QUALITY OF SERVICE PERFORMANCES OF THREE MOBILE AD HOC NETWORK PROTOCOLS

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A project report is submitted as partial
fulfilment of the requirement for the award of the
Master's Degree in Electrical Engineering

Faculty of Electrical and Electronic Engineering
Universiti Tun Hussein Onn Malaysia

NOVEMBER 2009

To:

My parents: Tuan Haji Adam b. Haji Ngah and Puan Hajjah Ropinah bt. Haji Abas.

My family:

Mohd Shah Iskandar b. Sidek, Khairul Anuwar b. Adam, Normazani bt. Ismail, Adib Rahimi b. Adam, Saliza bt. Sazali, Amirah bt. Adam, Mohd Hazwan b. Mohamed Norli, Mohd Faris b. Khairul Anuwar, Farah Najibah bt. Khairul Anuwar, Mohd Farhan b. Khairul Anuwar, Farah Najihah bt. Khairul Anuwar and Mohd Abyan Izdihar b. Adib Rahimi.

ACKNOWLEDGEMENT

First of all, all thanks are due to Allah.

I would like to thank my project supervisor, Dr. Hj. Jiwa bin Abdullah for his extraordinary patient and their enduring optimism. I admire his knowledge, intelligence and patience. I do appreciate his dedicated guidance, suggestion, critical comments and warm supports. I am blessed and honoured to be his student.

I would like to acknowledge Universiti Malaysia Terengganu (UMT) and the Ministry of Higher Education (MOHE) for sponsoring my master degree study.

Beside that, I would like to thank my parent Mr. Haji Adam bin Haji Ngah and Mss. Hajah Ropinah bt. Haji Abas for all her love and support. They were always there for me to help and provide constant guidance, shining a light upon the completion of this project. My sincere gratitude goes to my family for their loves and support over the years.

Last but not least, my appreciation also goes to Mss. Rosilah bt. Rahmat who give me cooperation while doing this project in the lab.

ABSTRACT

Mobile Wireless Ad Hoc Networks (MANETs) is network without infrastructure, where every node functions as transmitter, router and data sink. Every node must discover its local neighbours and through them it will communicate to nodes that are out of its transmission range. The routing mechanisms in MANET are challenged by the interaction of three fundamental difficulties such as contention, congestion and node connectivity. Every ad hoc routing protocol has their own advantages based on the performances in the network. The thesis proposed to evaluate the Quality of Service (QoS) performances of three types MANET protocols. The protocols included the Dynamic Source Routing (DSR), Ad Hoc On-demand Distance Vector (AODV) and Temporally Ordered Routing Algorithm (TORA) protocol. The analysis had been done theoretically and through simulation using an Optimized Network Engineering Tools (OPNET) Modeler. Using OPNET Modeler software, these performances had been analyzed by the following metrics: packet delivery ratio, end-to-end delay, packet dropped, routing load and end-to-end throughput.

ABSTRAK

Mobile Wireless Ad Hoc Networks (MANETs) adalah rangkaian tanpa infrastruktur, iaitu setiap stesen berfungsi sebagai pemancar, penghala dan kumpulan data. Dalam rangkaian ini, setiap stesen mesti menemui stesen-stesen berada berdekatannya dan melalui stesen-stesen itu ia akan berhubung untuk stesen yang terkeluar daripada julat penghantarannya. Mekanisma penghalaan dalam MANET dicabar oleh tindak balas tiga faktor asas seperti pertembungan, kesesakan dan persambungan antara stesen. Setiap protokol penghalaan *ad hoc* mempunyai kelebihan berdasarkan keadaan dalam rangkaian. Tesis ini telah dijalankan bagi menilai prestasi *Quality Service* (QoS) bagi tiga jenis protokol MANET. Protokol tersebut termasuklah *Dynamic Source Routing* (DSR), *Ad Hoc On-demand Distance Vector* (AODV) dan *Temporally Ordered Routing Algorithm* (TORA) protokol. Analisis telah dilakukan dari segi teori dan melalui simulasi menggunakan perisian *Optimized Network Engineering Tools* (OPNET) *Modeler.* Menggunakan perisian OPNET Modeler, prestasi ini telah dianalisis dari segi metrik yang berikut: nisbah penyampaian paket, hujung ke hujung kelewatan, kehilangan data, beban penghalaan dan daya pemprosesan hujung ke hujung.

