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Advanced Optimized Next Hop Routing Link State Routing In Wireless Sensor Network

Sonatte .A.A[1], Mrs. N. Gomathi M.E[2]

M.E Computer Science and Engineering, SVS College of Engineering, Coimbatore, Tamilnadu, India [1]

Assistant Professor, SVS College of Engineering, Coimbatore, Tamilnadu, India [2]

Abstract: A hybrid routing protocol named AOHR (AODV and OLSR hybrid routing) for wireless ad hoc networks is proposed in this paper. In AOHR, each node maintains topology information of a zone with radius not larger than a set value. By the proactive property of OLSR, when a node wants to communicate with another node within its zone, packets can be transmitted directly. Otherwise, a routing request procedure will be invoked by the reactive property of AODV. In addition, AOHR utilizes MPRs (multipoint relays) to reduce overheads of route requests. This paper also proposes dynamic zone radius maintenance for AOHR to dynamically adapt to various scenarios. Analysis and simulation results show that AOHR combines the characters of high data delivery fraction, low overheads, and short delay in AODV with the characters of optimized routing length in OLSR, which means that AOHR is immune from topological structures.

Keywords: Advanced Optimized Next Hop Routing (AOHR), Hybrid Routing Protocol, AODV, OLSR, MPRs.

I. INTRODUCTION

The paradigm, where wireless nodes communicate with each other and create their own adhoc network independent of any infrastructure, is most popular these days. It is called as peer to peer communication. Routing is the most essential part of this type of communication. The IETF MANET working group is concerned with standardizing IP (layer 3) routing protocol functionality suitable for wireless ad hoc networks. There are many routing protocols described for MANETs. Some of them are reactive i.e. Find route when needed and some are proactive or table-driven i.e. Find routes before needed. Destination Sequence Distance Vector (DSDV) and Optimized Link State Routing (OLSR) are commonly used proactive routing algorithms while Dynamic Source Routing (DSR) and Ad hoc On-Demand Distance Vector (AODV) are the most commonly used reactive protocol. The size of ad hoc network if increases beyond a certain limited area, the use of any single routing algorithm alone may not work efficiently. Therefore the usage scenario, number of nodes in a particular network and the occupancy of buffers of a node greatly affects the choice of routing algorithm.

For example the network can be as small as comprising only a few numbers of nodes in a small conference room or it can be as large as a sensor network where a great deal of nodes are needed. As the size and load of a network increases the probability of congestion and relative delay in packet delivering increases which can sometimes lead to loss of data. A hybrid routing algorithm that combines the merits of existing protocols can be used to address this issue of growth in network size and load balancing whose behavior can be modified according to the size of network.

Link State protocols work more efficiently, problem can arise. Usually problems occur cause of changes in the network topology (links go up - down), and all routers don't get updated immediately cause they might be on different line speeds, there for routers connected via a fast link will receive these changes faster than the others on a slower link. The hop-by-hop forwarding requirement presents the next challenge. As a result, a router cannot determine the entire path that traffic originating at it takes to its destination. Without this requirement, a projected gradient approach can be used to yield optimal iterative link-state algorithms that can be implemented with source routing, where the path a packet takes through the network is encoded in its entirety at the source. However, the need for source routing means that these techniques are not practical given the size of modern networks.

II. LITERATURE SURVEY

However, the obvious trade off has been lost performance. For instance, due to the poor resource utilization resulting from OSPF, network administrators are forced to overprovision their networks to handle peak traffic. As a result, on average, most network links run at just 30%–40% utilization. To make matters worse, there seems to be no way around this trade off. In fact, given the offered traffic, finding the optimal link weights for OSPF, if they exist, has been shown to be NP-hard [4]. Furthermore, it is possible for even the best weight setting to lead to routing that deviates significantly from the optimal routing assignment.

A. Routing Information Protocol

The Routing Information Protocol (RIP) is a veteran distance-vector routing protocol that uses UD Port 520 for message encapsulation. It consists of two message types. A request message is used to ask neighboring routers to send an update. A response message carries the update. When RIP is configured on a router, it sends Broadcast

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packets containing the request message out the Entire RIP enabled interfaces and then listens for response messages. Routers receiving the request message respond to it by sending their routing tables in the response message. This process continues until the network is converged. A RIP router sends out its full routing table in its update once in 30 seconds. If any new entry is found in an update, the RIP router enters it into the routing table along with the sending router's address. It uses the hop count as a metric for determining best paths. The maximum hop count is15; thereby preventing routing loops in the network. This also limits the size of the network supported by it. If the hop count of an incoming route is 16, it is considered to be inaccessible or undesirable and is at an infinite distance. RIP prevents inappropriate information from propagating throughout the network, by the use of its features like split horizon, route poisoning and hold down timers, thus providing stability to the network.

