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A SURVEY ON MULTI-PATH ROUTING PROTOCOLS IN MOBILE AD HOC NETWORK

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ABSTRACT

In recent years, researchers are paying much attention in the vicinity for developing routing protocols in mobile ad hoc networks (MANET). The effectiveness of the MANET routing protocol depends on the security, quality of service and power consumption of the route selected for the communication between mobile nodes. In the literature, several protocols exist for MANETs routing are discussed. The determination of the most appropriate routing protocol for varying network conditions such as network size, traffic density and network partitioning is a challenging task. In this paper, several multipath routing protocols for MANET is investigated. Also, routing protocols are categorized into various aspects to provide reliable communication, ensure load balancing and improve the quality of service of MANETs. Furthermore, various objectives, performances, advantages and disadvantages of several routing protocols are investigated and summarized in this paper.

Keywords: MANET, Multi-Path Routing, Optimization, Routing Protocol, Topology-Hiding.

I. INTRODUCTION

A mobile ad hoc network (MANET) consists of a set of mobile nodes without any central administration. The communication between the mobile nodes in MANET is realized in a multi hop manner i.e., a mobile node uses the intermediate nodes to send a data packet to the destination node. As, the communication relies on neighbour nodes, equal importance is given to all the nodes for the better performance of the network. Moreover, the network topology of the MANET is dynamic. Such limitation ascends the need for the efficient routing protocol in MANET. Designing such an efficient and reliable routing protocol is a challenging task and researchers are paying much attention toward this field.

Before the development of wireless networking, two algorithms such as link-state algorithm and distance vector algorithm were used by the wired networks for communication. In link state routing, each node in the network is updated with current view of the network based on a flooding scheme. The link state costs of neighbouring nodes of each individual node are broadcasted in the network view update. When a new data packet is received by the node, the view of the network and link state information is updated based on a shortest path algorithm for the selection of destination node. Thereby, the destination node for each hop is found in the link-state routing algorithms. A distance-vector routing protocol requires that a router periodically inform about the changes in topology to its neighbouring nodes. Based on which the node chooses the path with shortest distance to reach the destination. The limitations of these conventional link-state and distance-vector algorithm are that they are

inappropriate for large network (i.e. MANET) because routes are updated periodically or frequently in such networks. Moreover, the high consumption of available bandwidth, increased channel contention and frequent recharging of power supply required by the nodes are also appears to be sticky.

In order to overcome this issues related with the link-state and distance-vector algorithms, several routing protocols were proposed for MANETs and they are mainly classified into three types: Proactive routing protocols (table driven), reactive routing protocols (demand driven) and hybrid routing protocols. In proactive routing protocols, each node in the network maintains one or more tables containing topology information. The tables are updated regularly by gathering the current topology information about the network. In reactive protocols, the route for the source node to reach the destination is selected by a route discovery process. Hybrid routing protocols integrates the advantageous properties of both proactive and reactive protocols. That is, they are both reactive and proactive in nature. This paper is structured as follows: Section 2 discusses the review of the multi-path routing protocols in mobile ad hoc network. Section 3 briefly explains several existing routing protocols. Section 4 deliberates the research gaps and challenges, and section 5 concludes the paper.

II. REVIEW OF MULTI-PATH ROUTING PROTOCOLS

The taxonomy of the multi-path routing protocol based on the literature is provided in this section. Figure 1 shows the taxonomy of multi-path routing protocol.

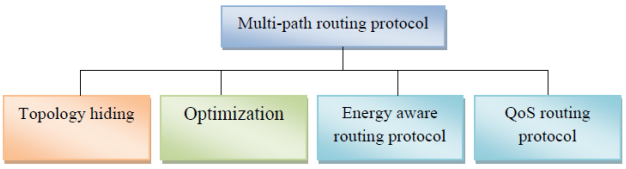

FIGURE 1. TAXONOMY OF MULTI-PATH ROUTING PROTOCOL

A. Topology hiding-based routing

In [1, 2], topology hiding multi-path routing was proposed to handle topology exposure problem in MANET. In these routing methodologies, the route request phase is utilized to hide the network topology at the time of data packet transmission. The concern over the security risk increases because of the dynamic grouping based clustering process. The security concern is critical because of the dynamic change of information. A new protocol called Topology-Hiding Multipath Routing (THMR) with risk of the topology exposure is proposed. The security aspect is preserved in THMR by the excluding the routing information from the packets. By doing so, the malicious nodes in the network cannot gather topology information. Moreover, multiple node disjoint routes are integrated in the route discovery attempt which rejects unreliable routes even before the data packet transmission, thereby increasing the network performance. Simulation of this proposed routing algorithm demonstrates the fact that it has ability to discover route and to perform the data packet transmission in the network with the attackers at the cost of low routing overhead. These works [1, 2] make use of route request phase additionally to hide the network topology when sending data packets.

