Multicast Routing protocol with Dynamic Core (MRDC)[1]

Shiyi WU and Christian BONNET
Institut Eurécom
{Firstname.Name}@eurecom.fr

Abstract - Multicast is efficient to support many-to-many communication in network. Mobile ad-hoc network needs special multicast routing protocol to adapt its characteristics including local broadcast capacity, arbitrary topology change, bandwidth constraint and power limitation. A multicast routing protocol for MANET should find compromise between routing message and data transmission efficiency to well use bandwidth and power. For this aim, this paper proposes a new multicast routing protocol called Multicast Routing protocol with Dynamic Core (MRDC) which constructs and maintains a group-shared tree using dynamically selected core only when group traffic is present. MRDC attempts to react more quickly to broken tree edge by detecting link failures during data forwarding.

Keywords: ad hoc network, multicast routing

I. Introduction

A Mobile Ad-hoc NETwork (MANET) is a collection of wireless mobile nodes forming a dynamical temporary network without the use of any existing network infrastructure or centralized administration. Multicast routing protocol is needed to support group oriented applications. The properties (ex: broadcast capacity, dynamic topology, bandwidth and power constraints) make multicast routing protocol for wired network not suitable for MANET.

Lots of multicast routing protocols have been proposed (AMRoute[1], AMRIS[2] CAMP[3], LAM [4], MAODV[5] and MZR[6]). These protocols can be classified to *tree-based* and *mesh-based* according to **routing structure** or *source-oriented* and *group-shared* according to **construction mechanism**. *Tree-based* approach is efficient in data transmission but needs many routing messages to repair tree if topology changes touch tree edges. On the contrary mesh structure is more robust than tree structure since it offers more connectivity. But mesh structure is less efficient for data delivery. Compared to *group-shared* mechanism, *source-oriented* mechanism can construct a structure for each source according to various criteria (ex: shortest path, various QoS requirements). Therefore it is more efficient in terms of data transmission than *group-shared* mechanism when a group has multiple sources. However this mechanism can easily suffer from scalability problem as the number of groups and sources per group increases.

In the rest of this paper, Section II presents the main design principles of the Multicast Routing protocol with Dynamic Core (MRDC) which constructs a group-shared tree for a multicast session on demand. Section III describes in details the creation and maintenance of multicast tree. Section IV evaluates the performance of MRDC in different traffic loading and mobility under *ns-2* simulator. Section V provides our conclusion.

II. Overview of MRDC

The aim of Multicast Routing protocol with Dynamic Core (MRDC) is trying to find tradeoff between routing overhead and data transmission efficiency in MANET. MRDC uses a tree structure to connect all group members but a mesh mechanism to forward data if the network has broadcast links. The idea is allowing each tree member to accept multicast packet coming from any neighbor and re-broadcast to its neighbors. A packet cache is essential to assure forwarding traffic packets only one time. This combination enriches the connectivity of tree.

MRDC differs from other group-shared tree-based multicast routing protocols which also use the concept of *core* ([1], [2], [3] and [4]). In our protocol, *core* is the first source of a multicast session. This choice guarantees that core is interested in participating to the multicast group and transmitting multicast traffic. If no core is present in the network, it is not necessary to construct and maintain tree and all receivers remain silent. This property can be named as "on demand" compared to other group-shared tree-based multicast routing protocols. In these protocols, tree should be maintained even when no multicast traffic is present. Another advantage of this choice is that MRDC reduces to source-oriented in the case of a single source, and is group-shared in the case of multiple sources.

All tree-based multicast protocols use *timeout-based path monitoring* to detect link failure. A link failure is detected when a node has not heard its tree neighbor during last period. If detecting a link failure, downstream (the direction from root to leaf nodes) node rejoins tree to maintain tree connection. This mechanism reacts slowly to link failure according to the time period value. Consequently, data transmission is blocked until the branch is repaired. MRDC proposes to use *reactive path monitoring* in which a tree member supervises links when it forwards data to other next nodes. Hence it can immediately discover broken branch[i] and react to this failure if necessary. The shortcoming of this maintenance is that it increases distance between tree members from one hop to multiple hops. This problem can be solved by periodical tree refresh. Therefore, routing overhead caused by tree maintenance (topology change) is reduced with on-demand local route

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discovery. On the other hand, data delivery efficiency is improved by periodical tree refresh.

