UNIVERSITI PUTRA MALAYSIA

# AMTREE PROTOCOL ENHANCEMENT BY MULTICAST TREE MODIFICATION AND INCORPORATION OF MULTIPLE SOURCES

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**DOCTOR OF PHILOSOPHY**
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# AMTREE PROTOCOL ENHANCEMENT BY MULTICAST TREE MODIFICATION AND INCORPORATION OF MULTIPLE SOURCES

**By**

**ALI MOHAMMED ALI AL-SHARAFI**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

**August 2008**

## DEDICATION

*Dedicated to my parents,*

*to my wife,*

*to my kids,*

*and to all my brothers and sisters.*

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy

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**Chairman:** **Associate Professor Mohamed Othman, PhD.**

**Faculty:** **Computer Science and Information Technology**

Multicasting is a process of sending packets from one source (multiple sources) to multiple destinations. In mobile environment, when the source is mobile and migrates to a new location, the multicast tree needs to be rebuilt. AMTree is an active network based protocol intended to make the sending packets to the tree after source migration an efficient process without much modifications to the multicast tree. It is separated into three phases: 1) construction of multicast tree. 2) Handoff process. 3) Optimization Process.

In AMTree protocol, after source migration, handoff latency is computed from the time of reconnecting to a new base station until finding nearest core to the mobile source. This process takes a long time and the number of messages sent is at least equal to the number of cores in the tree. In

optimization, the number of nodes that requesting optimization is high. This means the time of optimization process is also high. In addition, AMTree protocol is proposed for multicast with a single source.

This thesis proposes some techniques to enhance the AMTree protocol. First we propose two algorithms to improve the handoff process in AMTree protocol. Second we introduce a new method to construct the multicast tree in AMTree protocol. Third technique is incorporating multiple sources in AMTree protocol. This is an extension to AMTree Protocol.

The results from experiments show that handoff latency using the new algorithms is much lower than using AMTree handoff procedure in both cases, i.e. when the source connects to a subscribed base station or not subscribed base station. By modifying the multicast tree, the number of nodes to be optimized was reduced. Also the optimization time was minimized. Incorporation of multiple sources in AMTree protocol resulted with minimized end-to-end latency after handoff and after optimization.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**MEMPERBAIKI PROTOKOL AMTREE OLEH MENGUBAHSUAI PEPOHON BERBILANG SIARAN DAN POKOK DAN TERDIRI DARIPADA PELBAGAI SUMBER**

Oleh

**ALI MOHAMMED ALI AL-SHARAFI**

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Berbilang siaran merupakan satu proses penghantaran paket-paket dari satu sumber (berbilang sumber) kepada berbilang destinasi. Dalam persekitaran mudah alih, apabila sumber adalah mudah alih dan berpindah ke lokasi baru, pepohon berbilang siaran perlu dibina semula. AMTree adalah satu protokol berasaskan rangkaian yang aktif yang bakal membuat penghantaran paket-paket kepada pepohon setelah satu proses yang cekap bagi penghijrahan sumber tanpa banyak pengubahsuaian kepada pepohon berbilang siaran la terbahagi kepada tiga fasa: 1) Pembinaan pepohon berbilang siaran. 2) Proses penyerahan. 3) Proses pengoptimuman.

Dalam protokol AMTree, setelah penghijrahan sumber, kiraan kependaman penyerahan daripada masa penyambungan semula untuk satu stesen

pangkalan baru sehingga menemut teras terdekat dengan sumber bergerak. Proses ini mengambil masa yang panjang dan bilangan pesanan yang dihantar sekurang-kurangnya sama dengan bilangan teras-teras dalam sesuatu pepohon. Dalam pengoptimuman, bilangan nod-nod yang memohon pengoptimuman adalah tinggi. Ini bermakna masa bagi proses pengoptimuman juga tinggi. Selain itu, protokol AMTree dicadangkan untuk berbilang siaran dengan satu sumber tunggal.

Tesis ini mencadangkan beberapa teknik untuk meningkatkan protokol AMTree. Pertama, kami mencadangkan dua algoritma untuk memperbaiki proses penyerahan dalam protokol AMTree. Kedua, kami memperkenalkan satu kaedah baru untuk membina pepohon berbilang siaran dalam protokol AMTree. Teknik ketiga adalah menggabungkan pelbagai sumber dalam protokol AMTree. Ini merupakan satu penambahan kepada protokol AMTree.

Hasil daripada eksperimen menunjukkan bahawa penyerahan kependaman menggunakan algoritma-algoritma baru adalah lebih rendah berbanding menggunakan prosedur penyerahan AMTree dalam kedua-dua kes, iaitu, apabila sumber disambung kepada satu stesen pangkal yang dilanggan atau stesen pangkal yang tidak dilanggan. Dengan mengubah pepohon berbilang siaran, bilangan nod-nod yang akan dioptimumkan telah dikurang. Masa

pengoptimuman juga telah dikurangkan. Penggabungan pelbagai sumber dalam protokol AMTree terhasil dengan mengurangkan kependaman hujung ke hujung setelah penyerahan dan setelah pengoptimuman.

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Honestly, I can't express my warmest gratitude and feelings towards my parents in the way they really deserve. I owe my parents much of what I have become. I thank them for their love, their support, and their patience for being away from them for the last thirteen years. My parents have always put education as a first priority in my life, and raised me to set high goals for myself.

I would also like to thank all my friends whom we shared good and bad times together. I thank them for every thing.

Last but of course not least, this work would not have been achieved without the support and understanding of my wife and my kids. They have always supported me in everyway I have chosen in life.

