E2e	End-to-end
GPL	General Purpose Language
GPRS	General Packet Radio Service
ID	Identification
IEEE	Institute of Electrical and Electronics Engineer
IETF	Internet Engineering Task Force
IP	Internet Protocol
LB-AODV	Load Balancing AODV
LIN	Lifetime of an Intermediate Node
LR	Lifetime Ratio
MAC	Medium Access Control
MAD	Modified AODV Value
MANET	Mobile Ad hoc Network
MNH	Multiple Next Hops

NDMR	Node-Disjoint Multipath Routing
NED	Network Description
OMNeT++	Objectif Modular Network Testbed
OSI	Open System Interconnections
PAN	Personal Area Network
PDA	Personal Digital Assistant
PDR	Packet Delivery Ratio
PLR	Packet Loss Ratio
PoD	Percentage of Difference
PRNet	Packet Radio Network
QoS	Quality of Service
RERR	Route Error
RFC	Route Fragility Coefficient
RREP	Route Reply
RREQ	Route Request
SAD	Standard AODV Value
SNR	Signal to Noise Ratio
SWR	Sequence Window Routing
TCP	Transmission Control Protocol
TTL	Time to Live
TTLR	Ttl of the Particular Route
UDP	User Datagram Protocol
WLAN	Wireless Local Area Network
ZCF	Zone-based Controlled Flooding
ZRP	Zone Routing Protocol

CHAPTER 1

INTRODUCTION

Ad hoc is a network connection method which is most often associated with wireless devices. The connection is established for the duration of one session and requires no base station. Instead, devices discover others within range to form a network for those computers. Devices may search for target nodes that are out of range by flooding the network with broadcasts that are forwarded by each node. Connections are possible over multiple nodes (multihop Ad hoc network). Routing protocols then provide stable connections even if nodes are moving around. Routing refers to selecting paths in a computer network along which to send data. Routing directs forwarding, the passing of logically addressed packets from their source network, toward their ultimate destination through intermediary nodes; typically a hardware device called a router. The routing process usually directs forwarding on the basis of routing tables stored within the routers memory, which maintain a record of the best routes to various network destinations (Ramakrishnan, 2004). Thus the construction of routing tables becomes very important for efficient routing.

Figure 1.1 illustrates a simple three node Ad hoc network (Guemari, 2001). Assume that source node A intends to communicate with a destination node C, source node A and destination node C are not within the transmission range of each other. Therefore, they both use the relay node B to forward packets from

one to another. So, even though node B is primarily a host, node B is acting as a router at the same time.

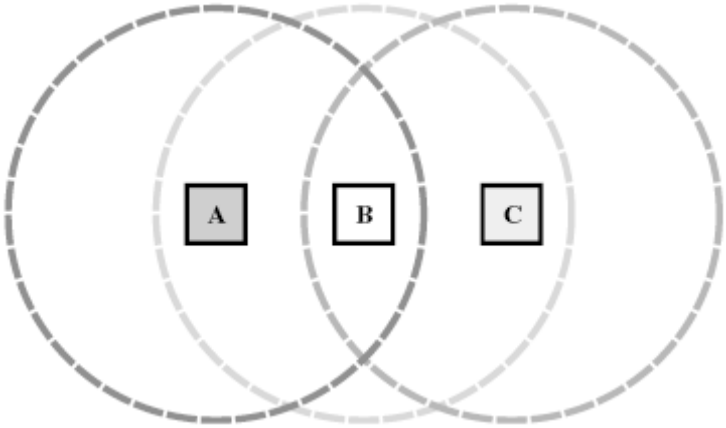

Figure 1.1: Ad hoc Networks with 3 Nodes

By definition, a router is an entity that determines the path to be used in order to forward a packet towards its final destination. The router chooses the next node to which a packet should be forwarded according to its current understanding of the state of the network.

