New Algorithms to Minimize Handoff Latency in AMTree Protocol

Ali Al-Sharafi, Mohamad Othman, and Shamala Subramaniam
Faculty of Computer Science and Information Technology, Universiti Putra Malaysia, Malaysia

Abstract: *In active networks, programs can be injected to network elements (routers/switches). This allows programmers to enhance existing protocols or deploy new protocols. AMTree protocol is an active network based protocol that makes sending packets to receivers, after source migration, an efficient process. In AMTree protocol, after source migration, handoff latency computed from the time of reconnecting to a new base station until finding nearest core to the mobile source. In this paper we present two new algorithms to minimize the handoff latency in AMTree protocol. We show that handoff latency is much lower than that of AMTree handoff algorithm if the mobile source connects to a base station which is subscribed to the multicast group. Also we show that our algorithm gets better results than AMTree if the new base station is not in the multicast group.*

Keywords: *Active networks, mobile networks, multicast, handoff.*

Received May 26, 2007; accepted October 30, 2007

1. Introduction

Multicast is communication between a single sender (or multiple senders) and multiple receivers on a network. Recently, more and more group communication applications (e.g., video-conferencing, online-gaming, and long-distance education) have emerged with the increasing popularity of the Internet. To support such multi-user applications, multicast is considered as a very efficient mechanism since it uses some delivery structures (e.g., trees or meshes) to forward data from senders to receivers, aiming to reduce duplicate packets. In traditional networks, the design of multicast protocols such as DVMRP [15], MOSPF [11], CBT [3] and PIM [8] was for fixed hosts in mind hence, it faces some problems in mobile networks. Active Networks [14] 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.

AMTree protocol [7] is an active network based approach to solve the problem of having mobile source in the multicast group. The algorithm to compute handoff latency in AMTree results in low latency compared with that of bidirectional home agent method [12].

In this paper we propose a new algorithm to reduce the handoff latency in AMTree. In the next section we present a background about active networks and AMTree protocol. Section 3 describes the proposed method and algorithm. In section 4 we present the simulation model and the results. The last section concludes this paper.

2. Background

The idea of AMTree protocol is to use capabilities of Active networks to give the source of multicast group the ability of being mobile and to continue sending data packets to the tree after migration. This capability is executing user instructions in the network elements. This section presents a brief look at Active Networks, AMTree Protocol, and some of related work.

2.1. Active Networks

Active network is a new paradigm to network architecture in which the switches of the network perform customized computations on the messages flowing through them. There are two possible approaches to build active networks. Programmable switches approach and capsule approach.

- Programmable switches approach: here programs are injected into the programmable active node separately from the actual data packets that traverses through the network. User would send the program to the network node (switch or router), where it would be stored and later executed when the data arrives at the node, processing that data. The data can have some information that would let the node decide how to handle it or what program to execute [2, 5].
- Capsule approach: in this approach, the program is integrated into every packet of data send to the network. Each message or capsule contains a program fragment that may or may not have some embedded data. When these capsules arrive at the active node, it interprets the programs and sends the embedded data depending on its interpretation of

these programs [16]. This concept is similar to Postscript code, where actual data is embedded in program fragments that the printer understands. In this approach, each active node would have built-in a mechanism to load the encapsulated code, an execution environment to execute the code and a relatively permanent storage where capsules would retrieve or store information.

2.2. AMTree Protocol

AMTree protocol is designed to solve some of the problems that may occur when there is a mobile source in the multicast group. AMTree takes advantage of the processing capabilities at routers which enable mobile source to continue sending packets to receivers after migration. This means that multicast tree can be maintained without much modification and incurs minimal packet latency. Hence, handoff latencies will be low and multicast tree is updated dynamically and efficiently.

After mobile source migration, it sends a message to old contact point (its local router before migration) to give its new address. The old contact point then multicast a message to the tree with the new address. Each core (core refers to any router with more than one subscriber) in the tree, after receiving the message, sends a CORE_CONNECT message to the new contact point as a designated core. This process uses the computation in each router to determine the nearest core to the mobile source's new address. The designated core is then used by the mobile source to unicast packets, the core in turn will multicast packets along the tree.

2.3. Related Work

P mobility er occurs int-of- proposed to proactive handover main], a latency. nets about cluster concept and triggering the preparation phase in advance. It proposed two alternatives after preparation phase.

