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Energy Reduction Routing In Wireless Ad-Hoc Network

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ABSTRACT - Ad hoc networks are dynamically created and maintained by the individual nodes comprising the network. They do not require a pre-existing architecture for communication purposes and do not rely on any type of wired infrastructure; in an ad hoc network all communication occurs through a wireless median. The main objective of this paper is to maximize the MANETs life time and minimize the energy consumption during the source to destination route establishment. Since nodes in mobile ad hoc network can move randomly, the topology may change arbitrarily and frequently at unpredictable times. We present a new multicast architecture and the corresponding multicast routing protocol for providing efficient and flexible multicast services over the Mobile AD-HOC network. The new multicast routing protocol called the Service-Centric Multicast Protocol (SCMP) can be able to handle simultaneous many-to-many communications efficiently. The multicast tree is computed in the m-router by employing the Delay-Constrained Dynamic Multicast (DCDM) algorithm, which dynamically builds a delay-constrained multicast tree and minimizes the tree outlay as glowing.

Keywords : Delay-Constrained Dynamic Multicast, delay-constrained, Mobile AD-HOC Network, Service-Centric Multicast Protocol.

I. INTRODUCTION

Many networking applications such as distributed interactive simulation, software upgrading, and distributed database replication require multicast communication, which is a basic type of group communications, over a large network such as the MANETs. In multicast communication, messages from the source are delivered to all the members of a multicast group. The demand for multicast communication from networking applications has been growing at an accelerated pace. As a result, efficient support for multicast communication remains to be a critical and challenging issue in networking research. MANET contains diverse resources; the line of defense is very ambiguous; Nodes operate in shared wireless medium; Network topology changes unpredictably and very dynamically. Radio link reliability is an issue connection breaks are pretty frequent [6].

Moreover, density of nodes, number of nodes and mobility of these hosts may vary in different applications. There is no stationary infrastructure. Each node in MANET acts a router that forwards data packets to other nodes. Therefore, selection of effective, suitable, adaptive and robust routing protocol is of utmost importance. The purpose of the MANET working group is to standardize IP routing protocol functionality suitable for wireless routing application within both static and dynamic topologies with increased dynamics due to node motion and other factors. The below figure shows the basic structure of Mobile Ad-hoc Network.

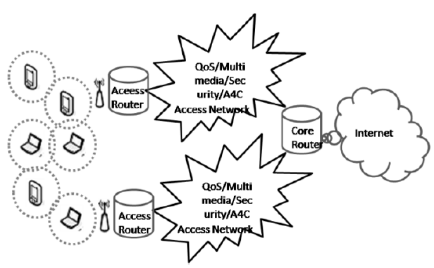

Fig. 1 Mobile Ad-hoc Network

II. MULTICAST ARCHITECTURE

Multicast architecture and the corresponding multicast routing protocol for providing efficient and flexible multicast services over the MANETs, to maximize the network life time and minimize the energy consumption during the source to destination route establishment [2], [4]. To implement the energy consumption, the Service-Centric Multicast Protocol (SCMP) builds a shared multicast tree rooted at the m-router for each group. The multicast tree is computed in the m-router by employing the Delay-Constrained Dynamic Multicast (DCDM) algorithm, which dynamically builds a delay-constrained multicast tree and minimizes the tree cost as well. The new multicast architecture has two different types multicast routers, which we call master multicast router (or m-router) and intermediate multicast router (or i-router).

An i-router functions as an ordinary multicast router for forwarding multicast packets, whereas an m-router is responsible for more complex service-related tasks such as multicast session, routing scheme control, transmission bandwidth management, and traffic scheduling and performs some service specific functions.