1.1 Research Background

Ad hoc network is a collection of two or more devices equipped with wireless communications and networking capability. Such devices can communicate with another node immediately within their radio range or to the one that is outside their radio range using intermediate node(s). The intermediate node(s)

is used to forward the packet from the source (sender) toward the destination (receiver). The Ad hoc wireless network is self-organizing and adaptive which means that the Ad hoc network does not rely on any fixed network entities. The Ad hoc network itself is essentially infrastructureless. The Ad hoc network can be heterogeneous, that means the nodes can be of different types (i.e. Personal Digital Assistant (PDA), laptop and mobile phone) with different computation, storage and communication capabilities. Commonly the Ad hoc network is also known as Mobile Ad hoc Network (MANET) (Corson and Macker, 1999).

MANET has several characteristics, which set them apart from existing wireless or wired network architectures (Naski, 2004), (Yang *et al.*, 2004), (Yi *et al.*, 2005):

i. Dynamic topologies - the nodes are free to move arbitrarily. Thus, the network topology may change randomly and rapidly at unpredictable times.

ii. Bandwidth constraints - Nodes in an Ad hoc network are mobile. Thus, they are using radio links that have far lower capacity than hardwired links could use. In practice the realized throughput of a wireless network is less than a radio's theoretical maximum transmission rate.

iii. Energy constrained operation - Mobile nodes are likely to rely on the batteries. That is why the primary design criteria may sometimes be energy conservation.

iv. Limited physical security - In general, mobile wireless networks are vulnerable to physical security threats compared to fixed networks. Existing link security techniques can be applied in wireless network to reduce security threats.

The nature of MANET causes for routes to be built dynamically as and when nodes are regrouping. Hence, MANET is more responsive towards topology changing than any wired networks. Consequently, routing protocols for MANET should be able to recover with link breakages (i.e. it occurs when the next hop node moves out of transmission range) (Alsharabi *et al.*, 2005) and make sure that the network would not collapse as nodes are moving or shutting down.

The concept of mobile Ad hoc networks is not new. It dates back to the Defense Advanced Research Projects Agency (DARPA) Packet Radio Network (PRNet) program in the 1970's (Kamal, 2004). With the current technology and increasing popularity of PDAs and laptops, interest in Ad hoc networks has greatly increased. Some applications of MANET technology could include industrial and commercial applications as follows (Frodigh *et al.*, 2000), (Rao, 2004):

a) Military battlefield. Military equipment now routinely contains some sort of computer equipment. MANET would allow the military to take advantage of common place network technology to maintain an information network between the soldiers, vehicles, and military information headquarters.

b) Commercial sector. MANET is being used in emergency/rescue operations for disaster relief efforts, such as in fire, flood and earthquake. Emergency rescue operations must take place where non-existing or damaged communications infrastructure and rapid deployment of a communication network is needed. Information is relayed from one rescue team member to another over a small handheld.

c) Local level application. The meaning of local level application in MANET is the connection and communication by using the MANET devices in the small areas. MANET autonomously links an instant and temporary multimedia network using notebook computers or PDAs to spread and share information among participants such as in conference or class room. Another appropriate local level application might be in home networks where devices can communicate directly to exchange information.

d) Personal Area Network (PAN). Short-range MANET can simplify the intercommunication between various mobile devices such as a PDA, a

laptop, and a mobile phone based on the wireless equipment that supported in the mobile devices. The wired cables are now replaced with wireless connections. Such an Ad hoc network can also extend the access to the Internet or other networks by mechanisms such as Wireless Local Area Network (WLAN) and General Packet Radio Service (GPRS).

The problems in this research are based on the MANET characteristics and issues. There are several research challenges which constantly need issues to be considered in Ad hoc networking. A research challenge in MANET is to increase the information transfer efficiency, while handling environmental conditions such as resource limited devices and resource limited wireless communications (Ramanathan and Redi, 2002). In addition, routing and transport protocols must be made more intelligent such that communication paths avoid nodes low on resources. The following are the research issues and challenges in MANET:

a) Medium access scheme. The Medium Access Control (MAC) protocol needs to be designed to add pertinent characteristics of wireless networks. Among which typical for wireless networks the nodes moves about, and this leads to hidden terminal problem, causing the collisions among the nodes to communicate with the same nodes. The second issue is fair access to the medium and subsequently minimizing collisions. The MAC protocol should also be able to adjust the power used for transmissions, because reducing transmission power at a node