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LIST OF ABBREVIATIONS

MANET	-	Mobile Ad Hoc Network
PDA's	-	Personal Data Assistant
QoS	-	Quality of Service
OPNET	-	Optimized Network Engineering Tools
DSR	-	Dynamic Source Routing
AODV	-	Ad Hoc On-Demand Distance Vector
TORA	-	Temporarily Ordered Routing Algorithm
DSDV	-	Dynamic Sequence Distance Vector
MAC	-	Media Access Control
IEEE	-	Institute of Electrical and Electronics Engineers
NS-2	-	Network Simulator-2
LAN	-	Local Area Network
TDMA	-	Time Division Multiple Access
CAC	-	Call Admission Control
PANs	-	Personal Area Networks
TCP/IP	-	Transmission Control Protocol and Internet Protocol
ZRP	-	Zone Routing Protocol
RREQ	-	Route Request Packet
RREP	-	Route Reply Message
SDLC	-	Software Development Life Cycle
CBR	-	Constant Bit Rate
TTL	-	Time to Leave

PC	-	Personal Computer
RAM	-	Random Access Memory
ESD	-	External System Domain
FTP	-	File Transfer Protocol
HTTP	-	Hypertext Transfer Protocol
WLAN	-	Wireless Local Area Network

CHAPTER I

INTRODUCTION

1.1 Background

In general, mobile ad hoc network (MANET) is formed dynamically by autonomous systems of mobile nodes that are connected via wirelessly without support of any existing network infrastructure or centralized administration. Without any wired-infrastructure, it is envisaged that MANET could be deployed in applications such as search and rescue, automated battlefields, disaster recovery and sensor networks.

The nodes that make up a network at any given time communicate with and through each other. In this way every node can establish a connection to every other node that is included in the MANET. Typically nodes could be personal devices like mobile phones, laptops and personal data assistant (PDA's). Smaller and simpler devices also utilized this concept, such as wireless headsets and hands free phone. Figure 1.1 shows an example of MANET.

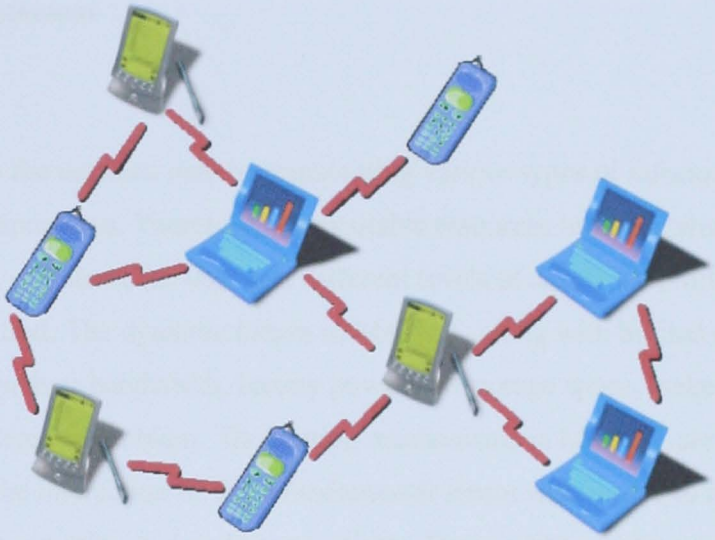

Figure 1.1: A mobile ad hoc network. (Morten Kronstad Vinje, 2006)

In this regard, MANET has to support multimedia applications, which make quality of service (QoS) a critical issue. Based on RFC2386 standard, QoS-based routing is defined as a routing mechanism under which paths for flows are determined based on some knowledge of resource availability in the network as well as the QoS requirement of the flows. In the other words QoS is a dynamic routing protocol that has expanded its path selection criteria to include QoS parameters such as available bandwidth, link and end-to-end path utilization, node resources consumption, delay and latency, and induced jitter.

1.2 Problem Statement

Each node in the network may be transmitting various types of information with different levels of importance. Therefore, the available resources in the network must be distributed in such a way that each user gets different levels of access according to the level of service required. The dynamic nature of MANET, along with limited resources that vary with time such as bandwidth, battery power and storage space, makes QoS provisioning, a challenging problem. The routing mechanisms in MANET are made complicated due to the interaction of three fundamental issues with regard to network such as contention, congestion and node connectivity. Every ad hoc routing protocol has their own advantages based on their individual performances in the network. By give the constant values of parameters such as: number of nodes, data rate, packet size and used constant bit rate (CBR) as a traffic type, this project is done to evaluate the performances of MANET protocols using appropriate metrics.

1.3 Objectives of Project

The objective of this project is to evaluate the QoS routing performances of three MANET protocols: dynamic source routing (DSR), ad hoc on-demand distance vector (AODV) and temporally ordered routing algorithm (TORA) protocol. The analysis had been done theoretically and through simulation using an Optimized Network Engineering Tools (OPNET) Modeler. Using OPNET Modeler software, these performances had been analyzed by using the following metrics: packet delivery ratio, end-to-end delay, packet dropped, routing load and end-to-end throughput.

