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Multicasting in Ad-Hoc Networks: Comparing AMRIS and ODMRP

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Abstract — **Multicasting can efficiently support a variety of applications that are characterized by a close degree of collaboration, typical for many ad-hoc applications currently envisioned. Within the wired network, well-established routing protocols exist to offer an efficient multicasting service. As nodes become increasingly mobile, these protocols need to evolve to similarly provide an efficient service in the new environment. This paper discusses the performance of two proposed multicast protocols for ad-hoc networks: Ad Hoc Multicast Routing Protocol Utilizing Increasing ID Numbers (AMRIS) and On-demand Multicast Routing Protocol (ODMRP).AMRIS builds and maintains a multicast tree based on hard state information, ODMRP maintains a mesh based on soft state. Our results show that in many scenarios AMRIS achieves a higher packet delivery ratio, while keeping its total control overhead less compare to ODMRP.**

Keywords — **AMRIS, ODMRP, Ad-Hoc Networks, Multicasting.**

I. Introduction

Multicasting is the transmission of data-grams to a group of hosts identified by a single destination address [1]. Multicasting is intended for group-oriented computing. There are more and more applications where one-to-many dissemination is necessary. The multicast service is critical in applications characterized by the close collaboration of teams (e.g. rescue patrol, battalion, scientists, etc) with requirements for audio and video conferencing and sharing of text and images.

The use of multicasting within a network has many benefits. Multicasting reduces the communication costs for applications that send the same data to multiple recipients. Instead of sending via multiple unicasts, multicasting minimizes the link bandwidth consumption, sender and router processing, and delivery delay [2].

Maintaining group membership information and building optimal multicast trees is challenging even in wired networks. However, nodes are increasingly mobile. One particularly challenging environment for multicast is a mobile ad-hoc network (MANET).

A MANET consists of a dynamic collection of nodes with sometimes rapidly changing multi-hop topologies that are composed of relatively low-bandwidth wireless links. Since each node has a limited transmission range, not all messages may reach all the intended hosts. To provide communication through the whole network, a source-to-destination path could pass through several intermediate neighbor nodes.

Unlike typical wire line routing protocols, ad-hoc routing protocols must address a diverse range of issues [3]. The network topology can change randomly and rapidly, at unpredictable times. Since wireless links generally have lower capacity, congestion is typically the norm rather than the exception. The majority of nodes will rely on batteries, thus routing protocols must limit the amount of control information that is passed between nodes.

The majority of applications for the MANET technology are in areas where rapid deployment and dynamic reconfiguration are necessary and the wire line network is not available. These include military battlefields, emergency search and rescue sites, classrooms, and conventions where participants share information dynamically using their mobile devices. These applications lend themselves well to multicast operation. In addition, within a wireless medium, it is even more crucial to reduce the transmission overhead and power consumption.

Multicasting can improve the efficiency of the wireless link when sending multiple copies of messages by exploiting the inherent broadcast property of wireless transmission. However, besides the issues for any ad-hoc routing protocol listed above, wireless mobile multicasting faces several key challenges. Multicast group members move, thus precluding the use of a fixed multicast topology.

Transient loops may form during tree reconfiguration. As well, tree reconfiguration schemes should be simple to keep the channel overhead low. Many multicast routing protocols have been proposed for ad-hoc networks, a survey can be found in [4]. Comparing these protocols is typically done based on extensive simulation studies.

Bagrodia et al. [5] simulated several multicast routing protocols developed specifically for MANET, some tree-based, some based on a mesh structure. The reported results show that mesh protocols performed significantly better than the tree protocols in mobile scenarios. In this paper the performance of ODMRP and CAMP are analyzed.

The reviews of AMRIS and ODMRP protocols for Ad-Hoc network have been given in section II. Algorithmic comparison is described in section III. The next section gives the comparison on performance, overhead and qualitative differences. Section V concludes this work.

II. Multicast Protocols for Mobile Ad-hoc Networks

A. AMRIS

Ad Hoc Multicast Routing Protocol Utilizing Increasing ID Numbers (AMRIS) is an on-demand protocol which constructs a shared delivery tree to support multiple senders and receivers within a multicast session. The key idea that differentiates AMRIS from other multicast routing protocols is that each participant in the multicast session has a session-specific multicast session member id (herein known as msm-id). The msm-id provides each node with an indication of its "logical height" in the multicast delivery tree. Each node except the root must have one parent that has a logical height (msm-id) that is smaller than it. Each participant calculates its initial msm-id dynamically during the Initialization phase, which is initiated by a special node called Sid, who has the smallest msm-id. Sid is normally elected from among the set of senders if there is more than one.

