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PROACTIVE ROUTING PROTOCOL IN MOBILE AD HOC NETWORKS USING PATH FINDING TECHNIQUES

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Abstract: Mobile Ad hoc Network (MANET) is a collection of wireless mobile nodes that dynamically form a network temporarily without any support of central administration. Moreover, Every node in MANET moves arbitrarily making the multi-hop network topology to change randomly at unpredictable times. There are several familiar routing protocols like DSDV, AODV, DSR, etc… which have been proposed for providing communication among all the nodes in the network. In this paper a new proactive source routing protocol incorporating a tree based software structure is proposed. In this paper, we propose a lightweight proactive source routing (PSR) protocol. PSR can maintain more network topology information than distance vector (DV) routing to facilitate source routing, although it has much smaller overhead than traditional DV-based protocols [e.g., destination-sequenced DV (DSDV)], link state (LS)-based routing [e.g., optimized link state routing (OLSR)], and reactive source routing [e.g., dynamic source routing (DSR)]. Our tests using computer simulation in Network Simulator 2 (ns-2) indicate that the overhead in PSR is only a fraction of the overhead of these baseline protocols, and PSR yields similar or better data transportation performance than these baseline protocols.
Keywords: MANET, DSDV, AODV, DSR, proactive routing, routing overhead control, source routing, tree-based routing.

I. INTRODUCTION

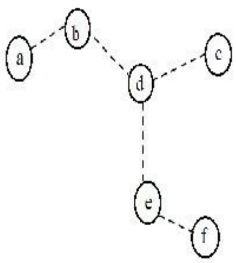
A mobile ad hoc network (MANET) is a wireless communication network, where nodes that are not within the direct transmission range of each other require other nodes to forward data. It can operate without existing infrastructure and support mobile users, and it falls under the general scope of multi-hop wireless networking. This networking paradigm originated from the needs in battlefield communications, emergency operations, search and rescue, and disaster relief operations. It has more recently been used for civilian applications such as community networks. A great deal of research results have been published since its early days in the 1980s [1]. The most salient research challenges in this area include end-to-end data transfer, link access control, security, and providing support for real-time multimedia streaming [2]. One of the important research areas in MANET is establishing and maintaining the ad hoc network through the use of routing protocols. Though there are so many routing protocols available, this paper considers DSDV, AODV and DSR for performance comparisons due to its familiarity among all other protocols. These protocols are analyzed based on the important metrics such as throughput, packet delivery ratio and average end-to end delay and is presented with the simulation results obtained by NS-2 simulator. Opportunistic data forwarding represents a promising solution to utilize the broadcast nature of wireless communication links [4]. Opportunistic data forwarding refers to a way in which data packets are handled in a multihop wireless network. Unlike traditional IP forwarding, where an intermediate node looks up a forwarding table for a dedicated next hop, opportunistic data forwarding allows potentially multiple downstream nodes to act on the broadcast data packet. One of the initial works on opportunistic data forwarding is selective diversity forwarding by Larsson [5]. In this paper, a transmitter picks the best forwarder from multiple receivers, which successfully received its data, and explicitly requests the selected node to forward the data. However, its overhead needs to be significantly reduced before it can be implemented in practical networks. This issue was successfully addressed in the seminal work on ExOR [6], outlining a solution at the link and network layers. In ExOR, nodes are enabled to overhear all packets on the air; therefore, a multitude of nodes can potentially forward a packet as long as they are included in the forwarder list carried by the packet. By utilizing the contention feature of the medium-access-control (MAC) sublayer, the forwarder closer to the destination will access the medium more aggressively. Therefore, the MAC sublayer can determine the actual next-hop forwarder to better utilize the long-haul transmissions. To support opportunistic data forwarding in a mobile wireless network as in ExOR, an IP packet needs to be enhanced such that it lists the addresses of the nodes that lead to the packet’s destination. This entails a routing protocol where nodes see beyond merely the next hop leading to the destination. Therefore, link state (LS) routing [e.g., optimized LS routing (OLSR)] or source routing [e.g., dynamic source routing (DSR)] would seem to be good candidates. On one hand, LS routing protocols include interconnectivity information between remote nodes, which is hardly useful for a particular source node, but this incurs prohibitively large overhead. This is even true with optimization techniques such as multipoint relaying, as in OLSR [7]. On the other hand, if we wish to support opportunistic data forwarding in a MANET with constantly active data communication between many node pairs, the reactive nature of DSR [8] renders it unsuitable. Meanwhile, source routing is able to tightly control data forwarding paths. Thus, it is not only of interest in opportunistic data forwarding but also in a wider scope such as avoiding congestion, bypassing malicious nodes, and allocating network resources. In this paper, we propose a lightweight proactive source routing (PSR) protocol to facilitate opportunistic data forwarding in MANETs. In PSR, each node maintains a breadth-first search spanning tree of the network rooted at itself. This information is periodically exchanged among neighbouring nodes for updated network topology information. Thus, PSR allows a node to have full-path information to all other nodes in the network, although the communication cost is only linear to the number of the nodes. This allows it to support both source routing and conventional IP forwarding. When doing this, we try to reduce the routing overhead of PSR as much as we can. Our simulation results indicate that PSR has only a fraction of overhead of OLSR, DSDV, and DSR but still offers a similar or better data transportation capability compared with these protocols.