After mobile entering the target subnet, it will find the multicast traffic flow already there. This case indicates a more readily handoff handling with eliminated both Internet Group Management Protocol (IGMP) and preparation latencies, but with resource consumption before it is actually needed. After mobile entering the target subnet, it waits for the first IGMP query to utilize the information gained from the preparation process that was triggered in advance (this case takes advantage of time gained through the processing of handoff but not consuming any resources until they are really needed). Another mechanism proposed in [10] called a Multicast Handoff Agent (MHA) to reduce the multicast handoff latency and the IGMP control overhead. This agent will be located at each base station and act as a proxy for the mobile nodes to reply to the periodic IGMP query messages sent by the multicast router. This agent has a Multicast Group Table (MGT) which keeps group membership information for multicast groups in its cell using a Multicast Group Identifier (MGID) and a Mobile Node Identifier (MNID). Finally, in [13], a solution to enhance handoff mechanisms in nested mobile networks is proposed. The proposed solution meaningfully reduces handoff latency and packet loss and achieves better throughput with TCP flows. It also optimizes communications within the nested mobile network in order to enable anticipated handoff solution like fast handoff.

3. Proposed Method

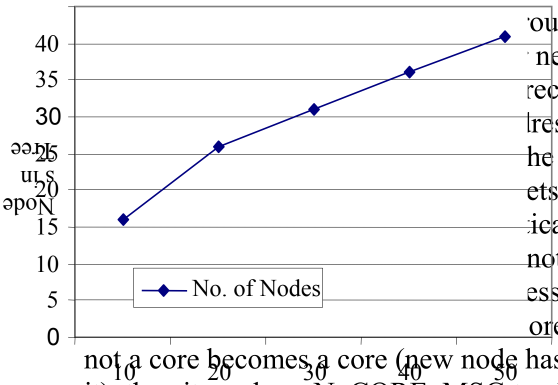
We have developed two algorithms to minimize the latency of handoff procedure in AMTree protocol. The two new algorithms take advantage of using computation capabilities of active networks. In order to minimize the number of messages sent using the algorithm proposed in AMTree protocol, we modified the existing acknowledgement message by adding the IP address of the first core in the path from the receiver to the source (which considered the nearest core to the receiver). Figure 1 shows the first algorithm.

***Algorithm**: (determine the nearest core when a base station subscribed to the group)*

If a node is not a core and becomes a core then
  Send N_CORE_MSG down to all subscribers
Else
  If a node is a core and received JOIN_MSG then
    Send ACK_MSG down to the receiver
If a core node received a N_CORE_MSG then
  Save the IP address which included in the message
  Discard the message

Figure 1. Algorithm to determine the nearest core for each node subscribed to multicast group.

The algorithm works as follows. When a receiver wants to join the multicast group, it indicates its interest in joining by sending a JOIN_MSG to its local router. The router will forward the message to the source through the shortest path. If a core router is found in the path it will send an ACK_MSG (containing its IP address as nearest core) down to the



outers) in the path
nearest core.
reconnect to the
ress of the nearest
he nearest core
ets from the
icast the packets
not subscribed in
essage to all nodes
ore. If a router but
not a core becomes a core (new node has subscribed to it), then it sends an N_CORE_MSG to all nodes subscribed to it containing its IP address as nearest core. If a core router receives an N_CORE_MSG then it saves the IP address which is included in the message and discards the message. The IP address will be used when this core becomes no core any more (when it has only one subscriber left and other subscriber's leaves the multicast group).

The above algorithm was proposed to be used when the mobile sources connected to a base station node that is subscribed to the multicast group.

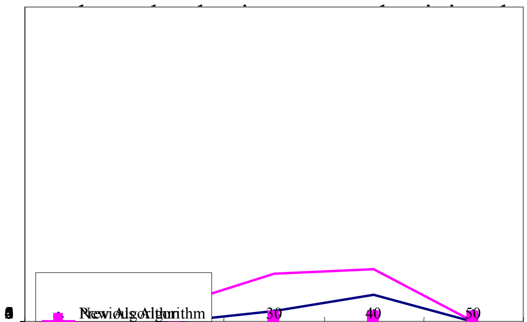
The second algorithm was proposed to be used when the mobile source connected to a base station node that is not subscribed to the group. Figure 2 shows the second algorithm.

> ***Algorithm***: *(determine the nearest core when a base station is not subscribed to the group)*
>
> *If a base station is not subscribed to the multicast group then*
> *Send GET_NEAREST_MSG to all nodes connected to it.*
> *Each node subscribed to the tree reply to the message with its nearest core*
>
> *If more than one reply received then*
> *Compare No. of Hops and choose the shortest one.*

Figure 2. Algorithm to determine the nearest core when the base station is not subscribed to the tree.

The idea of this algorithm is to send a message from the base station to all nodes connected to it asking for the nearest core to each one. Each node that is subscribed to the multicast group will send the IP address of its nearest core. By comparing the number of hops the base station node choose the nearest core node which the mobile source unicast its packets to, then it multicast them to the tree.