The relationship between the msm-id (and the node that owns it) and Sid (which is also the root of the tree) is that the msm-ids increase in numerical value as they radiate away from Sid. The msm-ids allow nodes that have broken off from the delivery tree (e.g. due to mobility, terrain) to rejoin the delivery tree in a localized fashion without causing permanent routing loops. Another key feature of AMRIS is that it does not depend on the unicast routing protocol to provide routing information to other nodes. AMRIS maintains a Neighbour-Status table which stores the list of existing neighbors and their msm-ids. Each node sends a periodic beacon to signal their presence to neighboring nodes. The beacon contains the msm-ids that each node presently has.

AMRIS consists of two main mechanisms: Tree Initialization and Tree Maintenance. Tree Initialization is the mechanism by which a multicast session is created and advertised to nodes within the ad hoc network. Nodes that are interested in joining the multicast session (herein known as I-Nodes) then join in the Initialization phase. Nodes that are not interested in joining the multicast session are herein known as U-nodes. It is important to note that U-Nodes may still become part of the multicast session subsequently when it is necessary for them to function as "intermediate" nodes within the delivery 2 of 5 tree to forward multicast traffic.

Tree Maintenance is the mechanism whereby nodes that become "detached" from the multicast delivery tree rejoin the tree to continue receiving multicast traffic, by executing a Branch Reconstruction (BR) routine. Nodes that did not join the multicast session during the initialization phase also make use of BR to join the tree. AMRIS uses a soft state beacon approach to determine if a link has broken between two neighboring nodes.

B. ODMRP

On-demand Multicast Routing Protocol (ODMRP) [6] is mesh based, and uses a forwarding group concept (only a subset of nodes forwards the multicast packets). A soft state approach is taken in ODMRP to maintain multicast group members.

No explicit control message is required to leave the group. In ODMRP, group membership and multicast routes are established and updated by the source on demand. When a multicast source has packets to send, but no route to the multicast group, it broadcasts a Join-Query control packet to the entire network. This Join-Query packet is periodically broadcast to refresh the membership information and update routes. When an intermediate node receives the Join-Query packet, it stores the source ID and the sequence number in its message cache to detect any potential duplicates. The routing table is updated with the appropriate node ID (i.e. backward learning) from which the message was received for the reverse path back to the source node. If the message is not a duplicate and the Time-To-Live (TTL) is greater than zero, it is rebroadcast.

When the Join-Query packet reaches a multicast receiver, it creates and broadcasts a “Join Reply” to its neighbors. When a node receives a Join Reply, it checks if the next hop node ID of one of the entries matches its own ID. If it does, the node realizes that it is on the path to the source and thus is part of the forwarding group and sets the FG_FLAG (Forwarding Group Flag). It then broadcasts its own Join Table built upon matched entries. The next hop node ID field is filled by extracting information from its routing table. In this way, each forward group member propagates the Join Reply until it reaches the multicast source via the selected path (shortest). This whole process constructs (or updates) the routes after the forwarding group establishment and route construction process, sources can multicast packets to receivers via selected routes and forwarding groups. While it has data to send, the source periodically sends Join-Query packets to refresh the forwarding group and routes.

When receiving the multicast data packet, a node forwards it only when it is not a duplicate and the setting of the FG_FLAG for the multicast group has not expired. This procedure minimizes the traffic overhead and prevents sending packets through stale routes.

In ODMRP, no explicit control packets need to be sent to join or leave the group. If a multicast source wants to leave the group, it simply stops sending Join-Query packets since it does not have any multicast data to send to the group. If a receiver no longer wants to receive from a particular multicast group, it does not send the Join Reply for that group. Nodes in the forwarding group are demoted to non-forwarding nodes if not refreshed (no Join Tables received) before they timeout.