II. RELATED WORK

To utilize the broadcast nature of wireless communication links, opportunistic data forwarding plays an important role [5]. Initial works on opportunistic data forwarding includes Larsson's selective diverse forwarding in radio networks [6]. From the receivers which satisfyingly received the data, the transmitter opts a best forwarder and requests it to forward data. However this incurs high overhead which is to be reduced before implementing in any practical networks. ExOR[7] addresses this issue providing a solution at link and network layer. In ExOR the forwarder list kept by transmitted packets includes the nodes that can forward data as they are enabled to overhear all transmitted packets in the network. The forwarder node closer to destination can be easily determined to better exploit long-haul transmissions as they aggressively access the medium. An IP packet needs to be upgraded, by listing out the addresses of nodes leading to packet's destination. This calls for a routing protocol where nodes see hops beyond the mere next hop leading to destination. This calls for the need of a source routing protocol. OLSR and DSR seems to be good candidates. However the Link state routing protocols include interconnectivity information of remote nodes which is hardly useful for the source node. This problem exists even with optimization techniques like multipoint relaying, as in OLSR [8]. DSR's reactive nature renders it unsuitable for a MANET with active data communications [9]. The path-finding algorithm (PFA) [12] improves the DV based protocols by incorporating one predecessor of destinations in a routing update. To reduce the overhead of LS algorithms link vector (LV) algorithm was developed. A source routing protocol of proactive nature is proposed in this paper. A tree based routing is proposed along with a security check done to find out whether any malicious nodes are present in the network. PFA and LV were both originally proposed for the Internet, but their ideas were later used to devise routing protocols in the MANET. The Wireless Routing Protocol (WRP) [13] was an early attempt to port the routing capabilities of LS routing protocols to MANETs. It is built on the same framework of the PFA for each node to use a tree to achieve loop-free routing. Although it is an innovative exploration in the research on MANETs, it has a rather high communication overhead due to the amount of information stored at and exchanged by the nodes. This is exacerbated by the same route update strategy as in the PFA, where routing updates are triggered by topology changes. Although this routing update strategy is reasonable for the PFA in the Internet, where the topology is relatively stable, this turns out to be fairly resource demanding in MANETs. (Our original intention was to include the WRP in the experimental comparison later in this paper, and we have implemented WRP in ns2. Unfortunately, our preliminary tests indicate that the changing topology in the MANET incurs an overwhelming amount of overhead, i.e., at least an order of magnitude higher WANG et al.: PSR 861 than the other mainstream protocols. Thus, we do not include the simulation result of WRP as a baseline in our comparison.)

