Stateless Multicasting In Ad-Hoc Networks Guided By Motion Estimation

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Abstract

Multicast routing protocols typically rely on the a priori creation of a multicast tree (or mesh), which requires the individual nodes to maintain state information. In sensor networks where traffic is bursty, with long periods of silence between the bursts of data, this multicast state maintenance adds a large amount of overhead for no benefit to the application. Thus, Chen-Hsiang Feng et al. have developed a stateless receiver-based multicast protocol that simply uses a list of the multicast members (e.g., sinks), embedded in packet headers, to enable receivers to decide the best way to forward the multicast traffic. This protocol, called RBMulticast (Receiver-Based Multicast), exploits the knowledge of the geographic locations of the nodes to remove the need for costly state maintenance (e.g., tree/mesh/neighbor table maintenance), making it ideally suited for sensor network multicast applications. But the problem in this approach is that to know geographic locations of all nodes at particular node frequent beacons must be sent by all nodes. Through these beacons, each node knows about the geographic locations of all other nodes. But if the node speed is high & nodes moves great distance in the beacon interval RBMulticast will fail. Routing will get longer hops & packet delivery ratio will drop. To solve this problem, we propose motion estimation & RBMulticast guided by location learnt using motion estimation.

Keywords : Ad-Hoc, MANET, multicast routing protocols, RBMulticast, stateless.

I. INTRODUCTION

Communication in sensor networks is hindered by the limited energy capacity of the individual sensor nodes. Consequently, reducing the total number of packets transmitted throughout the network is essential for power conservation. For sensor networks with multiple sink nodes, multicast routing is an ideal approach to manage and reduce network traffic. Reducing the number of packets transmitted when multicasting data requires both shorter routing paths from the multicast source to the multicast members, as well as improved efficiency in terms of the total number of links the packets traverse to get to all the multicast members, i.e., the packet should be split off to different routing branches only when necessary. Shorter routing paths lead to reduced packet delay, and improved efficiency leads to a reduction in the energy consumption from transmitting fewer packets. These two properties are usually contradictory to each other, and algorithms must make a trade-off to best fit their requirements. In the paper [1], author develop a novel multicast protocol called RBMulticast (Receiver-Based Multicast). RBMulticast is a completely stateless multicast protocol, using only location information with no tree creation or maintenance or even neighbor table maintenance, which makes it ideally suited for sensor networks. Packet routing and splitting packets into multiple routes relies solely on the location information of each multicast member, which is assumed to be known.

RBMulticast is a *receiver-based* protocol (as with the ExOR protocol [12]), which means that a sender can transmit packets without specifying the next hop node, because the potential receivers of this packet make the decision of whether or not to forward this packet in a distributed manner. This approach for transmitting packets means that routing is a result of the joint decisions of all participating nodes. Therefore, no routing tables are required within the sender node, as potential receivers decide on a valid route.

RBMulticast was motivated by the cross-layer protocol XLM [2], which is a receiver-based unicast protocol designed for WSNs. As in XLM, RBMulticast assumes a MAC protocol whereby receivers contend for channel access based on their assessed contribution towards forwarding the packet. Nodes with more energy and better links and nodes that make the most forward progress to the destination will contend earlier and hence have a higher chance to become the next hop node.

The solution works fine with good packet delivery ratio as long the nodes moves slowly & does not have big variation in between two consequent beacon intervals. As the nodes move faster in the beacon intervals, then position information on which routing is based is erroneous & false routing path is created. Due to this false routing path delay increases & also packet delivery ratio fails. Motivated by this fact, we propose a effective solution for this problem.

II. Related Work

Existing multicast protocols for WSNs and mobile ad hoc networks (MANETs) generally use a tree to connect the multicast members. For example, the Takahashi-Matsuyama heuristic can be used to incrementally build a Steiner tree for multicast routing [3]. Additionally, multicast algorithms rely on routing tables maintained at intermediate nodes for building and maintaining the multicast tree [4].