III. Algorithm Comparison

This section compares the differences between AMRIS and ODMRP as given in Table I. The following parameters are taken for comparison:

- Multicast topology
- Initialization
- Maintenance
- Node joins
- Node leaves
- Link-break

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Table I: Comparison between AMRIS and ODMRP

Parameters	AMRIS	ODMRP
Multicast topology	Shared Delivery Tree	Mesh of Nodes
Initialization	Generating msm-id	Store upstream info
Maintenance	All nodes periodically send beacon message	Sender periodically send J-Q msg
Node joins	Detect beacon msg and perform branch reconstruction	Detect J-Q and response J-R
Node leaves	Stop beacon msg;	Stop J-R or J-Q
Link-break	No more beacon msg and perform BR	Receive new J-Q and reply with J-R

The similarities between the two protocols have been listed in table II. They have the common characteristics as given in the following terms:

- Mobility support
- Driven Mode
- Broadcast message
- Unicast capabilities
- Periodic message

Table II: Similarities among AMRIS and ODMRP

Parameters	Similarities
Mobility support	Yes, based on MANET
Driven mode	On-demand, does not store whole network topology
Broadcast message	Yes
Unicast capabilities	Yes

IV. Comparison of AMRIS and ODMRP

This section describes the comparisons between AMRIS and ODMRP in terms their performance, overhead and qualitative metrics.

C. Performance Comparison

Packet Delivery Ratio which is a function of mobile speed is shown in Fig. 1. The properties are

- Number of data packets actually delivered to the destinations versus number of data packets supposed to be received.
- PDR of ARMIS is speed sensitive

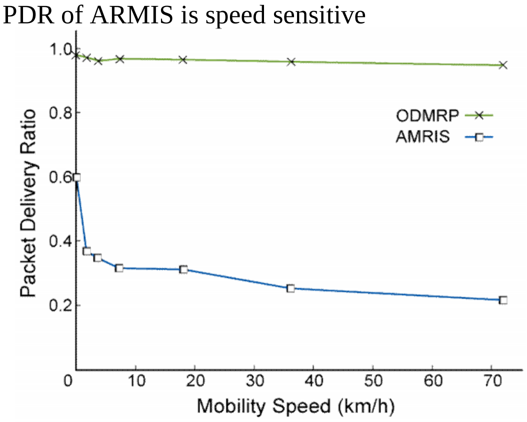

Fig.1. Mobility versus Packet delivery ratio of AMRIS and ODMRP

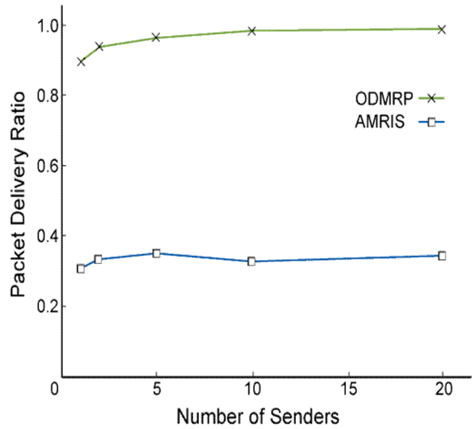

Fig.2. Number of senders versus Packet delivery ratio of AMRIS and ODMRP

Fig. 2 shows the Packet Delivery Ratio as a function of number of senders. It has,

- PDR of AMRIS is not sensitive to number of senders
- ODRMP's performance improves as number of senders increases

Next the Packet Delivery Ratio as a function of multicast group size is shown in Fig. 3. The Characteristics are

- PDR of ODMRP is not sensitive to group size
- AMRIS's performance improves as group size grows

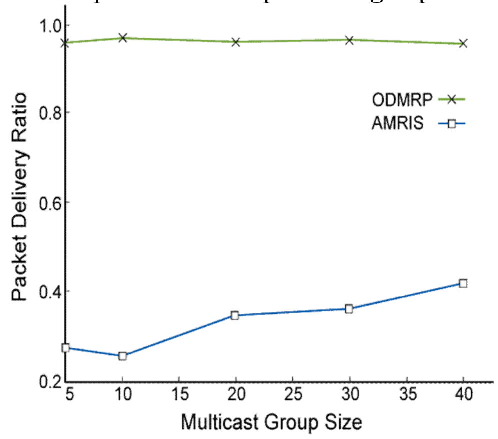

Fig.3. Multicast group size versus Packet delivery ratio of AMRIS and ODMRP

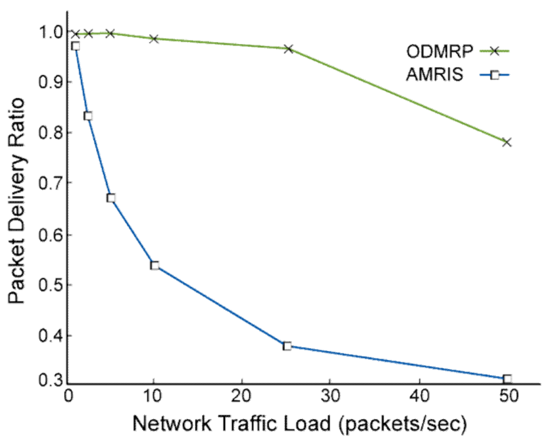

Fig.4. Network Traffic Load (packets/sec.) versus Packet delivery ratio of AMRIS and ODMRP