III. PROPOSED SYSTEM

In this paper a source routing protocol of proactive nature is proposed which supports efficient data forwarding in MANETs. Connectivity range of nodes specifies the nodes that can communicate in a single hop. An adjacency matrix based on the connectivity range of nodes should be created taking into account the location coordinates, which shows the nodes that are in direct connectivity and nodes that require intermediaries for forwarding the packets. Nodes that are in direct range with a particular node should be represented by one's and other nodes that needs an intermediate node to forward the packets should be represented by zero's in the adjacency matrix.



$$A = \begin{array}{c c} & \begin{array}{cccccc} a & b & c & d & e & f \end{array} \\ \begin{array}{c} a \\ b \\ c \\ d \\ e \\ f \end{array} & \begin{pmatrix} 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 \end{pmatrix} \end{array}$$

Fig.1 Network Topology and its adjacency matrix

A minimum spanning tree of the network should be found out from the adjacency matrix as shown in the figure 3. This gives a shortest path to reach all the nodes from any specific node in the network. Thus it provides a node with full path information to all other nodes in the network. Mobile ad hoc networks have a topology which changes as a result of active data communications and the adjacency matrix and minimum spanning tree is changed accordingly. Route updates must be done based on the new topology. This allows PSR to support source routing along with conventional IP forwarding. Simulations can be done in NS2 to evaluate the performance of PSR compared with OLSR, AODV and AOMDV.

IV. PERFORMANCE EVALUATION

We study the performance of PSR using computer simulation with Network Simulator 2 version 2.34 (ns-2). We compare PSR against OLSR [7], DSDV [9], and DSR [8], which are three fundamentally different routing protocols in MANETs, with varying network densities and node mobility rates. We measure the data transportation capacity of these protocols supporting the Transmission Control Protocol (TCP) and the WANG et al.: PSR 863 User Datagram Protocol (UDP) with different data flow deployment characteristics. Our tests show that the overhead of PSR is indeed only a fraction of that of the baseline protocols. Nevertheless, as it provides global routing information at such a small cost, PSR offers similar or even better data delivery performance. Here, we first describe how the experiment scenarios are configured and what measurements are collected. Then, we present and interpret the data collected from networks with heavy TCP flows and from those with light UDP streams.

A. TCP With Node Density

We first study the performance of PSR, OLSR, DSDV, and DSR in supporting 20 TCP flows in networks with different node densities. Specifically, with the default 250-m transmission range in ns-2, we deploy our 50-node network in a square space of varying side lengths that yield node densities of approximately 5, 6, 7, . . . , 12 neighbors per node. These nodes move following the random waypoint model with vmax = 30 m/s.