B. Open Shortest Path First (OSPF)

Link-state routing protocol is also known as shortest path routing protocol, as it compute the finest path in the network which is the shortest path available from the source network to the destination network. Each router joined the routing domain, will held link state databases which consist of a router list in the network. Every router has the same database. The database then is used to describe to network topology. Each router in the same domain will run the algorithm using their link-state database. Firstly, they will build a tree with each router as the root. Then, the tree consists of shortest path available to each router in that network. Other router which is joined the network will be known as leave. Link state advertisement (LSA) is responsible for the routing information exchange between routers. Neighbor router information can be known each time LSA is received.LSA is sent by each routing using flooding method. Each router floods its LSA to the network, and then each router will receive the LSA and processed it. Every time a network topology altered, router will send LSA to the networks.

Thus the other routers will know about the network topology changes soon. Dijkstra algorithm is used to computes the shortest path from each router to other router in the same routing domain. Dijkstra algorithm used cost for each link available in the router for the computation. OSPF is a routing protocol developed by Interior Gateway Protocol (IGP) working group of the Internet Engineering Task Force (IETF) for Internet Protocol (IP) network. OSPF is a connect state routing protocol that is used to distribute routing information within a single Autonomous System (AS).

C. Enhanced Interior Gateway Routing Protocol (EIGRP)

Distance vector routing protocol present routes as function of distance and direction vectors where the distance is represented as hop count and direction is represented interface. In the distance vector routing protocol, Bellman-Ford algorithm is used for the path calculation where router take the position of the vertices and the links. For each destination, a specific distance vector is maintained for the entire router joined the network. The distance vector consists of destination ID, shortest distance and after that hop. Now every node passes a distance vector to its neighbor and informs about the shortest paths. Each router depends on its neighboring routers for collecting the routing information. The routers are responsible for exchanging the distance vector. When a router in the network receives the advertisement of the lowest cost from its neighbors, it followed by add this admission to the routing table. In distance vector routing protocol, the router do not know the information of the entire path. The router knows only the information about the direction and the interface where the packet will be forwarded. One of distance vector routing protocol is Enhanced Interior Gateway Routing Protocol (EIGRP). EIGRP is a CISCO proprietary protocol, which is an improved version of the interior gateway routing protocol (IGRP). Route computation in EIGRP is done through Diffusion Update Algorithm (DUAL).

D. Hop-by-Hop Adaptive Link-State Optimal Routing (HALO)

To eliminate this trade off between optimality and ease of implementation in routing. The result is Hop-by-hop Adaptive Link-state Optimal (HALO), a routing solution that retains the simplicity of link-state, hop-by-hop protocols while iteratively converging to the optimal routing assignment. To the best of our knowledge, this is the first optimal link-state hop-by-hop routing solution. Present HALO, the first link-state routing solution crying traffic through packet-switched networks. At each node, for every other node, the algorithm independently and iteratively updates the fraction of traffic destined to that leaves on each of its outgoing links. At each iteration, the updates are calculated based on the shortest path to each destination as determined by the marginal costs of the network's links. The marginal link costs used to find the shortest paths are in turn obtained from link-state updates that are flooded through the network after each iteration. For stationary input traffic, we prove that HALO converges to the routing assignment that minimizes the cost of the network.

III. PROPOSED HYBRID PROTOCOL

In this proposed model packet loss due to congestion and excessive load at intermediate nodes is tried to be reduced. Balancing load to avoid congestion inside novel scheme of flow control is actually performed by creating a cycle on a node where the congestion probability is high i.e. at near sink node to find all those nearer nodes where buffer occupancy is high. Near sink node and nodes nearer to it contains the routing table including information about its own I.P. address, I.P. address of nearer neighbor nodes, distance between the nodes, & queue length of each node.

AODV and OLSR are combined to form AOHR (AODV and OLSR hybrid routing). Here the characteristics of high data delivery fraction, low overheads, and short delay in AODV are combined with the characteristics of optimized routing length in OLSR, which means that AOHR is immune from topological structures.

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A. Network Model
The wireless ad hoc network shown in Figure 1 considers mobile nodes, which are not supported by an external device or control mechanism and have their communication range according to coverage area of the individual node. It may be seen that sending and destination nodes are connected using multihop communication and thus need congestion free path to achieve reliable communication.

B. AOHR Protocol
Although AOHR protocol has some excellent performance no actual network utilizes AOHR as routing protocol. It is because that this protocol cannot interoperate with AODV protocol, which is the most famous routing protocol and used all over the world. The cost will be very huge to replace AODV protocol with AOHR protocol for existing networks, so the only feasible method is to modify AOHR protocol to interoperate with AODV as introduced in this paper. The simulation results prove that the modified AOHR protocol can help the existing AODV protocol provide routing service, and the interoperation of these two routing protocols is realized. Protocol can provide minimal energy information of every routing to destination nodes and source nodes by RREQ packets and RREP packets respectively. In this way, destination nodes and source nodes can choose a routing respectively with the max-min energy value among all routings as the path for packet delivery. Simulation results and analysis prove that AOHR protocol can effectively provide longer network's lifetime and steadier end-to-end delay without any performance loss compared to HALO protocol.

