ISSN 2319 – 7757 EISSN 2319 –7765

Indian Journal of

Engineering

Novel routing protocol to improve the packet delivery ratio for mobile AD HOC networks

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Publication History
Received: 28 September 2013
Accepted: 10 November 2013
Published: 26 November 2013

Citation
Shyam sundar M, Maniratnam M, Karthik N. Novel routing protocol to improve the packet delivery ratio for mobile AD HOC networks. *Indian Journal of Engineering*, 2013, 6(16), 28-31

ABSTRACT
This paper addresses the issue of routing in mobile ad hoc networks (MANETs) using directional antennas. Existing directional routing schemes either assume a complete network topology beforehand or simply use Omni-directional routing schemes to forward packets in underlying directional environment. In this paper we propose a Directional Routing Protocol (DRP) for MANETs. The main features of DRP include an efficient route discovery mechanism, establishment and maintenance of directional routing and directional neighbor tables (DRT and DNT respectively) and novel directional route recovery mechanisms. Results show that DRP considerably improves the packet delivery ratio.

Keywords: Packet delivery ratio, Routing Protocol.

1. INTRODUCTION
Wireless networks is an emerging new technology that will allow users to access information and services electronically, regardless of their geographic position. Wireless networks can be classified in two types:- infrastructure network and infrastructure less (ad hoc) networks. Infrastructured network consists of a network with fixed and wired gateways. A mobile host communicates with a bridge in the network (called base station) within its communication radius. The mobile unit can move geographically while it is communicating. When it goes out of range of one base station, it connects with new base station and starts communicating through it. This is called handoff. In this approach the base stations are fixed.

In contrast to infrastructure based networks, in ad hoc networks all nodes are mobile and can be connected dynamically in an arbitrary manner. All nodes of these networks behave as routers and take part in discovery and maintenance of routes to other nodes in the network. Ad hoc networks are very useful in emergency search-and-rescue operations, meetings or conventions in which persons wish to quickly share information, and data acquisition operations in inhospitable terrain

An ad hoc network is a collection of mobile nodes forming a temporary network without the aid of any centralized administration or standard support services regularly available on conventional networks. In this paper, it is assumed the mobile hosts use wireless RF transceivers as their network interface, although many of the same principles will apply to infra-red and wire based networks. Some form of routing protocol is necessary in these ad hoc networks since two hosts wishing to exchange packets may not be able to communicate directly. Routing Protocols are used to discover and maintain routes between the source and destination nodes. For MANET, there are two main kinds of the routing protocol: on-demand protocols (also called reactive protocols) and table-based protocols (also called proactive protocols). For reactive protocols, nodes only compute routes when they are needed. Usually, caches are used to reduce the effort of route discovery. For proactive protocols, each node maintains a routing table containing routes to all nodes in the network. Nodes must periodically exchange messages with routing information to keep routing tables up-to-date. What's more, some hybrid protocols are proposed. This is because both proactive and reactive routing has specific advantages and disadvantages that make them suitable for certain kinds of scenarios. The hybrid methods try to take the advantages of those two and achieve better performance.

2. PROPOSED ROUTING PROTOCOL

DRP is an on-demand directional routing protocol, and is inspired in large by omnidirectional Dynamic Source Routing (DSR) protocol used heavily in MANETs (Park et al. 2004). DRP closely couples the routing layer with the MAC layer and assumes a cross-layer interaction between some of the modules. In DRP the Directional Routing Table (DRT) is local to routing layer and maintains the routing information to different destination. The Directional Neighbor Table (DNT) on the other hand is shared with MAC.

Unlike DSR which maintains only the index of the node ID in a forwarding path; DRP also maintains node indices and the beam IDs used by the nodes to receive a packet in the forwarding path. The beam ID stored in the DRT helps the source node to estimate the angular position of its destination relative to itself (Ramesh et al. 2010). DRP uses the beam ID kept in the DRT to do an efficient route recovery.

In addition to the shared DNT, in DRP the network layer is aware of the different antenna beams at the MAC layer. The MAC, in turn, has separate buffers for each antenna beams. Accordingly, the link layer follows this approach by maintaining separate queues for each beam. In order to place the packet in the correct link layer queue, the network layer determines the antenna beam which the MAC will use for transmission of the packet (through DNT), and puts the packet in the link layer queue corresponding to this antenna beam. It is to be noted that broadcast packets are kept in a separate dedicated queue.

2.1. Route discovery

The route discovery mechanism in DRP works similar to DSR. For a given source *X*, and destination *Y*, if *Y* is not in the DNT of *X*, *X* floods a *RREQ* packet in the network. DRP enforces broadcast optimizations to reduce packet redundancy and route discovery latency (Setty et al. 2010). Whenever a node receives a *RREQ* packet it starts a delay timer. If the same *RREQ* packet is received again before the expiration of this timer, the node makes a note of all the beams where that packet arrived from. The node forwards (or sweeps) the packet in only those beams/directions other than those in which the packet arrived. Amongst the selected beams, DRP initiates a rebroadcast in the beams which are vertically opposite to the beams where the node received the broadcast packet. Next, the beams which are adjacent to these vertically opposite beams are chosen. This shall continue till all the selected beams are covered.