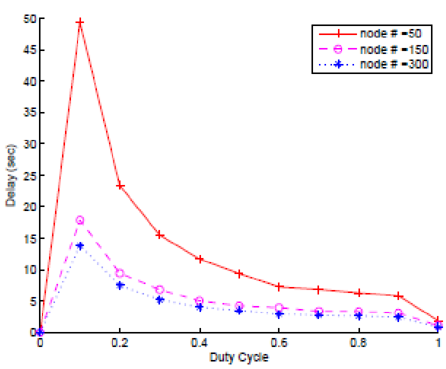
Due to the specificities of WSNs, knowing sensor nodes locations is a reasonable assumption. In the location-based approach to multicast routing, nodes obtain location information by default as an application requirement (e.g., a home fire alarm would know where it is located) or as provided by a system module (e.g., GPS or a location-finding service). If location information is known, multicast routing is possible based solely on location information without building any external tree structure. For example, PBM [5] weights the number of next hop neighbor nodes and total geographic distance from the current node to all destination nodes and compares this to a predefined threshold to decide whether or not the packet should be split. Geocast [6] delivers multicast packets by restricted flooding. Nodes forward multicast packets only if they are in the Forwarding Zone calculated at run time from global knowledge of location information.

RBMulticast differs from these approaches in that it is completely stateless and hence no costly state maintenance is required. PBM [5] uses a similar idea of stateless multicast but requires information about neighbor nodes. RBMulticast further eliminates the requirement of knowing a node's neighbors by using a receiver-based mechanism, and only the location of the nodes is needed for multicast packet routing. Additionally, RBMulticast includes a list of the multicast members in the packet header, which prevents the overhead of building and maintaining a multicast tree at intermediate sensor nodes, because all the necessary information for routing the packet is included within the packet header. We believe that RBMulticast requires the least state of any multicast routing protocol and is thus ideally suited for WSNs Receiver-based communication is a different way of thinking about protocol design in that decisions are not required to be made at the sender side but instead are made at the receiver side. For example, a source node in ExOR [1] broadcasts packets that include a potential forwarders' list inside the header, and these potential forwarders will contend to forward the packet through the use of different back-off times, which depend on the network distance to the destination. A source node in XLM [2] broadcasts packets with the destination's geographic location in the header, and every receiver contends to forward the packet through the use of different back-off times, which depend on the geographic distance to the destination. In other words, in receiver-based routing, decision-making is deferred to the possible receivers, who make decisions in a distributed manner.

Receiver-based routing is different from "On-demand" or "Reactive" routing in that reactive routing calculates a route at the time a packet is sent down to the MAC layer. For example, AODV [7] begins transmission by first sending a "RouteRequest" to create temporary routes among intermediate nodes and then transmits data packets through this route. The ability to transmit data without requiring a route to be formed is enabled via extra knowledge in the MAC layer and join decisions of sensor nodes. For example, nodes could be assigned an ID in a structured manner and hence next hop nodes are implied in the destination address itself. In this case, packets are broadcast by the MAC layer, and only potential next-hop nodes relay it to the destination. As another example, nodes may have statistics (e.g., energy, channel quality) that could assist in making forwarding decisions. A source node can send an RTS packet, enabling potential receivers to contend for the ability to forward the packet, with the receiver node that has the best route being the first to return a CTS to receive this packet.

We simulated the use of RBMulticast under different network densities for large-scale WSNs.There are a total of either 50, 150 or 300 nodes randomly distributed throughout the simulation area. The source node is located at the bottom left corner (0,0), and the multicast receiver nodes are scattered over the boundary of the region. We set the nodes movement as 30m/sec & set the beacon interval as 5 sec.

From this we see the delay is in order of seconds even for a network of 50 nodes. This becomes the objective for the paper to reduce this delay.



III. PROPOSED SOLUTION

As we analyze the RBMulticast protocol, the delay is caused due to inaccurate position information available at nodes. The inaccurate information is more as the node speed increases.

In most MANET networks, the nodes don't do random movement they follow a pattern in the movement. The pattern is either directional, circular etc. If node initial position & its pattern of movement is known well in advance at each node, then the position of a node at particular time can be easily estimated. This position information is then used by the RBMulticast protocol to do region based routing.

