GMNF-DVMRP : A Modified Version of Distance Vector Multicast Routing Protocol

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Abstract

In this paper, we make a survey of Distance Vector Multicast Routing Protocol (DVMRP) and find that it is not optimal in the aspect of network cost (NC). Therefore, we propose a modified version of DVMRP, called "Group Membership Near First-DVMRP" (GMNF-DVMRP), to decrease the NC of the multicast tree formed by DVMRP. A simulation is implemented to compare our modified version and the original DVMRP. We find that our method save about 5-7 percent of NC of the multicast tree formed by DVMRP.

1: Introduction

A multicast routing protocol is a set of standards and parameters that two end points of communication agree upon to route packets. The Internet Group Management Protocol(IGMP)[1] is used to carry messages between the multicast router and the end-host or between multicast routers themselves. A variety of multicast routing schemes have been developed and used. They include Distance Vector Multicast Routing Protocol(DVMRP)[2] Core-Based Trees multicast protocol (CBT)[3] and Protocol Independent Multicast protocol(PIM)-Dense Mode and Sparse Mode[4]. A simple comparison of these schemes is given in Table 1. However, we lay our focus on DVMRP because it has been implemented in the mrouted program.

Two optimality criteria are used to evaluate the efficiency of the multicast tree formed by a multicast routing protocol, namely network cost(NC) and destination cost(DC)[5]. NC is a value that measures the utilization of the network resources, such as total used bandwidth. DC is a value that measures the average delay experienced by each destination. Minimizing DC is simpler than minimizing NC, because finding the minimum NC multicast tree on a given network topology is an NP-complete problem--also called a minimal Steiner tree problem[6].

The DC of the DVMRP multicast tree is optimal because it is built on the shortest paths from the source to each destination. However, the NC of the DVMRP multicast tree may be high or low, depending on the network topology and the distribution of group members. Shared medium networks, especially the Internet, have sensitive NCs. Redundant use of one hop on the multicast tree will cost much bandwidth, especially when the volume of multicast data is large. Therefore, we should try to decrease the NCs of multicast trees formed by the multicast routing protocol. In this paper, we developed a new version of DVMRP as GMNF-DVMRP to decrease the NC.

In the following sections, we propose a modified version to improve DVMRP in section 2. A simulation that compares DVMRP and our modified version is presented in section 3. Finally, a conclusion is given in section 4.

Protocol	Tree Type	Group Distribution	Protocol Independence	State Mechanism	Scalability
DVMRP	source-based	dense	NO	hard	Bad
CBT	shared-based	sparse	NO	hard	Good
PIM-DM	source-based	dense	YES	soft	Bad
PIM-SM	mixed	sparse	YES	soft	Good

Table 1: A simple comparison of multicast routing schemes.

2. Modified Version of DVMRP

2.1: An example

Consider an example of building a multicast tree of

DVMRP on the network topology illustrated in figure 1. Multicast packets are sent from the source to multicast router MR1. MR1, the designated multicast router of subnetwork S2 and S3, then delivers these multicast packets onto S1 and S2. Assume that the addresses of MR2 and MR3 are 140.113.136.110 and 140.113.136.111, respectively. MR2 becomes the designated multicast router of subnetwork S2 with a lower address than MR3, though they have the same distance of 2 hops to the source. As a result, MR2 is responsible for delivering these multicast packets onto S1 but MR3 is not. MR3 will send a prune message back to its predecessor MR1. We consider NC as the total hop number used by the multicast tree. Thus, the NC of this multicast tree is 4. If, however, MR3 wins to be the designated multicast router, MR3 will be responsible for delivering multicast packets onto S4 rather than sending a prune message back. On the contrary, MR2 will send a prune message to its predecessor MR1 and MR1 will then stop delivering multicast packets onto S2. The NC of the new multicast tree is 3, resulting in one hop saving. Since MR2 and MR3 own the same distance to the source, the DC of the new multicast tree is equivalent to that of the previous multicast tree. The new multicast tree is shown in figure 2.
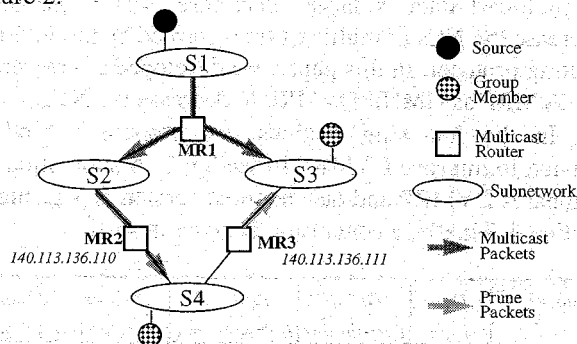