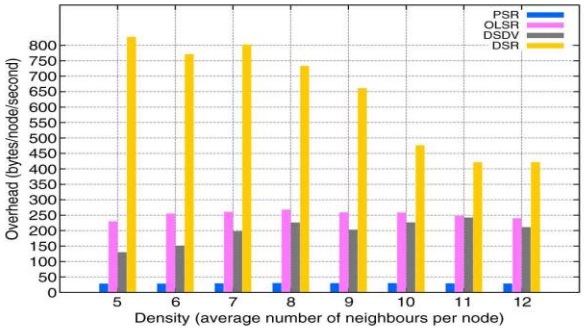


Fig. 2. Routing overhead with density

We plot in Fig. 2 the per-node per-second routing overhead, i.e., the amount of routing information transmitted by the routing agents measured in B/node/s, of the four protocols when they transport a large number of TCP flows. This figure shows that the overhead of PSR (20 to 30) is just a fraction of that of OLSR and DSDV (140 to 260) and more than an order of magnitude smaller than DSR (420 to 830). The routing overhead of PSR, OLSR, and DSDV goes up gradually as the node density increases. This is a typical behavior of proactive routing protocols in MANETs. These protocols usually use a fixed-time interval to schedule route exchanges. While the number of routing messages transmitted in the network is always constant for a given network, the size of such message is determined by the node density. That is, a node periodically transmits a message to summarize changes as nodes have come into or gone out of its range. As a result, when the node density is higher, a longer update message is transmitted even if the rate of node motion velocity is the same. Note that when the node density is really high, e.g., around 10 and 12, the overhead of OLSR flattens out or even slightly decreases. This is a feature of OLSR when its multipoint relaying mechanism becomes more effective in removing duplicate broadcasts, which is the most important improvement of OLSR over conventional LS routing protocols. PSR uses a highly concise design of messaging, allowing it to have much smaller overhead than the baseline protocols. In contrast, DSR, as a reactive routing protocol, incurs significantly higher overhead when transporting a large number of TCP flows because every source node needs to conduct its own route search. This is not surprising as reactive routing protocols were not meant to be used in such scenarios. The test against all four protocols supporting only a few UDP streams for a different perspective. Here, the routing overhead of DSR decreases with the node density going up and the network diameter going down. This is because the number of hops to a destination is smaller in a denser network; therefore, the shorter and more robust routes break less frequently and do not need as many route searches. Furthermore, compare with IP forwarding, the fact that DSR is source routing and that intermediate nodes cannot modify the routes embedded in data packets works against its performance in a mobile network, both in terms of the increase in search operations and the loss of data transportation capacity. The reason is that, because a source node can be quite a few hops away from the destination, its knowledge about the path as embedded in the packets can become obsolete quickly in a highly mobile network. As a packet progresses en route, if an intermediate node cannot reach the next hop, as indicated in the embedded path, it will be dropped. This is very different from IP forwarding, where intermediate nodes can have more updated routing information than the source and can utilize that information in forwarding decisions.

B. TCP With Velocity

Study on the performance of PSR and compare it to OLSR, DSDV, and DSR with different rates of node velocity. In particular conduct another series of tests in networks of 50 nodes deployed in a 1100 × 1100 (m2) square area with vmax set to 0, 4, 8, 12, . . . , 32 (m/s). The network thus has an effective node density of around seven neighbours per node, i.e., a medium density among those configured earlier. As with before, 20 TCP one-way flows are deployed between 40 nodes, and we measure the routing overhead, TCP throughput, and end-to-end delay.

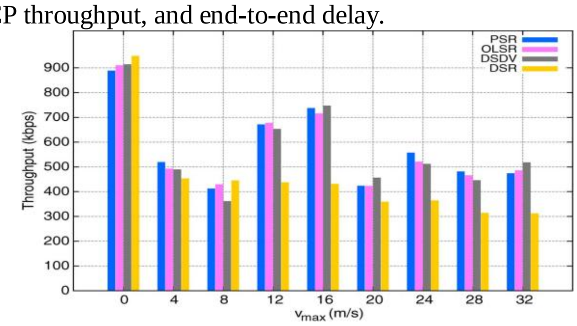


Fig. 3. TCP throughput with velocity

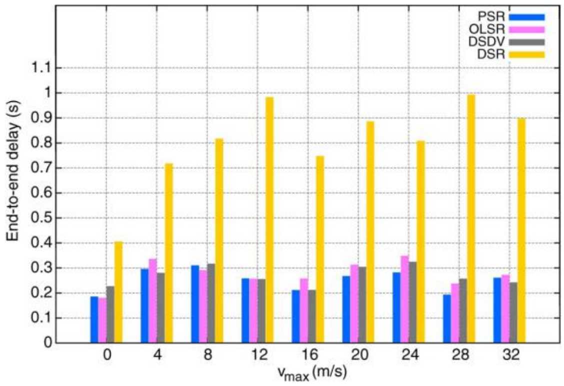


Fig. 4. End-to-end delay in TCP with velocity.

V. CONCLUSION

This paper has been motivated by the need of a proactive source routing scheme to support opportunistic data forwarding in MANETs. A tree-based routing protocol, which is proactive in nature and supports source routing is proposed , PSR. Each node has the full-path information to reach all other nodes in the form of a Minimum spanning tree of the network. PSR proves to provide better throughput and similar or better performance in transporting TCP data flows in mobile networks. With the distributed and shared nature of the wireless channel a number of security issues can arise. A step towards finding out a maliciously behaving nodes in the network and avoiding a path through such a node is incorporated in the paper. Thus PSR provides a secure and efficient routing scheme for MANETS.

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