The protocol works as follows. During the system initialization time, each node will broadcast information of its current position & its pattern of movement to all other nodes. After broadcasting this information each node must wait for configurable time period T before starting the movement.

If the node wants to change the pattern of movement, it must stop its movement & broadcast the change request to all nodes. It must wait for time T before starting the movement. The time T is expected time that broadcast reaches all the nodes. Each node caches the position & pattern of movement in its memory.

Whenever the nodes receives RBMulticast receive packet, it has to first find the estimated movement of the targets in the receive packet.

The estimation must be done using the position & pattern of movement. The pattern is nothing but a combination of speed & direction.

Say initial position of node is (100,100) in a total plane of 1000 x 1000.

If it moves in direction of 45 degree at speed of 10 m/ sec , then the new position at any point of time can be estimated using trigonometric formula

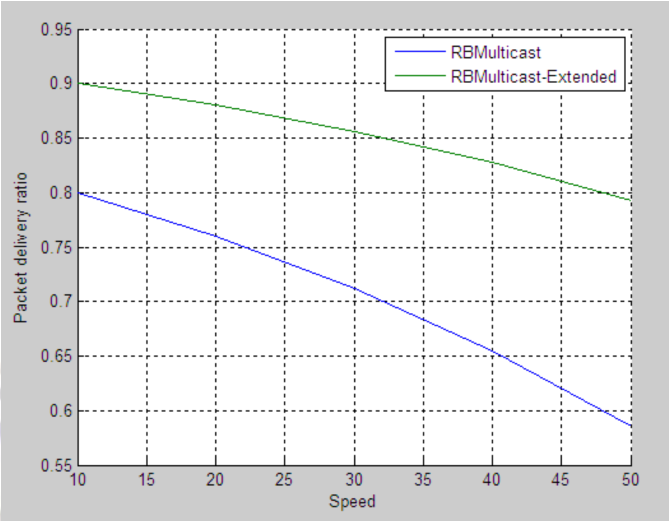
$Y(t) = y(0) * \tan 45 + t * 10;$

$X(t) = x(0) * \tan 45 + t * 10;$

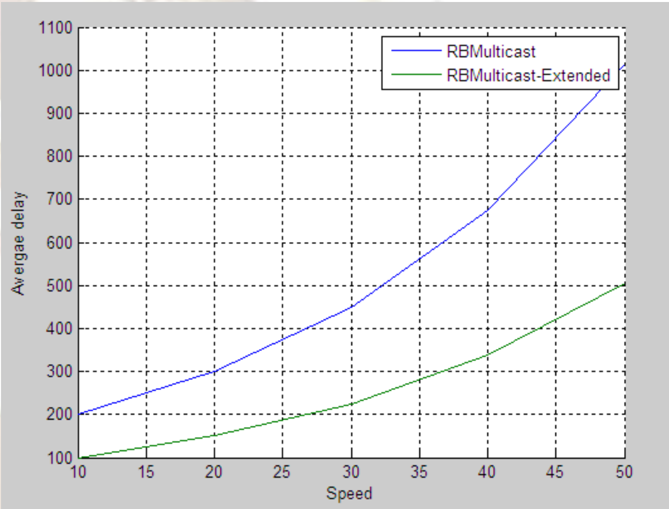
Using the information of estimated position, the RBMulticast Send procedure will split targets to region & forward multicast packets.

IV. PERFORMANCE ANALYSIS

We implemented the RBMulticast and the proposed estimation method to reduce delay & increase packet delivery ratio using JProwler simulator. We simulated for different speed of 10 to 50 for a network of 100 nodes. For each node density we measure the average packet delay & packet delivery ratio with RB Multicast and proposed extension to RBMulticast.



The packet delivery ratio drops faster in RBMulticast compared to our approach as speed of movement of node increases.



The delay increases faster in RBMulticast compared to our approach as the speed of movement increases.

V. CONCLUSION AND ENHANCEMENTS

In this paper, we improved the RBMulticast by adding motion estimation to learn the position of nodes with our proposed solution. Though simulation we proved that out approach reduces the delay & also increases the packet delivery ratio. In future we plan to do a detailed analysis for different patterns of movement to arrive at the estimation method for finding the position of nodes.

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