III. Protocol description

MRDC consists of two aspects: *Tree construction* and *Tree maintenance*. *Tree construction* is the aspect by which a core is selected and advertised to the network. Nodes that are interested in the multicast session join in the tree. *Tree maintenance* is the aspect where tree members detect broken branches and rejoin the tree to continue receiving multicast traffic.

A. Tree construction

Each node in MANET possesses a multicast routing table which stores multicast routing information. The existence of an entry in the table, which corresponds to a multicast session tree, means that traffic is present in the group. A source can know whether it should act as core of this multicast session or just participate to the multicast tree as a normal source by checking if there is an entry. Similarly, a receiver can decide that it should join the tree or remain silent by regarding multicast routing table. Routing entry has two states: active and inactive. A node that is tree member has an active entry and other nodes are inactive.

Tree construction is based on following mechanism: a core broadcasts *Core Advertisement* (CA) message to the network. A CA message contains multicast group address, core address and reference to identify CA. The reverse path is created when CA propagates in the network. A node that is interested in the multicast group sends a *Route Active Request* (RAR) message towards core when receiving the CA and waits for a *Route Active Acknowledge* (RAA). This procedure is called RAR/RAA phase. A RAR message is unicast along reverse path towards core. The first tree member receiving RAR replies RAA to active route entries of nodes in the potential branch. When the initiator of RAR receives RAA, the branch is added to the multicast tree.

B. Tree maintenance

During data transmission, a tree member finds a branch broken when it cannot forward data packet through a tree edge. There are two cases for a broken branch: the branch is towards upstream tree member or the branch is towards downstream member. In the former case, the node sends a local broadcast RAR to find the upstream node and rejoin the tree. In the latter case, the node sends a *Join Invitation* (JI) to invite the downstream node to rejoin the tree. Upon receiving JI, the destination takes part in tree by running RAR/RAA phase.

Core periodically broadcasts CA to refresh multicast tree and reverse path to core. Group member will implicitly leaves the tree if next period of CA arrives soon. This node will not reply CA so that the branch will be pruned silently. Otherwise, nodes should explicitly leave tree by sending a message to its upstream node. In the case that core wants to leave group, it checks whether there is another source in tree that can become new core. If it is the only source, it dismisses the tree.

IV. Performance simulation

A. Simulation Environment

We use *ns-2* simulator for performance analysis. Different movement scenarios and group traffic scenarios are used as inputs to the simulation. The goal of simulation is to study the performance of MRDC in different traffic load (group size, number of sources per group, etc.) and mobility (speed, pause time, etc.)

B. Simulation Results

The following metrics are used to analyze the performance of MRDC:

- **Packet delivery ratio**: The percentage of data packets correctly delivered to receivers.
- **Routing overhead**: Number of routing packets per data packet delivered.
- **Data delivery efficiency**: Number of data packet transmitted in the network per data packet delivered.
- **Number of data and routing packets per data packet delivered**
- **Average end-to-end delay**: The average time between a transmission of a data packet and a successful reception at a receiver.

The simulation results reveal that MRDC do not create many routing packets when node's mobility increases. It can efficiently transmit a great percentage of packets and sends a small number of data and routing packets per data packet.

V. Conclusion

This paper has proposed a new on-demand multicast routing protocol utilization dynamic core for MANET. MRDC constructs group-shared tree and designed to find trade-off between data transmission efficient and routing overhead.

We analyze the performance of MRDC using *ns-2* simulator with different traffic scenario and movement scenario. MRDC is scalable to mobility. And it is economic in bandwidth and power consumption since it sends little packets for delivering a data packet to all receivers.

Reference

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[i] Link failure can be detected by using MAC layer call back if IEEE802.11 is employed or by not hearing that next tree member re-broadcasts the same packet.