Figure 1: An example of building multicast tree of DVMRP where MR2 is the designated router of S4.
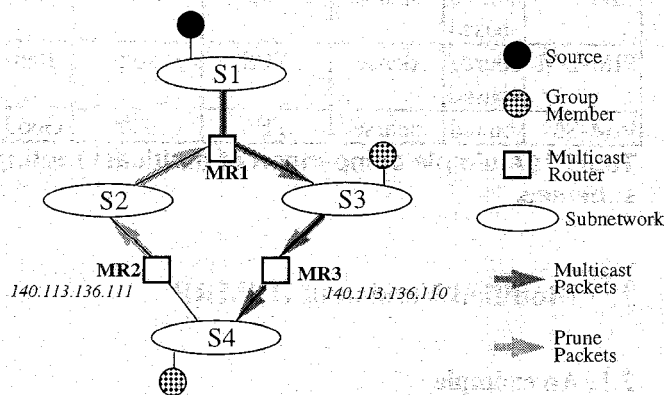

Figure 2: An example of building multicast tree of DVMRP where MR3 is the designated router of S4.

2.2: Idea

The idea of our modified version of DVMRP is simple. If two or more shortest paths exist between a source and its destination, choose the path where the first predecessor has one group member. Whenever a host joins a group, the interrogating multicast router of the host(MR_A) sends this group address to its neighboring multicast routers(MR_B). Multicast router MR_B now knows that a member of such group address exists on the subnetwork of MR_A. From now on, whenever MR_B receives multicast packets, it checks if the multicast address of these packets is the group address it received from its neighboring multicast routers, for example MR_A. If it matches , then *GMN(source address)* of MR_B is set to be true, where *source address* is the source address of these multicast packets. *GMN(source address)* means that group membership of the sender with source address exists on the neighboring subnetwork. Now MR_B has higher priority to become the designated multicast router under the situation that other multicast routers on the same subnetwork have the same shortest distance to this source. Consider the example shown in figure 1 again. MR1, the interrogating multicast router of S3, sends a message to MR3 to announce that a member of a particular group address exists on S3. When MR3 receive multicast packets of such group address, it retrieve the source address from the header of the first packets and set *GMN(source address)* to be true. Now MR3 has higher priority to become the designated multicast router for forwarding multicast packets from that source although its address is not the lowest.

2.3: Algorithm

We call our modified version of DVMRP as GMNF-DVMRP. GMNF is short for "Group Membership Near First". It means that if there is a member on the neighboring network, the algorithm should consider the router attached to this neighboring subnetwork first to become the designated multicast router of its subnetwork.

Each interrogating multicast router of a subnetwork sends the message of group membership to its neighboring multicast routers periodically. The packet format of the message is shown as the following:

multicast group address1	multicast group address2	......

After receiving this message, the receiving multicast router will record these multicast group addresses in a table. Whenever multicast packets from a particular source come, this multicast router will compare the multicast address in the packet header with those in the small table. If the multicast address of the incoming packets exists in the

small table, GMN(the source address) of the multicast router is set to be true. The DVMRP algorithm is modified as follows:

WHILE R receives "routing updates" entry (d, D, next-hop-address) from n
    IF (next-hop-address <> k) AND
        (NO n such that (n.subnet=k AND
        (n.distance[d] < D OR
        (n.distance[d] = D AND (NO R.GMN(d) AND n.GMN(d) OR
        (R.GMN(d) AND n.GMN(d) AND n.address on k < R.address)))))
    THEN   k is a child of R on the multicast tree rooted at d
    IF (NO n that (n.subnet=k and n.distance[d]=infinity))
    THEN   k is a leaf of R on the multicast tree rooted at d

Procedure 1: Modified version of DVMRP.

