Hybrid Routing Protocol for Wireless Ad-Hoc Networks

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Abstract. Wireless ad-hoc network is a decentralized network of autonomous nodes able to communicate with each other over wireless links. A fundamental assumption in ad-hoc networks is that any node can be used to forward packets between arbitrary sources and destinations. Some sort of routing protocol is needed to make the routing decisions. In addition, in a wireless environment the ad-hoc network presents many problems such as mobility and limited bandwidth which makes routing difficult. Therefore, this paper presents a routing protocol for wireless ad-hoc networks. The proposed protocol is hybrid type where each node maintains routing information only to those that are within its zone, and information regarding only its neighboring zones. This proposed protocol is evaluated in effectiveness and advantages it can offer with respect to HARP and FSR protocols.

Keywords: HARP protocol, FSR protocol, routing, ad-hoc network, hops.

1 Introduction

Wireless ad-hoc networks are autonomous systems of nodes forming network in the absence of any centralized support. By routing packets cooperatively among the nodes, these nodes can communicate with each other without any infrastructure where each node itself acts as a router for forwarding and receiving packets to/from other nodes [1]. The problem in the ad-hoc networks is the change in network topology due to the node mobility. In addition to, the design of network protocols for ad-hoc networks is a complex issue. Ad hoc wireless network routing protocols are usually divided into two groups: proactive (table driven) and reactive (on-demand) routing [2]. Proactive protocols exchange routing information periodically between hosts and maintain a set of available routes in the network [3], [4]. In contrast, reactive protocols, such as [5] and [6], delay route discovery until a particular route is required, and propagate routing information only on demand. The hybrid protocols combine proactive and reactive routing strategies [7], [8].

To determine the network organization and routing in the ad-hoc networks we need establish efficient distributed algorithms [9]. In a decentralized network the message

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routing is not a well-defined problem because the network topology changes. Therefore, it is necessary to design routing protocols where any node can be used to forward packets between source and destination [10]. A wireless ad-hoc environment presents many problems such as mobility and limited bandwidth which makes routing difficult. Therefore, this paper presents a novel routing protocol for wireless ad-hoc networks. The proposed protocol is a hybrid type where each node maintains routing information only to those that are within its zone, and information regarding only its neighboring zones. This proposed protocol is evaluated in effectiveness and advantages it can offer with respect to the routing protocols: Hybrid Ad hoc Routing Protocol (HARP) [8] and Fisheye State Routing (FSR) [11]. Where FSR is a proactive routing protocol and it fisheye technique to reduce information required to represent graphical data, to reduce routing overhead. FSR maintains the accurate distance and path quality information about the immediate neighboring nodes, and with the progressive detail as the distance increase. In FSR, link state packets are not flooded. In addition to, nodes exchange link state information only with the neighboring nodes to maintain up-to-date topology information. Through this exchange process, the table entries with larger sequence numbers replace the ones with smaller sequence numbers. The complete topology information of the network is maintained at every node and the desired shortest paths are computed as required. The topology information exchange takes place periodically rather than being driven by an event. This is because instability of the wireless links may cause excessive control overhead when event-driven updates are employed. Moreover, HARP is a hybrid routing scheme, which exploits a two-level zone based hierarchical network structure. Different routing approaches are utilized in two levels, for intra-zone routing and inter-zone routing, respectively. The Distributed Dynamic Routing (DDR) algorithm is exploited by HARP to provide underlying supports. In DDR, nodes periodically exchange topology messages with their neighbors. A forest is constructed from the network topology by DDR in a distributed way. Each tree of the forest forms a zone. Therefore, the network is divided into a set of non-overlapping dynamic zones. A mobile node keeps routing information for all other nodes in the same zone. The nodes belonging to different zones but are within the direct transmission range are defined as gateway nodes. Gateway nodes have the responsibility forwarding packets to neighboring zones. In addition to routing information for nodes in the local zone, each node also maintains those of neighboring zones [12].

The remainder of this paper is organized as follows. In section 2, we present the operation of the proposed routing protocol. Our proposed routing protocol is simulated and compared with FSR and HARP in section 3 and the conclusions of this work are provided in the last section.