If the base station is not subscribed to the multicast group, we still have high probability of having one of
cribed to the
odes subscribed
f receivers.



No. of Receivers

Figure 3. Number of nodes subscribed to the tree versus number of receivers.

4. Simulation and Results

We have tested our algorithm after re-simulating AMTree protocol. Delphi 5 is used to code the simulator and all the experiments are executed in a computer with Pentium 4 processor 3.8MHz, and ram 1GB under Windows XP professional operating system.

To build the simulator we used 2-level hierarchical networks. This topology is produced using GT-ITM generator as suggested in [17] and [6] which is the most realistic model for modelling networks. After reading the topology from a text file, the simulator needs to determine the set of shortest paths that will be computed by the routers based on the current topology and configuration. The routing stage, in this simulator, computes the shortest paths between any pair of routers using Dijkstra's algorithm [1].

We have tested AMTree protocol and new algorithm on a network of 50 node mesh topology with degree ranging from one to six with average three. The data rate of interconnecting links between active routers is set to 10mb/s. The wireless links have a data rate of 2mb/s. Bit errors at the wireless link are assumed to be handled by a data link layer protocol. Each base station is assumed to manage a cell and overlapping of cells means there are no silent areas. The mobile source controls the time of handoff, meaning the time of handoff and the duration of the handoff procedure can be measured. The mobile source migrates randomly to any of the receiver's subnet. Hence, the migrations are not necessarily local. There is only one ongoing session in any moment and the packets generated by the source are of size 1024 bytes at rate one packet per second. The performance studied was on varying number of receivers, ranging from 10 to 50, and ten simulation runs were done and results averaged.

We compared the handoff latency achieved by AMTree protocol and after we applied our algorithms and we found out that our algorithms achieved much lower latency, either in case of a base station is subscribed to the multicast group or not subscribed.

This is due to existing of the address of the nearest core in the new base station which mobile source connected to, and no need to send a message to the entire tree to find the nearest core. Figure 4 shows results of our first algorithm compared to the previous algorithm proposed in AMTree protocol. Figure 5 shows the results for both cases of the base station (i.e., subscribed or not subscribed). The handoff latency in the case of connecting to unsubscribed base station is a bit higher than first case (but still lower than that of AMTree) because the message that is sent to all neighbours to find the nearest core for the unsubscribed base station.

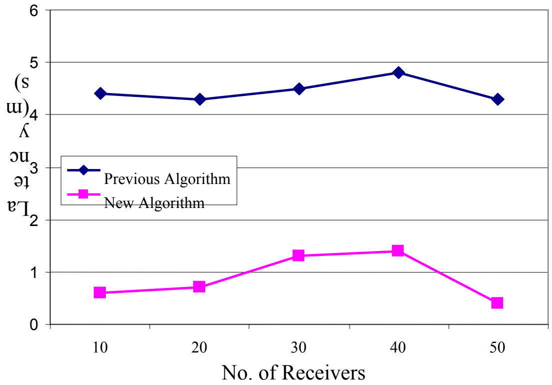


Figure 4. Handoff latency for verying receiver size.

We manage to get almost the same results for other parameters after this improvement. Figure 3 shows an example of one of the parameters which is number of cores. The term core refers to an active router with more than one subscriber. The higher the number of cores, the higher the degree of abstraction. This means that less modifications are required, which leaves a large proportion of the tree unaffected after handoff.

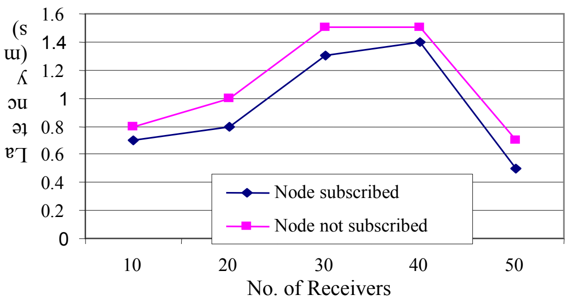


Figure 5. Handoff latency when node subscribed to the group and when it is not subscribed.

5. Conclusion

In this paper we presented two new algorithms to minimize the latency for handoff procedure in AMTree protocol either the mobile source connected to a base station that is subscribed to the multicast group, or a base station that is not subscribed. We showed that the handoff latency achieved by our algorithms in both cases is much lower than that of previous algorithm proposed in AMTree protocol.