The significant privacy factors in the wireless environments are anonymity, location privacy and un-linkable communication. In MANETs, privacy perseverance is a difficult task to attain. This is because of the altering characteristics of the network, such as dynamic topology, mobility of nodes, limited resources etc. For the privacy is such networks, protection scheme is essential. In [6], a new multicast routing protocol with privacy

concern for mobile ad hoc networks is proposed. This protocol has the ability to extend the anonymous routing from the unicast communication scenarios to multi cast scenarios. Moreover, some privacy properties are included in this routing algorithm protecting the network performance from the intruders. This algorithm is unfeasible to search for the optimal route when more than one leader emerges in the network, and also for sub mesh group communication.

B. Optimization-based algorithms

Optimization based routing algorithm is the one of the state of art research topic in the field of the MANET routing. The application of ant colony optimization algorithms to solve the routing problem in MANETs is addressed in [7]. The communication of the agents in the ant colony algorithm is done indirectly. The solution is provided by laying pheromone on the links. The stagnation problem is avoided by the evaporation and aging mechanism exhibited by the ants. In ant Colony algorithms, agent to agent to communication is done which is similar to node to node communication in MANET which makes it more suitable for MANETs. This algorithm is more apt for the adaptive route finding in the volatile network. Here, the swarm system is inefficient as they are redundant and does not have central control.

Ant colony algorithm is a significant type of meta-heuristics techniques, which can provide an efficient solution to multipath routing. The local optima problem in the ant colony algorithm because of the search space exploration without initializing the search direction is detriment. To solve this problem, the orientation factor is considered [4] and is applied in MANETs. Hence keeping this point in view, an orientation based ant algorithm (OANTALG) for Routing in MANETs was presented in [4]. This algorithm depends on the orientation factor for the selection of the destination nodes and data packet exchange i.e. in ant algorithm perspective change of search agents between the source and destination depends on an orientation factor. The pheromone tables and data structures are generated during the movement of ants which records the ants' trip time between the nodes. The experimental results shows that the OANTALG algorithm performs better than the other state of art algorithms, which are traditional and other ant based algorithms. The highest pheromone value reduces the convergence risk in this proposed algorithm. But the security aspects are not considered well in their approach. The sequences of random decisions are also found to be dependent which reduces the network performance.

An intelligent model to find QoS anycast route in MANETs by using ANFIS is proposed in [5]. The scheme employed an agency consisting of static Anycast Manager Agent (AMA), Optimization Agent (OA), and mobile Anycast Route Creation Agent (ARCA). OA optimizes fuzzy inference system according to the requirement by using a neural technique. ARCA discovers multipaths from the clients to individual servers. AMA at client chooses a QoS anycast path from a set of multipaths by employing optimized fuzzy technique and server with higher stability. Since the agent based architectures are utilized in this model, the decision making for the network management appears to be flexible and adaptable. This proposed work is simulated for various MANET network environments for the performance validation. From the simulations, it was observed that the presented scheme performs better in terms end-to-end delay, packet delivery ratio, path success ratio and control overhead. The limitation rises with the different QoS requirement.

In [8], E-Ant–DSR routing algorithm was demonstrated. The proposed routing algorithm is based on emergence and self-organizing behaviour of the ants. This algorithm intends to search optimal path for the network by avoiding the congestion in the network and linkage breakage phenomena. The energy consumption of this

routing algorithm is also found to be superior over other evolutionary algorithm based routing algorithms. The performance of the E-Ant–DSR routing algorithm is demonstrated by comparing the experimental results over other ACO algorithms and artificial intelligence algorithms utilizing the measures such as packet data delivery ratio, broken route, routing overhead and energy consumption. Effort needed for the calculation of individual nodes seems problematic in this algorithm.