2 Proposed Routing Protocol

The objective of the proposed routing protocol is that communication between nodes is efficient taking into account the cost, route, distance, bandwidth used, and delay. Where the cost is the value assigned to each node to form the route path, the route is the path from the source node to the destination node, and the distance is the value obtained from the path of the route.

The structure of the proposed protocol is based on several features, including: routing table, network structure, sectors, intra-zones, and preferred neighbor node [8], [11].

The routing table in the proposed protocol is used to store the information of nodes that are within of the network. Figure 1 shows an example of a routing table.

The network structure in the proposed protocol is used to place the available nodes to transmit. A value 0 indicates that position is available for a node, except the 0s that are in the border of the network and these serve to delimit it (see figure 2).

Nodes

Location of Nodes

	1	2	3
1	1	8	2
2	2	11	7
3	3	2	8
4	4	12	11
5	5	7	3
6	6	5	6
7	7	3	10
8	8	6	3
9	9	4	9
10	10	9	5
11	11	3	12
12	12	10	4
13	13	6	4
14	14	7	2
15	15	12	12

Fig. 1. Routing table of the proposed routing protocol.

The sectors are determined by levels according to network matrix taking the node into account that needs to transmit the message. The first sector is composed of neighboring nodes of the destination node. The second sector is formed by the nodes around the first sector, and the third sector will be conformed by the nodes that are around the second sector, as shown in figure 3.

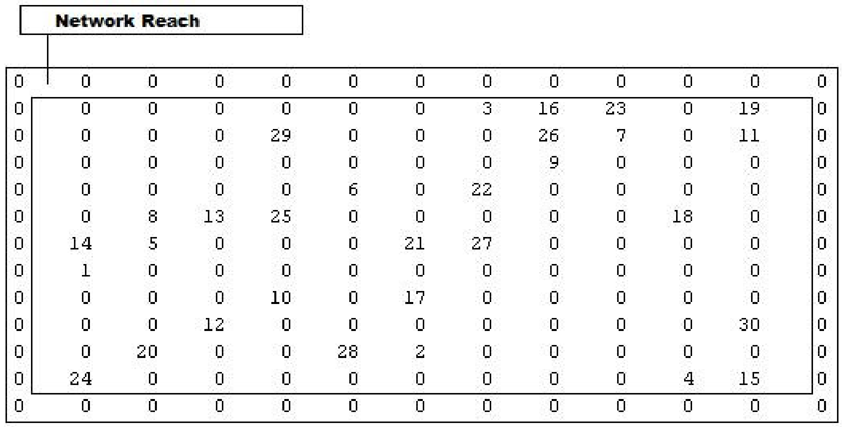

Fig. 2. Network structure for the proposed routing protocol.

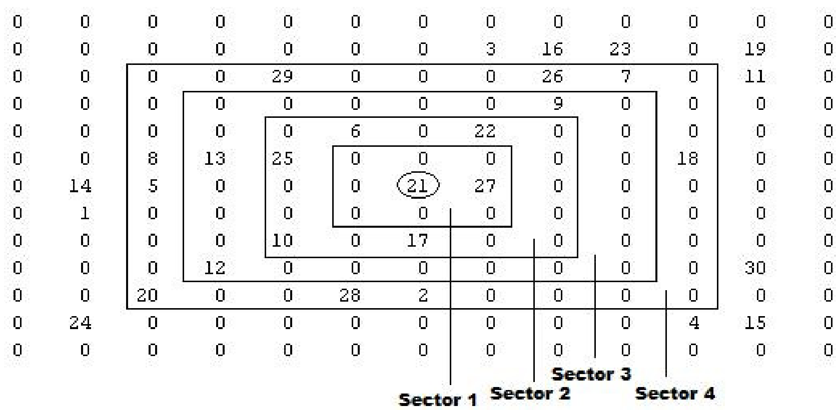

Fig. 3. Sectors location for the proposed routing protocol.

The intra-zones are located within a sector as shown in Figure 4. This is a difference of proposed protocol with respect to the HARP protocol, because the hops number between transmitting node and receiving node is less due it moves according to the sector in which it is.