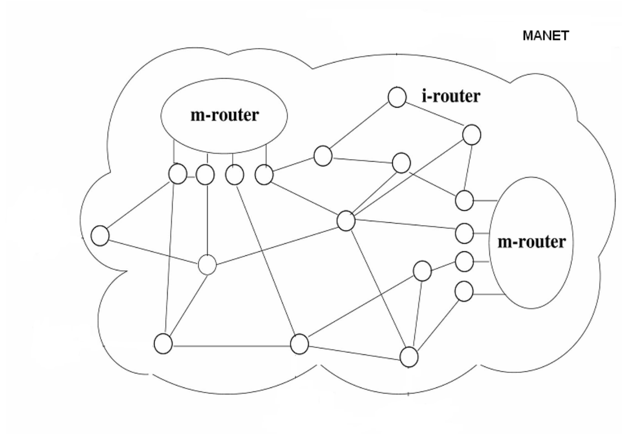

Fig. 2 Illustration of m-router and i- router of MANETs

III. DATA TRANSMISSION

The path selection, maintenance and data transmission are consecutive process which happen in split seconds in real-time transmission. Hence the paths allocated priory is used for data transmission. The data is transferred through the highlighted path. The m-router plays a very important role in the multicast architecture because it handles most multicast-related tasks, and it is the root of the multicast trees. To avoid traffic jam around the m-router, it is required that the m-router is capable of handling multiple multicast tasks simultaneously and forwarding heavy multicast traffic efficiently.

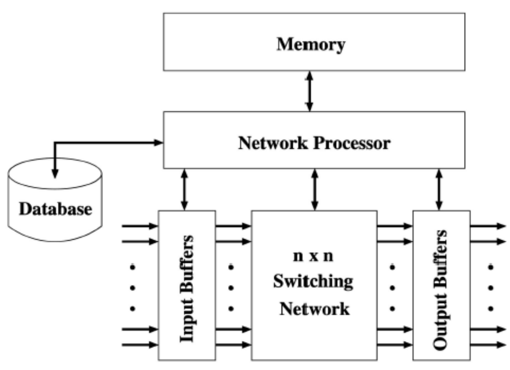

Fig. 3 Internal structure of m-router

Many tasks in the m-router, such as managing multicast group membership, generating multicast trees, scheduling, routing, and transmission, are relatively independent, which can be performed in parallel. Thus, the m-router can adopt a multiprocessor or cluster computer architecture. Efficient hardware support from the underneath switching fabric with multicast capability is the key for the m-router to provide various multicast services and handle heavy multicast traffic. For a multicast connection, a source may or may not belong to the multicast group. Also, there may be several multicast connections from different sources to the same multicast group, which can be referred to as many-to-many communication. To support multiple such many-to-many communications in the Internet, the multicast switching fabric can be designed by adopting the concepts from conference switching networks, but the switching fabric of the m-router is required to support more general communication patterns and fully make use of the multicast trees built in the Internet.

IV. AN OVERVIEW OF MULTICAST ROUTING PROTOCOL

SCMP is an intradomain multicast protocol that constructs the multicast tree within the domain in which a link-state unicast routing protocol is running. The multicast routing protocol for the proposed architecture is expected to satisfy the following requirements. It allows any sophisticated network wide routing algorithms to be used for constructing multicast trees. The computation effort for multicast trees is centralized at the m-router, saving the computation resource of other routers [3]. Multicast routing information is transmitted only through the i-routers on the multicast tree and does not affect the rest of the Internet.

In SCMP, the m-router's IP address is known to all the routers in the domain in advance. This can be realized by putting the IP address of the m-router in every router's configuration file. After a router is notified by one host in its subnet that it wants to join or leave a group, the router sends a JOIN/LEAVE request message to the m-router, indicating the group ID and the IP address of the router. The m-router keeps track of all the group members in the group. When the m-router receives such JOIN/LEAVE request message, it updates the multicast tree according to the change of the group membership. A network wide routing algorithm is run on the m-router to generate a multicast tree for a given multicast group. This is achievable because the m-router has all group membership and global network topology information. The multicast tree is generated in the m-router based on the collected topology and membership information. After the multicast tree is generated in the m-router, it should be physically formed in the domain. The routers on the tree should update the routing table according to the generated multicast tree. SCMP uses a special type of packet, called TREE packet, to accomplish this. Each TREE packet contains the complete information about a sub tree of the multicast tree.