I certify that an Examination Committee has met on / /200 to conduct the final examination of Ali Mohammed Ali Al-Sharafi on his Doctor of Philosophy entitled "Enhancements to AMTree Protocol by Modifying the Multicast Tree and Incorporation of Multiple Sources" 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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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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Date: 13 November 2008

## DECLARATION

I declare that the thesis is based on 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 UPM or at any other institution.

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**ALI MOHAMMED ALI AL-SHARAFI**

Date:

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| DVMRP | Distance Victor Multicast Routing Protocol |
| MH | Mobile Host |
| AN | Active Network |
| MOSPF | Multicast Open Shortest Path First |
| PIM | Protocol Independent Multicast |
| CBT | Core-Based Tree |
| RIP | Routing Information Protocol |
| Mbone | Multicast Backbone |
| RPM | Reverse Path Multicast |
| PIM-SM | Protocol Independent Multicast – Sparse Mode |
| PIM-DM | Protocol Independent Multicast – Dense Mode |
| OSPF | Open Shortest Path First |
| IGMP | Internet Group Management Protocol |
| IGP | Interior Gateway Protocol |
| AS | Autonomous System |
| DR | Designated Router |
| LSA | Link State Advertisement |
| ABR | Area Border Router |
| RP | Rendezvous Point |
| IETF | Internet Engineering Task Force |

| | |
|---|---|
| MN | Mobile Node |
| CN | Correspondent Node |
| HoA | Home Address |
| CoA | Care-of-Address |
| HA | Home Agent |
| FA | Foreign Agent |
| DHCP | Dynamic Host Configuration Protocol |
| CH | Correspondent Host |
| DMSP | Designated Multicast Service Provider |
| DFA | Domain Foreign Agent |
| DVM | Dynamic Virtual Micro-cell |
| RSVP | Resource Reservation Protocol |
| ACK | Acknowledgment |
| NACK | Negative Acknowledgment |
| EE | Execution Environment |
| API | Application Program Interface |
| VPI | Virtual path Identifier |
| VCI | Virtual Circuit Identifier |
| ATM | Asynchronous Transfer Mode |
| JVM | Java Virtual Machine |
| Node OS | Node Operating System |
| AA | Active Application |



| | |
|---|---|
| CPU | Central Processing Unit |
| Mgmt EE | Management Execution Environment |
| UDP | User Datagram Protocol |
| ANEP | Active Network Encapsulation Protocol |
| ORB | Object Request Broker |
| AR | Active Router |
| LD | Location Directory |
| DNS | Domain Name Server |
| APM | Active Program Manager |
| MHA | Multicast Handoff Agent |
| SPT | Shortest Path Tree |
| DCM | Distributed Core Multicast |
| QoS | Quality of Service |
| DCSP | Distributed Core Selection Protocol |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Today's user community is demanding a level of mobility not previously anticipated by designers of distributed systems and computer networks. Hardware technological advances have made inexpensive and powerful portable computers a reality. This convergence of a desire for mobility and products to satisfy that desire has created much interest in problems related to the mobile computing paradigm. Concurrent with this growth in the popularity of mobile computing has been a significant growth, in the Internet community at least, in the use of multicast network applications.

Multicasting can be defined as a one-to-many (or many-to-many) type of communication, that is, the transmission of the same information from one or multiple senders to several destinations. With multicasting, a sender's data stream is transmitted only once on links that are shared along the paths to a targeted set of destinations. This data stream is duplicated at the network nodes where the paths diverge in order to reach receivers located on different networks [1].

In the Internet, IP multicast is used, and the most popular implementation of IP multicast is based on the distance vector multicast routing protocol (DVMRP) [2]. Each group is identified by a group address and members join and leave this group as they wish. Multicasting is a more efficient method of supporting group communication than unicasting or broadcasting, as it allows transmission and routing of packets to multiple destinations using fewer network resources. Multicasting in heterogeneous environments is an area under investigation. Traditional multicast protocols did not consider sources and receivers to be mobile. There has been little work done in the area of multicasting specifically routing to Mobile Hosts (MHs) and current solutions suffer from limitations such as sub-optimal path and scalability issues [3].

Multicast over wireless networks is an important and challenging goal, but several issues must be addressed before many group applications can be deployed on a large scale [4]. Along with widespread deployment of wireless networks, the fast-improving capabilities of mobile devices, and an increasingly sophisticated mobile work force worldwide, content and service providers are increasingly interested in supporting multicast communications over wireless networks.

Active Networks (ANs) are a new paradigm for solving network problems. This paradigm uses the computational power at intermediate network nodes to facilitate processing of traffic passing through. An AMTree (AN-based approach) takes advantage of the processing capabilities at routers which enable MHs to continue sending packets to receivers after migration. Hence, the multicast tree can be maintained without much modification and incurs minimal packet latency. This means low handoff latencies and minimal disruptions to packet flow. Furthermore due to intra-network processing, signaling overheads are low and tree is updated dynamically in an efficient way [3].

**Problem Statement**

The AMTree protocol was designed to solve some problems with multicasting in mobile networks. These problems are:

- After migration, multicast protocols that are based on shortest path tree such as DVMRP may route packets incorrectly or drop packets due to reverse path forwarding.
- At the receiving end, when a MH migrates to a cell with no other group members, it will experience delay. This is mainly caused by subscription delay, tree rebuild or due to non-existent multicast routers in the region.

Although the AMTree allows for an efficient method for updating the multicast tree during migration by exploiting the characteristics of ANs, but AMTree protocol still has many problems need to be solved. These problems are:

1. The handoff process takes a long time and it is not feasible because of high signaling messages occurred. The signaling messages increase accordingly with the increase of nodes subscribe to the multicast tree.
2. Another problem in AMTree protocol is the mobile source movement transparency. The source migration is not transparent to the receivers because of the design of the tree (the receiver sends its interest to join the multicast tree directly to the source using the shortest path). After the