The preferred neighbor node is determined by taking the shortest distance between nodes of one sector to another (see figure 5), i.e. in order to reduce the delay time of transmission of the message. This is a difference between proposed protocol and FSR.

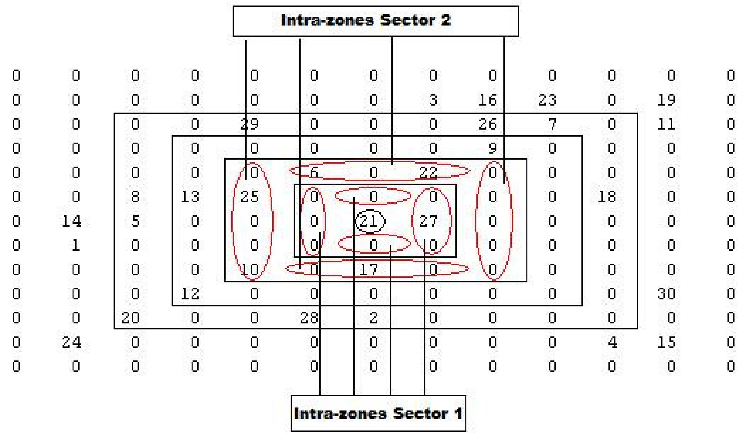

Fig. 4. Intra-zones belonging to each network sector.

2.1 Operation

Step1. When a node of the network needs to transmit a message, it is situated in the center of the network. In addition to, the proposed protocol establishes the sectors and intra-zones and these determine the reach of each node with their neighboring nodes (see figure 6).

Step 2. Having defined the node transmitter and receiver, the proposed protocol analyzes the first sector. In this case, it verifies the routing table of each intra-zone and if there is no information about the destination node, then it goes to other sectors taking the preferred node into account (see figure 7).

Step 3. The destination node in sector 1 is searched, but in case of not receiving affirmative answer then the search continues into other sectors. For this, locate the preferred neighbor node which is determined based on the nearest node of the new sector, as shown in figure 7. The result of this would be a decrease in the transmission delay. When the preferred neighbor node is found the search can continue at sector 2 and performs the same operation as step 2.

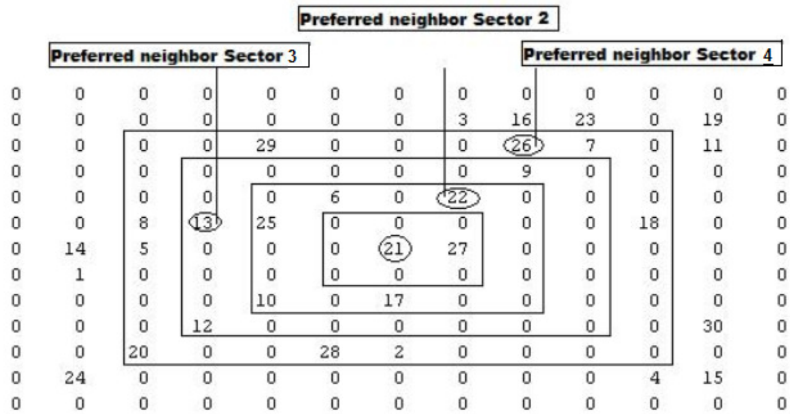

Fig. 5. Preferred neighbors of network sector.

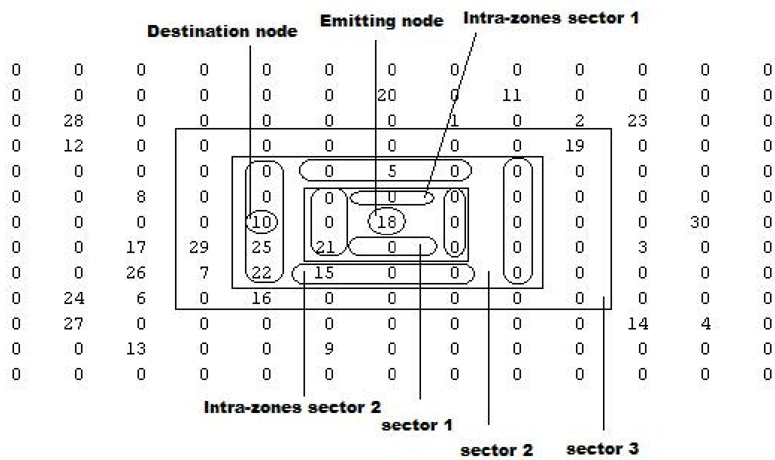

Fig. 6. Network structure in the transmission of the message.