3: Simulation

We have written programs to simulate the above two algorithms. We measure the NC of a multicast tree in a simple way, namely, by its total hop counts.

3.1: Network model

We model the network as an undirected graph where nodes represent multicast routers and edges represent links or subnetworks connecting routers. Precisely speaking, a node represents a multicast router and its connected hosts. A node, where one of its connected hosts is the sender of multicast packets, is the source and a set of nodes, where one or more of its connected hosts are the receiver of multicast packets, excluding the source node are group members.

To create such a network with N nodes, each node is assigned a random coordinate in the unit square. The edge between two nodes is generated depending on the probability function of its length. We adopt the following probability distribution function described in Ken Calvert's Technical report[7] to generate edges:

$$R\alpha = \begin{cases} \alpha & \text{if } d \leq 0.3 \\ \alpha\sqrt{2} - \alpha(\sqrt{2} - 0.3) & \text{if } d > 0.3 \end{cases}$$

where d is the Euclidean distance between two nodes, and α is a constant that affects the average degree of the graph. If the distance between two nodes is no more than 0.3 unit, the probability to generate an edge between these two nodes is fixed to be α. If the distance is more than 0.3, the probability decreases linearly with the distance. In order not to create any isolated node in the graph, we connect nodes one by one at the beginning, that is, node 1 to node2, node2 to node3, and so on. An example of such a graph with 100 nodes is illustrated in figure 3.
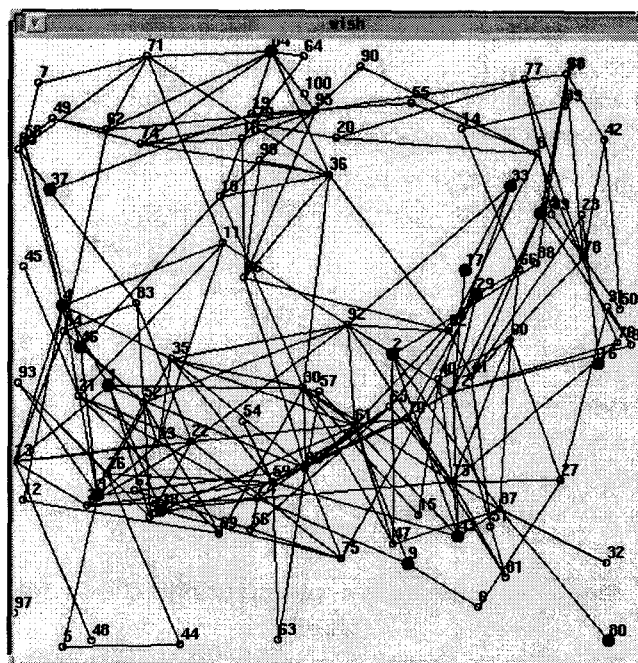

Figure 3: An example of 100 nodes graph.

3.2: Simulation result

Two combinations of size and connectivity is used: a 400-node graph with an average degree of 5.0375 and a 900-node graph with an average degree of 3.47. We generated 10 graphs of each combination.

The simulation results of the two multicast algorithms under these two combinations are shown in figure 4, 5, 6, and figure 7. Our GMNF-DVMRP algorithm has the best effect when the number of receiver nodes is about half of the total node number. It decreases about 7 percent of NC in the 900-node graph. Although 7 percent is a small number, saving one hop on a multicast tree may result in saving lots of network bandwidth because the volume of multicast packets is large.

4: Conclusion

We have made a survey of DVMRP and found that it is not optimal in the aspect of NC(network cost). Therefore, we propose a modified method of DVMRP, called GMNF-DVMRP, to decrease the NC of the multicast tree formed by DVMRP. A simulation has been implemented to compare our modified method and the original DVMRP. We find that our method save about 5-7 percent of NC of the multicast tree formed by DVMRP.