The m-router is responsible for generating the original TREE packets. The i-router receives a TREE packet, which represents a sub tree rooted at the i-router itself. After receiving the TREE packet, the i-router sets the routing table according to the information in the TREE packet and sends a new TREE packet to each i-router, which is the child of the i-router in the multicast tree. The procedure is performed recursively on the multicast tree until it reaches the leaf routers. The resulting multicast tree is a shared bidirectional tree that is rooted at the m-router. The reasons for running a network wide routing algorithm at the m-router and passing the multicast tree information along the tree are the following. A routing algorithm that constructs a near-optimal multicast tree usually has higher time complexity. Thus, it should be run only once network wide and should be run by the router with more computation power. It is not necessary to run the same algorithm for the same multicast tree repeatedly on many i-routers with less computation power. On the other hand, the packet size of the TREE packet is comparable to that of the packet containing the multicast membership information; thus, it will not increase the message payload much. Besides, the information is transmitted only through the i-routers on the multicast tree, and all the routing related operations are performed only once during a multicast session.

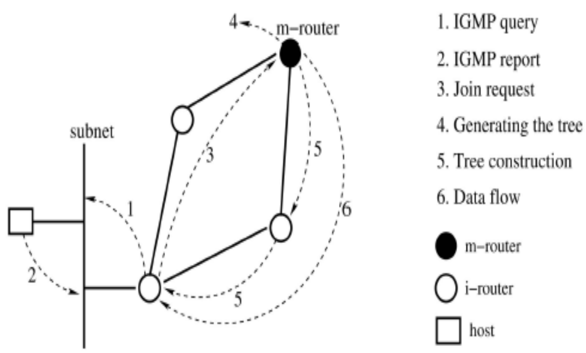

Fig. 4 An Overview of SCMP Protocol

The m-router encapsulates the packet and forwards it along the tree as a multicast packet. If the source is on the tree, the packet can be forwarded along the tree directly because the tree is bidirectional. Figure 3 shows an overview of the SCMP.

V. DELAY-CONSTRAINED DYNAMIC MULTICAST

DCDM algorithm is used to update the multicast tree. For each pair of nodes in the network, there exists a path that has the least cost among all the paths connecting these two nodes, and we use Plc to denote this path. Similarly, for each pair of nodes in the network, there exists a path that has the shortest delay among all the paths connecting these two nodes, and we use Psd to denote this path. Once the network is given, we can recalculate these two paths for every pair of nodes and store them for future routing. The unicast delay between two nodes is the delay of path Psd.

The unicast delay of a group member is the unicast delay between the group member and the m-router, which is denoted as ul. For any group member, there is a unique path on the tree connecting the group member to the m-router. The multicast delay of the group member is the delay of the unique path and is denoted as ml. The longest multicast delay of all group members is the tree delay. The upstream router is denotes as US, and the downstream set is denoted as DS. A multicast routing entry is a triple with three fields (group ID, upstream, downstream). If a router is on the multicast tree of a group, then "group ID" is the ID of the group, "upstream" is the upstream of the router, and "downstream" is the downstream of the router. The multicast routing table is composed of one or more multicast routing entries.

A. Problem Formalization

We first formalize the problem considered in the DCDM algorithm. The problem is called the Delay-Constrained Dynamic Steiner Tree-Nonrearrangeable (DCDST-N) problem, which adds delay constraint to the DST-N problem. A point-to-point communication network can be represented by an undirected graph G(V,E), where V is the set of nodes, and E is the set of edges. The nodes in V represent the routers in the network. The edges in E represent the communication links connecting the routers.

Two positive real functions are defined on E is Link cost function LC and Link delay function LD.

$$E \rightarrow R+ \qquad (1)$$

Link cost is determined by the utilization of the link. It denotes the cost to use the link. The higher the utilization, the higher the link cost [1], [6]. Link delay is defined as the sum of the perceived queuing delay, transmission delay and propagation delay over the link. The two functions will not change with time. Suppose P is a path, in G which is composed of links i.e.: i =1; 2; . . . p. The cost and the delay of the path Cost (P) and Delay (P) are defined as follows

$$Cost(P) = \sum_{i=1}^{p} LC(e_i) \text{ and } Delay(P) = \sum_{i=1}^{p} LD(e_i).$$

In a multicast communication session, there is a source node S€ V and a group member set M€ V. S is the node corresponding to the source that generates the data. The nodes in M, called group member nodes, correspond to the group members that receive the data. s may or may not be in M.