Fig. 4 represents the analysis of PDR against the network traffic load. The observations are

- AMRIS has severe packet loss rates
- ODMRP suffers less

D. *Overhead Comparison*

Number of Control Bytes Transmitted Per Data Bytes Delivered as a function of mobility speed is shown in Fig. 5. The outcomes are,

- Control bytes are control packets and data packet headers
- Not speed sensitive
- AMRIS has lower ratio

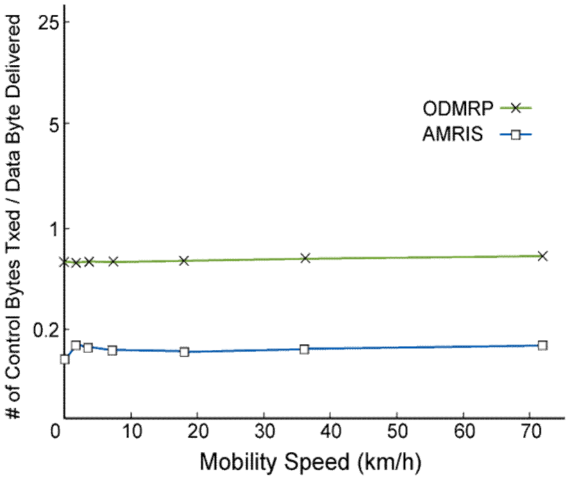

Fig.5. Number of Control Bytes Transmitted Per Data Bytes Delivered as a function of mobility speed.

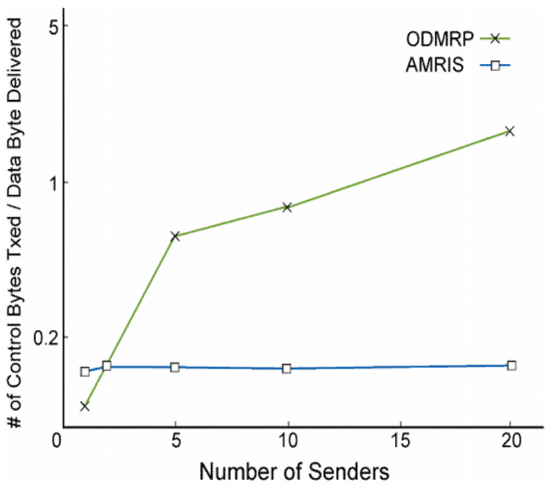

Fig.6. Number of Control Bytes Transmitted versus number of senders.

Fig.6. Shows the Number of Control Bytes Transmitted Per Data Bytes Delivered as a Function of number of Senders. It has the following factors:

- AMRIS is not affected by number of senders
- ODMRP may not be efficient in large networks

E. *Qualitative Comparison*

The following points describe the qualitative comparison among the so far discussed protocols. They are

Bandwidth Consumption

- ODMRP tends transmit more control bytes than AMRIS
- However, ODMRP has higher packet delivery ratio

Power Consumption

- Depends on mobility speed, number of senders, network traffic load, etc.
- Not a problem for vehicle-based mobile nodes

V. Conclusion

Multicasting can efficiently support a wide variety of applications that are characterized by a close degree of collaboration, typical for many MANET applications currently envisioned. Within the wired network, well-established routing protocols exist to offer efficient multicasting service. As nodes become increasingly mobile, these protocols need to evolve to provide similarly efficient service in the new environment. Adopting wired multicast protocols to MANETs, which are completely lacking in infrastructure, appears less promising.

These protocols, having been designed for fixed networks, may fail to keep up with node movements and frequent topology changes due to host mobility increase the protocol overheads substantially. Rather, new protocols that operate in an on-demand manner are being proposed and investigated.

Existing studies and our results show that tree-based on-demand protocols are not necessarily the best choice. In a harsh environment, where the network topology changes very frequently, mesh-based protocols seem to outperform tree-based protocols, due to the availability of alternative paths, which allow multicast data-grams to be delivered to all or most multicast receivers even if links fail. Much room still exists to improve protocol performance (as measured by the packet delivery ratio) while reducing the associated overhead.

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