The IEEE 802.11 basic Carrier Sense Multiple Access is followed before transmitting in the first beam of a particular sweep (Setty et al. 2010). For subsequent beams of the same sweep, we simply carrier sense and transmit. However if a beam has been marked as busy (i.e., the Directional NAV is set in this direction), that beam is ignored and the next free beam amongst the selected beams is chosen. It should be noted that we do not wait for the beam to become free. Deferring in every beam would lead to an extremely high sweeping delay. Further, we do not post-backoff after successfully transmitting in a beam and before initiating transmission in another beam. A node post-back offs after completing a sweep of all the selected beams.

The sequence of hops taken by the route request packet as it propagates through the network during the route discovery phase is recorded in a data structure in the packet. It is termed as directional route record. The directional route record appends both the node indices of the intermediate nodes and the beam ID used by these nodes to receive the packets from uplink. For example, an intermediate node *Z* which forwards the route request packet, also adds the antenna beam at which it received the RREQ packet in addition to its own ID.

3. MODEL

We consider the average packet delivery rate (PDR) And RSSI obtained from every probe node as instances of a random variable. We then apply kernel density estimation to identify the corresponding probability density function (PDF). Such method is particularly accurate in the absence of information on the underlying probability distribution. The data we obtain grants a 95% confidence interval. The PDF indeed shows a single maximum for low values of PDR,

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although some packets may still be occasionally received. We show the PDF for PDR at a node in the middle of the transmission lobe.

4. PACKET DELIVERY RATIO

Packet delivery ratio is defined as the data packets received by the destination to those generated by the sources. Mathematically it can be defined as

PDR= P.R/P.S

Where P.R is the sum of data packets received by each destination, where P.S is the sum of data packets generated by each source

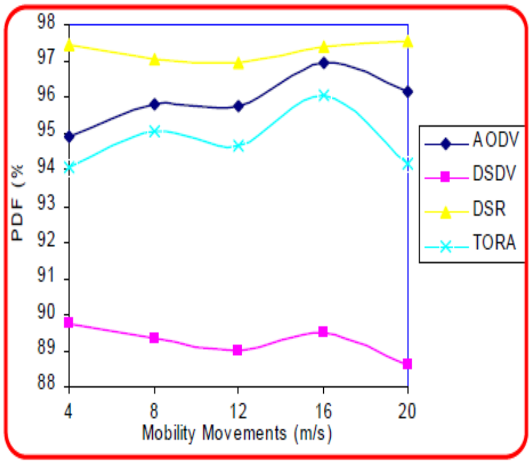

Figure 1

Packet delivery ratio for 32 nodes

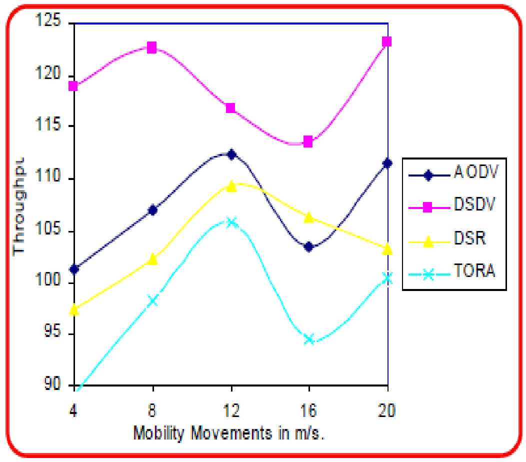

Figure 2

Throughputs for 32 nodes

5. PERFORMANCE EVALUATION

We have implemented a complete directional antenna module in ns-2 (version 2.26) (Ramanathan et al. 2005). This module models most of the aspects of a directional antenna system including variable number of antenna beams, different gains for different number of antenna beams among others. The transmission range of an omni directional, 4, 8 and 12 beam antenna is assumed as 250, 370, 550, and 710 meters respectively (Yan et al. 2006). We have implemented MDA (a directional medium access control) and DRP (directional routing protocol with MDA as the MAC layer). We assume CBR traffic and a 2Mbps channel for all our scenarios. Simulation is run for 200secs and all results are averaged over 10 different seeds. We compare the performance of DRP with DSR over Omni-directional antennas (referred simply as OMNI or DSR) and DSR over directional antennas (referred to as DDSR). It should be noted that DDSR also uses MDA as its underlying MAC. This is essential for a fair comparison which offsets any MAC layer benefits. We mention DRP and DDSR over an M beam model as DRP_M and DDSR_M respectively. DDSR also uses MDA at the MAC layer. In the following subsections we thoroughly evaluate all the modules of DRP under static and mobile scenarios.

6. RESULTS

From the plots (Figure 1) we found that the DSDV's performance is the lowest and DSR's performance is the highest in terms of PDF. Here, the performance of TORA is better than AODV but AODV performs much better than DSDV. DSR's performance is almost same in various movement speeds of the nodes but other protocols performance varies according to the change of mobility movements. Throughputs of all routing, protocols plotted in the graph (Figure 2), are varying with the change of mobility movements. DSDV shows the highest performance. In all the cases TORA shows the lowest performance. The throughputs of AODV are marginal.

7. CONCLUSION

In this paper, we have introduced a cross layered directional routing protocol (DRP) specifically tuned to the underlying directional antennas. DRP attempts to alleviate some of the inherent drawbacks involved in directional communications while exploiting the potential benefits such as increased coverage range and directionality. Our simulation results indicate that DRP has a substantial decrease in route.

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