A multicast tree T is a tree in graph G such that T spans S∩M. We use T^v and T^e to represent the node set and edge set of T, respectively. The tree cost is defined by the sum of the link cost in the tree.

$$Cost(T) = \sum_{e \in T^e} LC(e).$$

VI. MEMBER JOINING

When a host wants to join a group G, it sends an IGMP report message identifying the group id gid in response to the DR's IGMP query message. When the DR receives an IGMP report for group gid, it checks whether it is on the multicast tree of group gid first. This is done by checking whether there exists a multicast routing entry whose "group ID" is gid. Such a multicast tree, it checks whether the interface connected to the host is included in the "downstream" of the multicast routing entry. If not, add it to the "downstream." If the interface is the first interface added to the "downstream," the DR will send a JOIN message to the m-router. Although the multicast tree does not need to be updated, the m-router needs this information for possible accounting and billing purposes.

If the DR is not on the multicast tree, it sends a JOIN message to the m-router, indicating the gid and the IP address of the DR. A timer is set, and the DR will resend the JOIN message if the TREE packet is not received before the timer expires. The pseudo code of the member joining procedure is shown in Table 1.

TABLE I

MEMBER JOINING PROCEDURE


```
input: group id gid, interface inf.
output: JOIN message.
algorithm:
if there exists a multicast routing entry whose group id field is gid
  if inf is not in the multicast routing entry
    add inf to downstream of the routing entry;
  if inf is the only interface element in downstream
    send JOIN message to m-router;
else
  store (gid, inf) for creating the multicast routing entry in the future;
  send JOIN message to m-router;
end
```

VII. MEMBER LEAVING

When the last group member of a subnet sends an IGMP leave report to the DR, the DR removes the interface from the "downstream" of the routing entry first. After that, the DR checks whether it becomes the leaf node of the multicast tree. A router is a leaf node of the multicast tree when the downstream of the router is null.

If the DR is not a leaf node, there are two cases:

1. There is at least one interface element in the downstream. In this case, no action is needed.
2. All the elements in the downstream are routers.

In this case, although the multicast tree remains the same, the DR should send a LEAVE message to the m-router for possible accounting and billing purposes. If the DR is a leaf node after receiving the IGMP leave report, in addition to sending a LEAVE message to the m-router, it also sends a PRUNE message to the upstream router so that the upstream router will no longer forward the multicast packet to it. Similarly, if the upstream router finds itself as a leaf node, it triggers another PRUNE message to its upstream router. This PRUNE message will continue until it reaches a no leaf router. If the DR receives a data packet after it leaves the group, it triggers a retransmission of the LEAVE message and the PRUNE message. The pseudo code of the member leaving procedure is shown in Table 2.

TABLE II

MEMBER LEAVING PROCEDURE

```
input: group id gid, interface inf.
output: LEAVE message and PRUNE message.
algorithm:
remove inf from downstream of the multicast routing entry;
if downstream becomes NULL
  send a PRUNE message to upstream router;
  send a LEAVE message to m-router;
else
  if all the elements in downstream are routers
    send a LEAVE message to m-router;
end
```

VIII. CONCLUSION

In this paper proposed a new multicast architecture and the corresponding multicast routing protocol for providing efficient and flexible multicast services over the MANETs, to maximize the network life time and minimize the energy consumption during the source to destination route establishment. To implement the energy consumption, the Service-Centric Multicast Protocol (SCMP) builds a shared multicast tree rooted at the m-router for each group. The multicast tree is computed in the m-router by employing the Delay-Constrained Dynamic Multicast (DCDM) algorithm, which dynamically builds a delay-constrained multicast tree and minimizes the tree cost as good. When the primary m-router fails, the secondary m-router will take over the job automatically. The new architecture can adopt any sophisticated network wide routing algorithms in the m-router to construct a near-optimal multicast tree, which makes it easier to be adapted to various applications with different QOS requirements.

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