1.4 Scope of Project

The scopes of this project is to evaluate three MANET routing protocols through research and simulation. OPNET Modeler software will be used in this project to develop these protocols. After that, the performances of three MANET protocols had been analyzed based on metrics. Then, the results will be compared between the protocols and results from literatures.

1.5 Thesis Layout

The thesis is organized as follows:

Chapter 1: In this chapter will explain an introduction to the QoS performances for Mobile Ad Hoc Network. The introduction consists of background, problem statement, objectives of project, scope of project and research methodology.

Chapter 2: This chapter consists of the previous study and the theoretical of the project. Its will cover the literature research based on routing in Mobile Ad Hoc Network.

Chapter 3: In order to achieve the objectives of this project, this chapter will explain the methodology of the project. The simulation parameters and the metrics that will be analyzed during this project also had discussed in this chapter.

Chapter 4: The results of the studies are presented and compared within this chapter. With the comparison, some analysis considering different kind of characteristics that have an effect on the results is provided.

Chapter 5: This chapter summarizes all the results and done the conclusions of the project and recommendation for future works.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Literature survey has been carried out in order to gain enough knowledge regarding this project. The objective of this chapter is to critically review the existing research on mobile ad hoc networks (MANETs) protocols. Particular emphasize will be given to the metrics that had been used to analyzed the performances of three MANETs protocols: DSR, AODV and TORA. The following reviewed articles were of greatest significance, providing substantial and authoritative information from the pervious researches on MANET protocols.

2.2 Previous Case Study

Josh Broch *et al.* (1998) presents the results of a detailed packet-level simulation comparing four multi-hop wireless ad hoc network routing protocols that cover a range of design choices: DSDV, TORA, DSR, and AODV. They have extended the Network Simulator-2 (ns-2) simulator to accurately model the MAC and physical-layer behavior of the IEEE 802.11 wireless LAN standard, including a realistic wireless transmission channel model, and present the results of simulations of networks of 50 mobile nodes. Each of the protocols studied performs well in some cases yet has certain drawbacks in others. DSDV performs quite predictably, delivering virtually all data packets when node mobility rate and movement speed are low, and failing to converge as node mobility increases. TORA, although the worst performer in our experiments in terms of routing packet overhead. The performance of DSR was very good at all mobility rates and movement speeds, although its use of source routing increases the number of routing overhead bytes required by the protocol. Finally, AODV performs almost as well as DSR at all mobility rates and movement speeds and accomplishes its goal of eliminating source routing overhead, but it still requires the transmission of many routing overhead packets and at high rates of node mobility is actually more expensive than DSR.

The actual work consisted of representing and comparing some researches on ad hoc routing performance had been presented by Sampo Naski (2004). Three studies were reviewed and their results were compared. The comparison was done with respect to three major protocols: DSDV, DSR and AODV. The studies compared were based on simulations. After all the simulations results of the different studies were quite similar. On the other hand, the special scenarios and simulations runs with larger networks pointed out that the performance of ad hoc routing protocols may decrease rapidly especially if there are some bottlenecks in the network. It was also concluded that any protocol does not scale up with out problems. After all, the researcher comes clearly out

that no protocol is better than other with respect to every metric on different situations. That is fundamentally because of the very nature of the ad hoc network.

Besides, Mamoun Hussein Mamoun (2007) also has studied and done the comparison for the performance evaluation of DSR and AODV on the bases of packet delivery ratio, normalized routing load, normalized MAC load, and average end to end delay by varying the number of sources, speed and pause time. The simulation results bring out some important characteristic of differences between the protocols. The presence of high mobility implies frequent link failures and each routing protocol reacts differently during link failures. The different basic working mechanism of these protocols leads to the differences in their performances.

Chenxi Zhu and M. Scott Corson (2002) had developed an on-demand QoS routing protocol based on AODV for TDMA-based mobile ad hoc networks. It can build a QoS route from a source to a destination with reserved bandwidth. They developed a distributed algorithm for calculating the end-to-end bandwidth on a path efficiently. This bandwidth calculation algorithm is integrated into the AODV protocol in search of routes satisfying the bandwidth requirements. The QoS routing protocol can also restore a route when it breaks due to some topological change. Therefore, it can handle some degree of network mobility. Its performance had compared with that of the original AODV protocol with simulations. In the simulations, the QoS routing protocol can produce higher throughput and lower delay than the best-effort protocol. It works the best in small networks or over short routes under low network mobility.