In this paper, we lay emphasis on DVMRP because it is implemented in the mrouted program. However, DVMRP is considered as the first generation multicast routing protocol.

Other multicast protocols have been developed and considered to be better than the DVMRP. For future research, we are going to study these second generation multicast protocols and try to find a better solution.
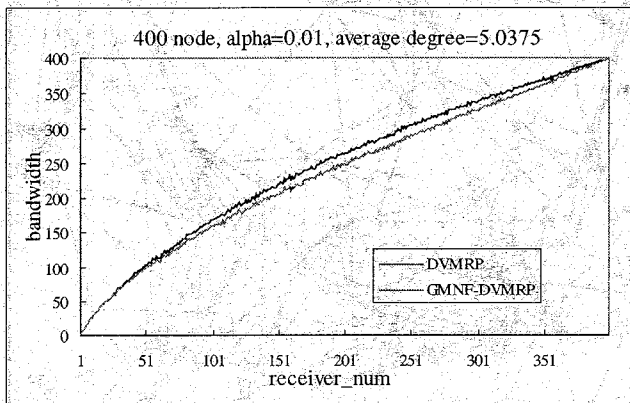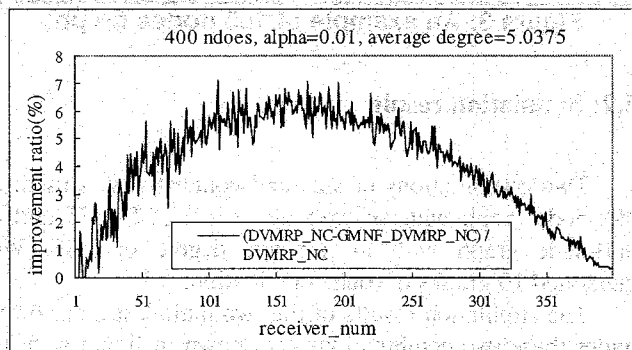

Figure 4: Bandwidth consumption in 400-node graphs.

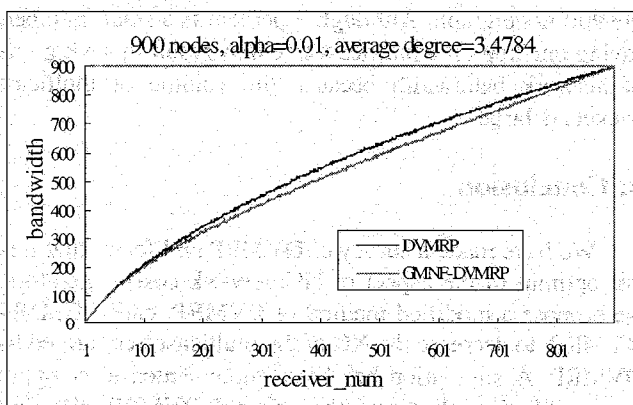**Figure 5: Improvement ratio of bandwidth in 400 node-graphs.**

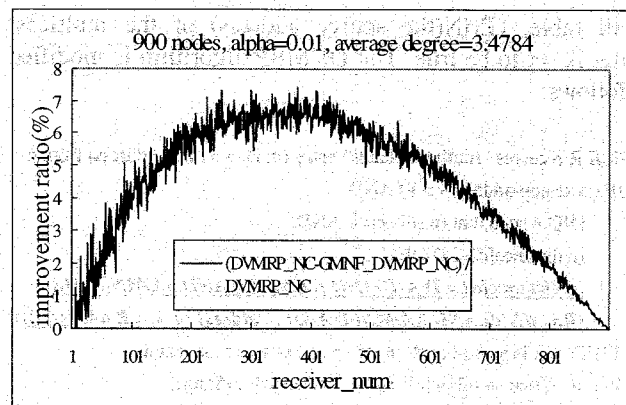**Figure 6: Bandwidth consumption in 900-node graphs.**

Figure 7: Improvement ratio of bandwidth in 900-node graphs.

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