C. Multipath Relay Selection
The AOHR can be regarded as a kind of hybrid multipath routing protocol which combines the proactive and reactive features. It sends out HELLO and TC messages periodically to detect the network topology, just like OLSR. However, MP-AOHR does not always keep a routing table. It only computes the multiple routes when data packets need to be sent out. The core functionality of MP-AOHR has two parts: topology sensing and route computation. The topology sensing is to make the nodes aware of the topology information of the network. This part benefits from MPRs like OLSR. The route computation uses the Multipath Dijkstra Algorithm to calculate the multipath based on the information obtained from the topology sensing. The source route (all the hops from the source to the destination) is saved in the header of the data packets. The topology sensing and route computation make it possible to find multiple paths from source to destination. In the specification of the algorithm, the paths will be available and loop-free. However, in practice, the situation will be much more complicated due to the change of the topology and the instability of the wireless medium. So route recovery and loop detection are also proposed as auxiliary functionalities to improve the performance of the protocol.
The route recovery can effectively reduce the packet loss, and the loop detection can be used to avoid potential loops in the network as depicted.

D. Multipath Dijkstra Algorithm
For a source node sin the network, MP-OLSR will keep an updated flag for every possible node in the network to identify the validity of the routes to the corresponding node. Initially, for every node i, the $updatedFlag_i$ is set to false, which means the route to the corresponding destination does not exist or needs to be renewed. When there is a route request to a certain node i, the source node will first check the $updatedFlag_i$.

- If the $updatedFlag_i$ equals false, the node will perform Algorithm 1 to get the multiple paths to node i, save it into the multipath routing table, and renew the corresponding updatedFlagi to true.
- If the udpdatedFlagi equals true, the node will find a valid route to node i in the multipath routing table. Every time the node receives a new TC or HELLO message and results in the changes in the topology information base, all the updatedFlags will be set to false.

The algorithm to obtain the N paths from s to d is detailed in Algorithm 1.

Algorithm 1. Calculate N routes in G from s to d

```
MultiPathDijkstra( s; d;G;N)
c1← c
G1← G
for i 1 to N do
SourceTreei ←Dijkstra(Gi; s)
Pi ← GetPath(SourceTreei,d)
for all arcs e in E
if e is in Pi OR Reverse(e) is in Pi then
ci+1(e) ← fp(ci(e))
else if the vertex Head(e) is in Pi then
ci+1(e) ← fe(ci(e))
else
ci+1(e) ← ci(e)
end if
end for
Gi(1 (V;E; ci1))
end for
return (P1,P2, . . . ,PN)
```

By using the cost functions, we can expect to find diversity in the N paths regarding the network topology. But contrary to providing strictly node-disjoint paths, the multiple paths generated by our algorithm do not need to be completely disjoint. The reason for this choice is that the number of disjoint paths is limited to the (s,d) minimal cut (defined as the size of the smallest subset of edges one cannot avoid in order to connect s to d). This minimal cut is often determined by the source and destination neighborhoods. For example, if s only has three distinct neighbors, one cannot generate more than three disjoint paths from s to d. As a consequence, this limitation of diversity may be local, the rest of the network being wide enough to provide far more than three disjoint paths. Another drawback of completely disjoint paths algorithms is that it may generate very long paths since every local ‘cutoff’ can only be used once.

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E. Route recovery

By using the scheme of the Topology Sensing, we can obtain the topology information of the network with the exchange of HELLO and TC messages. All this information is saved in the topology information base of the local node: link set, neighbour set or topology set. Ideally, the topology information base can be consistent with the real topology of the network. However, in reality, it is hard to achieve, mainly because of the mobility of the ad hoc network.

Firstly, for the HELLO and TC messages, there are certain intervals during each message generation (2s for HELLO and 5s for TC by default [1]). During this period, the topology might change because of the movement of the nodes. Secondly, when the control messages (especially the TC messages) are being transmitted in the network, delay or collision might happen. This will result in the control message being outdated or even lost.

F. Loop detection

In theory, the paths generated by the Dijkstra algorithm in MP-AOHR are loop-free. However, in reality, the LLN and route recovery which are used to adapt to the topology changes make the loops possible in the network. With LLN, when a node tries to send a packet over a link but fails in the end, the link layer will send feedback to the routing protocol to notify it of the link loss. This kind of abrupt interruption will result in additional operations on the topology information base rather than just regular HELLO and TC messages. This means that other nodes cannot be aware of these changes immediately. So, LLN might cause some inconsistency of the topology information in different nodes. And with route recovery, which might change the path in intermediate nodes, loops can occur temporarily in the network.