Hence, Agustin Zaballos *et al.* (2005) present a comparative study, through simulation, of four routing protocols: DSR, TORA, AODV, and OLSR for MANETs using OPNET Modeler, whose models include these algorithms. According to the simulations results, AODV presents the best all around performances. Its improvement of DSDV and DSR protocol turn it a highly versatile protocol. DSR is a suitable approach for mobile networks and all around data load environments. The extremely high delay introduced in the network gets increased as the number of nodes and network

size do. In those environments, routes are larger, increasing packet length more and more. This is the reason to restrict DSR use to small and medium sized mobile networks. In most common MANET cases, TORA would cause a collapse in the network. Its dependence of an underlying protocol as IMEP which generates such a lot of control traffic makes its use not very recommended, as simulation results demonstrate. However, it may be suitable for environments where a non critical performance level is required, and it needs to be constantly maintained.

The performance evaluation and simulations of routing protocols in ad hoc networks has been studied by Bu Sung Lee *et al.* (2006). In their paper, they consider the problem from a different perspective using the simulation model with a dynamic network size and an invariable pause time which should be zero under weakest case because a longer pause time of the node may be insignificant for MANETs with frequently and fat moving nodes. Furthermore, based on the metrics: delay, jitter, throughput, loss ratio, routing load and the connectivity, this paper systematically discusses the performance evaluation and comparison of four typical routing protocols of MANETs with different simulation model and metrics. The simulator for evaluating routing protocols is implemented with the network simulation version 2 (ns2).

2.3 Theoretical Evaluation of Mobile Ad Hoc Network (MANET)

2.3.1 Introduction

Ever since the early 1990s the use and demand for mobile networks and devices has continued to grow. This is largely due to the ever-growing popularity of mobile phones. The parallel growth in popularity of the Internet has sparked new interests in providing Internet-type applications over mobile wireless networks.

A MANET is a system of wireless mobile node that can freely and dynamically self-organize in arbitrary and temporary network topologies without the need of a wired backbone or a centralized administration. People and devices can be seamlessly internetworked in areas without any preexisting communication infrastructure or when the use of such infrastructures requires wireless extension.

With these in mind, mobile ad hoc networking offers unique benefits and versatility for certain environments and applications. First, since they have no fixed infrastructure including base stations as prerequisites, they can be created and used anytime, anywhere. Second, such networks can be intrinsically fault resilient, for they do not operate under the limitations of a fixed topology. Indeed, since all nodes are allowed to be mobile, the composition of such networks is necessarily time varying. Addition and deletion of nodes occurs only by interactions with other nodes; no other agency is involved.

Traditionally, mobile wireless networks can be classified into two categories: infrastructured and infrastructureless. The infrastructured networks are coordinated by a centralized controller (also known as a base station or an access point), which directs the flow of traffic to and from each end-user node. The infrastructureless (also known as ad hoc) networks are made up of end-user nodes only. This means all nodes in the

networks are capable of transmitting, receiving, and routing data to different nodes in their network without using the services of a base station.

In ad hoc networks, nodes can be fixed or static or mobile, or a mixture of the two. The ad hoc networks that have mobile nodes are commonly referred to as MANETs. In MANETs, each node is characterized by its transmission range, which is limited by the transmission power, attenuation, interference, and terrain topology. Direct communication can occur between two intermediate nodes if they are within each other's transmission range. Indirect communication can be established by determining a route through a number of intermediate nodes between the source and the destination.

2.3.2 Applications of Mobile Ad Hoc Networks

MANETs are useful in dynamic networking environments where the topology of the network changes continuously. They are also useful in areas where a networking infrastructure cannot be easily implemented. Some typical applications of these networks include: coordinating military operations in the battlefield, disaster relief operations, conferencing, sensor networking, vehicular networking and personal area networks (PANs).

In the highly dynamic battlefield environment, efficient communication between different types of forces may give significant advantage to one side over other. In disaster relief operations, the search and rescue teams can coordinate their effort using MANETs to save the victims of fires, hurricane, earthquakes, and other natural disasters. During conferences or exhibitions, where a temporary networking infrastructure may be required, MANETs can provide a more cost-effective and rapid

implementation solution than wired networks. In sensor networking, MANETs can be used to control mobile devices gather data in contaminated areas instead of sending an emergency team. In vehicular networking, MANETs can be used to control traffic in the city by providing drivers with up-to-date traffic information from the surrounding streets and intersections. Another application for MANETs is to provide communication between small devices in PANs with a dynamic networking environment.

2.3.3 Challenges

The applicability of MANETs to a variety of different applications (mentioned above) has attracted interest from many different organizations such as large companies, governments, and universities. This has made MANETs one of the most highly researched areas in wireless local area networking. The current research in MANETs ranges throughout all layers of the Transmission Control Protocol and Internet Protocol (TCP/IP) model, as they very nature of these networks demands some redesign for each layer to provide efficient end-to-end communication. Furthermore, before MANETs can be used successfully in the scenarios, a number of critical issues should be addressed.

- Bandwidth

  The capacity of wireless networks is significantly lower than the capacity of wired networks. Route discovery and updates may cause significant bandwidth problems as the size or the density of the network grows.

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