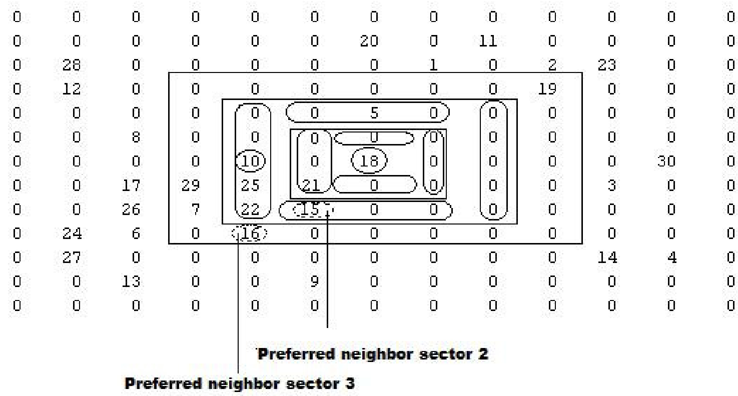

Fig. 7. Selecting the preferred neighbor.

Step 4. At the time receiving response of an intra-zone of which destination node is in that sector, the proposed protocol begins to analyze the possible routes and using Dijkstra selects the best route [13].

Step 5. The proposed protocol calculates distance, hops number and delay once selected the route.

The evaluation results of the proposed routing protocol are presented in the next section.

3 Performance Evaluation

The proposed protocol is evaluated and compared with respect to HARP [8] and FSR [11] by a simulation process, and it was made through the design of a program in Matlab, on a personal computer, which considers the aspects of modeling of proposed routing protocol mentioned in section 2, as well as the properties and the behavior of the system. We have considered a network with 105 nodes, where these are located randomly. The number of point-to-point links in a transmission path is the hops count. Within the network each node is assigned a value and it is called as cost. Distance is obtained value of the path from source node to destination node. Delay is the average time duration of packet transmitting in the network form a source node to the destination node. The simulation results are the following.

a) Hops number. Figure 8 shows that proposed protocol achieves an improvement of 12% and 35% as compared to the existing FSR and HARP protocols, respectively. On the other hand, this improvement is attributed to that the proposed protocol chooses the nearest node, and protocol FSR takes a neighbor node but it does not verify if it is the closest. The protocol HARP does not have complete information of all the nodes of the network, and it has to go asking for zone and intra-zone to reach the destination node.

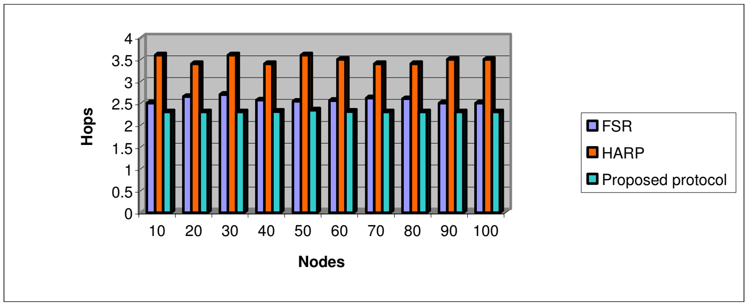

Fig. 8. Hops number behavior under FSR, HARP and proposed protocol.

b) Distance. When compared to the FSR and HARP with our proposed protocol illustrated in figure 9, improves in 14% to FSR and 27% to HARP. This improvement, is because the route selection in HARP is based on stability with the destination node. With respect to FSR, it does not take into account the preferred neighbor node to consult to the other sectors on destination node information, when not doing this the protocol takes a random node but not always it is nearest.