IV. SIMULATION AND PERFORMANCE EVALUATION

The simulations are performed to evaluate MP-AOHR which includes both the core functionality and the auxiliary functionality (route recovery and loop detection). The rest of the section is organized as follows. The simulation environment and assumption are first introduced. Then we compare the performances between HALO and MP-AOHR in different scenarios. The difference between the reactive and proactive protocols is also analysed.

To compare the performances of the protocols, the following metrics are used.

- Packet delivery ratio: The ratio of the data packets successfully delivered at destination.
- Average end-to-end delay: Averaged over all surviving data packets from the sources to the destinations. This includes queuing delay and propagation delay.
- Average time in FIFO queue: Average time spent by packets in the queue.
- Distribution of delay of received packets: This measurement can give an idea of the jitter effect.

Table 1 Packet Delivery Ratio

Protocols	No of Nodes						
	5	**10**	**15**	**20**	**25**	**30**	**35**
HALO	54	50	64	79	84	88	91
AOHR	65	67	85	83	87	94	98

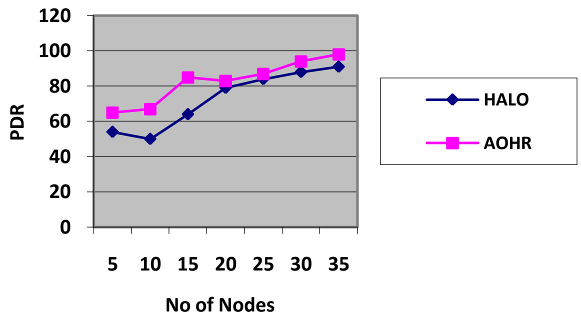

Fig .1. Shows packet delivery ratio against the number of nodes. It shows that the AOHR protocol has a better PDR compare to HALO.

Table 2 Compare Throughput

Protocol	No of Nodes						
	5	**10**	**15**	**20**	**25**	**30**	**35**
HALO	5.1	6.4	7.5	8.2	8.7	9.1	9.5
AOHR	5.8	6.9	7. 6	9.1	10.3	11.7	12.4

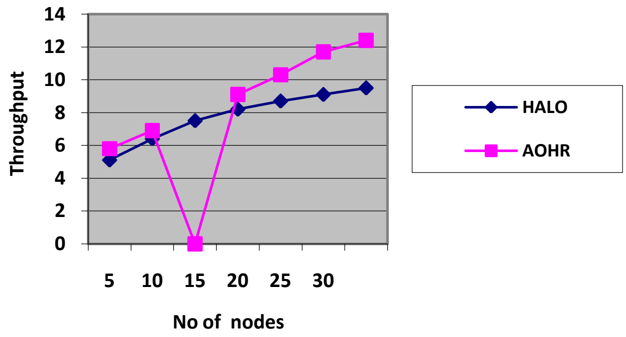

Fig. 2 show throughput against the number of nodes. It shows that when the number of nodes is 80 with up to seven jammers, the AOHR has higher throughputs than HALO, respectively.

Table 3 End to End delay

Protocols	No of Nodes						
	1	**2**	**3**	**4**	**5**	**6**	**7**
HALO	5.8	4.1	3.2	3.1	2.8	2.5	2.1
AOHR	4.1	3.2	2.7	2.1	1.9	1.2	0.5

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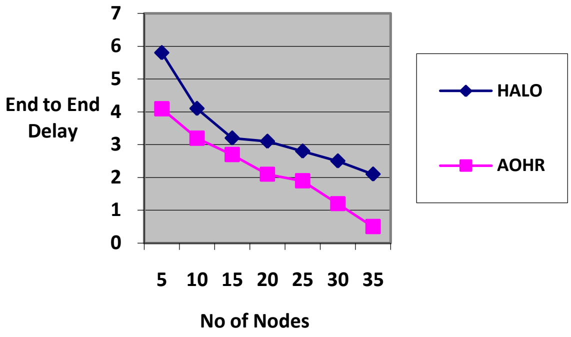

Fig. 3 show delay against the number of nodes. It shows that when the number of jammer nodes high it take more delay time. The AOHR has lower delay value compared to existing HALO.

V. CONCLUSION

The proactive property of OLSR, when a node wants to communicate with another node within its zone, packets can be transmitted directly. Otherwise, a routing request procedure will be invoked by the reactive property of AODV. In addition, AOHR utilizes MPRs (multipoint relays) to reduce overheads of route requests. This paper also proposes dynamic zone radius maintenance for AOHR to dynamically adapt to various scenarios. Analysis and simulation results show that AOHR combines the characters of high data delivery fraction, low overheads, and short delay in AODV with the characters of optimized routing length in OLSR, which means that AOHR is immune from topological.

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