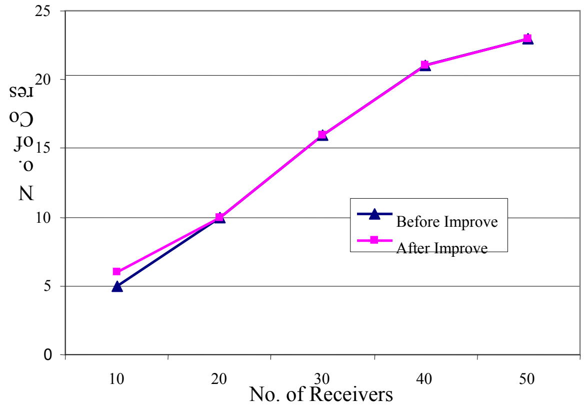


Figure 6. Number of cores vs. number of receivers.

References

[1] Ahuja R., Magnanti T., and Orlin J., *Network Flows Theory, Algorithms, and Applications*, Prentice Hall, US, 1993.

[1] Alexander D., Shaw M., Nettles S., and Smith J., "Active Bridging," *in Proceedings of ACM SIGCOMM'97*, pp. 29-262, 1997.

[1] Ballardie A., Francis P., and Crowcroft J., "Core Based Trees (CBT): An Architecture for Scalable Inter-Domain Multicast Routing," *in Proceedings of ACM SIGCOMM'93*, San Francisco, pp. 85-95, 1993.

[1] Baykal B., Akdemir O., and Akan O., "An IP Multicast Handoff Scheme with Focus on IGMP Sourced Latency," *in the 5th IEEE International Conference on High Speed Networks and Multimedia Communications*, pp. 1-10, July, 2002.

[1] Bhattacharjee S., Calvert L., and Zegura E., Architecture for Active Networking," *in Proceedings of High Performance Networking (HPN'97)*, pp. 64-69, 1997.

[1] Calvert K., Doar M., and Zegura E., "Modeling Internet Topology," *IEEE Communication Magazine*, vol. 35, no. 6, pp. 160-163, 1997.

[1] Chin K. and Kumar M., "Amtree: An Active Approach to Multicasting in Mobile Networks," *Mobile Networks and Applications*, vol. 6, no. 4, pp. 361-376, 2001.

[1] Deering S., Estrin D., Farinacci D., Jacobson V., Liu G., and Wei L., "An Architecture for Wide-Area Multicast Routing," *in Proceedings of ACM SIGCOMM'94*, San Francisco, pp. 126-135, 1994.

[1] Helmy A., Jaseemuddin M., and Bhaskera G., "Efficient Micro-Mobility Using Intra-Domain Multicast-Based Mechanism (M&M)," *Journal of ACM SIGCOMM Computer Communications Review*, vol. 32, no. 5, pp. 61-72, 2002.

[1] Kim B. and Han K., "Multicast Handoff Agent

Mechanism for All-IP Mobile Network," *Mobile Networks and Applications*, vol. 9, no. 3, pp. 185-191, 2004.

[1] Moy J., *Extension to OSPF*, Internet Draft 1584, 1994.

[1] Perkins C., *IP Mobility Support*, RFC2002, 1996.

[1] Sabeur M., Jouaber B., and Zeghlache D., "Seamless Handoff Solution for Nested Mobile Networks," *Journal of Networks*, vol. 1, no. 4, pp. 21-28, 2006.

[1] Tennenhouse D. and Wetherall D., "Towards an Active Network Architecture," *Journal of Computer Communication Review*, vol. 30, no. 2, pp. 5-18, 1996.

[1] Waitzman D., Patridge C., and Deering S., *Distance Vector Multicast Routing*, RFC1075, 1988.

[1] Wetherall D., Guttag J., and Tennenhouse D., "ANTS: A Toolkit for Building and Dynamically Deploying Network Protocols," *in Proceedings of IEEE Open Architectures and Network Programming (OPENARCH'98)*, San Francisco, pp. 3-4, April, 1998.

[1] Zegura E., Calvert K., and Bhattacharjee S., "How to Model an Internetwork," *IEEE Proceedings on Networking the Next Generation*, vol. 2, pp. 24-28, 1996.

Ali Al-Sharafi obtained his BSc in computer science from Irbid National University, 1999. He got his MSc in computer science from University Putra Malaysia, Malaysia, 2002. Currently, he is a PhD student at the Department of Communication Technology and Network, Faculty of Computer Science and Information Technology, University Putra Malaysia. His research interests are in wireless and mobile networks, active networks, and multicast protocols.

Mohamad Othman is an associate professor at the Faculty of Computer Science and Information Technology, Department of Communication Technology and Network, University Putra Malaysia. He received his PhD from the National University of Malaysia with distinction (best PhD thesis in 2000 awarded by Sime Darby Malaysia and Malaysian Mathematical Science Society).

Shamala Subramaniam obtained her BSc in computer science from University Putra Malaysia in 1996, MSc in computer science from University Putra Malaysia, in 1998 and completed her PhD at University Putra Malaysia. Her research interests are computer network, simulation and modeling, scheduling, and real time systems.