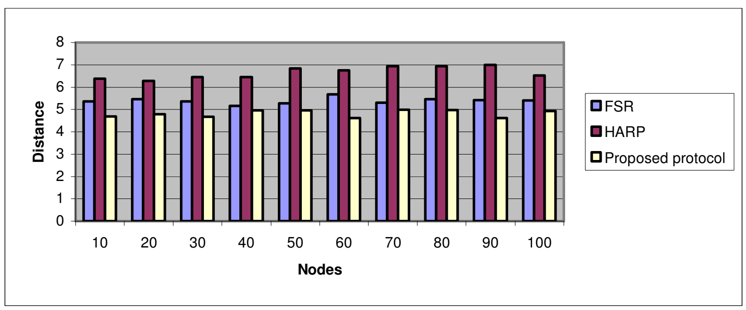

Fig. 9. Distance comparison of FSR, HARP and proposed protocol.

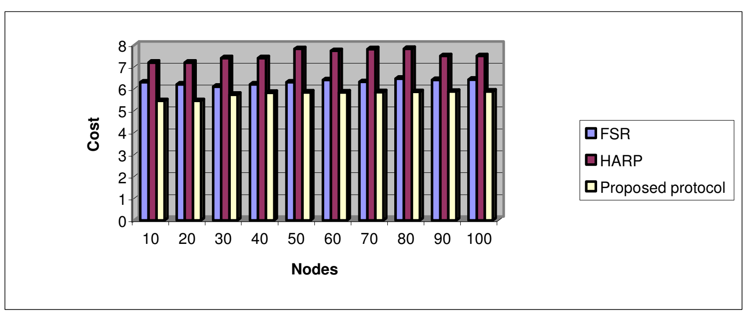

Fig. 10. Simulation result to cost.

c) Cost. Figure 10 shows the behavior of FSR, HARP, and proposed protocol. We observe that the proposed protocol has a lower cost. For the case HARP, having a greater distance it goes through a larger nodes number requesting information of the destination node. The protocol FSR does not have a preferred neighbor node, so it can pass through nodes that are not required to obtain information of the destination node.

We have seen the advantages of our proposed protocol in terms of hops, distance and cost. We are now going to analyze the behavior of another very important system parameter, which is the delay.

d) Delay. The delay result is illustrated in figure 11. In this figure we observe that the proposed protocol has less delay that HARP and FSR because if the node is within the sector then it can be easily localized with the table of the intra-zones, in case it is not in the sector then it chooses the preferred neighbor, thereby ensuring communication with the other area is optimal. Moreover, the protocol HARP searches the information of the destination node in each intra-zone and therefore a greater delay in the transmission. Additionally, the FSR protocol has no preferred neighbor property; therefore the selected node is not the most appropriated. In addition, as FSR does not use intra-zones then has greater delay because the protocol FSR must consult the routing table of all the sector and when not finding information it takes a node of the following sector without evaluating if it is nearest.

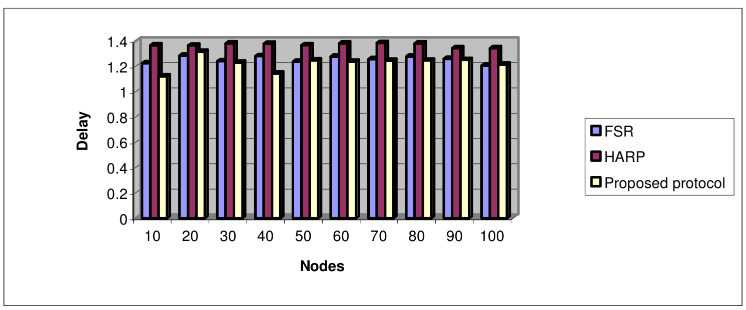

Fig. 11. Simulation result to delay.

4 Conclusions

By according to the results we conclude that the proposed protocol is more efficient and dynamic as it manages the bandwidth efficiently to the node or nodes that need to transmit, selects the shortest route by analyzing each node and obtaining a lower cost. Because the industry of the telecommunications is growing, there is a good option for the implementation of an ad-hoc network under proposed protocol since it would guarantee a very good service to the users and it would stay stable according to the amount of users who connect themselves to the network.

5 References

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