In [10], a hybrid routing algorithm model by integrating the PSO approach and the ACO approach for routing in MANT was presented. The simulation result shows that the hybrid routing intelligent algorithm (PSO_ACO) is capable of handling vast networks i.e. network with large number of nodes. From the performance analysis, it was concluded that the path selected by this hybridized algorithm has minimal distance and delay. The power consumption and cost was also found to be minimal compared to the performance of other ACO algorithms. The significant advantage of this algorithm is the competent ability to find the optimal route in the MANETs. The problems related to scattering, optimization and non-coordinate system is inept to solve by this algorithm.

C. Energy aware protocol

In mobile ad hoc network, all the nodes are mobile. The battery power and the channel bandwidth of the MANET are limited. The Ad hoc network is more frequently used in emergency situations, so that power conservation is very important.

In [3], a modified Ad Hoc on demand distance vector routing algorithm called MAODV is proposed by modifying the AODV (Ad Hoc on demand distance vector routing) algorithm for selecting optimal route in MANET. Route request phase (RREQ) of the MAODV is same as that of the AODV. The modification is done in the route reply phase (RREP) of ADOV in two phases. In the first phase, the destination node which needs path for the packet reception replies to the intermediate nodes with minimal distance. In the second phase, RREP packet is acknowledged by the node with enough power centred on the threshold initialized. Since the node only with apt threshold is selected, the energy conservation is achieved in MAODV. The shortcoming of this approach is high overhead. This is because the data packets are delivered to too many unintentional nodes. The reliability of the data delivery is also found minimal.

In [11], energy efficient clustering routing protocols for WSNs is discussed. They aimed to select the path for the data packet transmission with QoS satisfaction in WSNs and VANETS. Cluster based routing protocol is more advantageous than the flat network topology based routing protocol for large scale WSN's. Some of the gains are i) reduction in the number of messages propagated through the network because of clustering process ii) improved power control. For the data routing in WSN, Quality of Service is the most important feature. Vehicular Ad Hoc Networks (VANETs) is a technology projected to improve the inter-vehicle coordination which is an integral part of the intelligent transport systems. The road safety and travel comfort are the ultimate goals of VANET. The routing protocol in VANRET depends on the WSNs that are placed along the road side ways to monitor the road condition based on which the route is selected. The satisfaction of end to end QoS requirement is significant in the routing protocol of VANET. But, the computational complexity ascends with QoS aware routing.

D. QoS protocol

In [9], an approach for multipath multicast routing in MANETs using the reliable neighbour node selection method was proposed. The primary factor i.e. neighbour node selection is performed based on a threshold of reliability pair factor. The node which satisfies this threshold is selected as the non-pruned neighbours. Upon the selected neighbours, the multicast routes are established. The routes are assigned to the nodes based on the priority level regarding the request and reply control packets. The priority level of the node is assessed from the node database containing the neighbour and routing information. Since, the path is provided based on priority, priority data's are sent to the multicast destination with reliability. The results in terms of packet delivery ratio, different overheads and packet delays demonstrate the efficiency of the proposed method. However, information exchange requirement between the nodes seems knotty in their approach increasing the overhead and complexity of the receivers.

A multicast routing protocol with load balancing called LBMRP for wireless MANET was proposed in [12]. The load balancing scheme is utilized in this work to increase the packet delivery ratio, and also to decrease the packet delivery delay and the total energy consumption in the network. The route stability of the multi cast routing is also improved with traffic load balance. The stability of the route reduces the traffic overhead for the route construction, subsequently reducing the number of re-route constructions. Moreover, the network life time is also extended by the load balancing multicast route protocol. The problem with the LBMRP method is that it does not uses better search algorithm.

III. REVIEW AND ANALYSIS

Table 1 reviews the literature of MANET routing protocols and the major advantages of the method.

TABLE 1. LITERATURE REVIEW

Authors	Methods	Advantages	Disadvantages
Yujun Zhang *et al.* [1]	Topology-Hiding Multipath Routing protocol (THMR)	Robust against various attacks	Fault detection in the route selected centered on THMR is unattainable
Yujun Zhang *et al.* [2]	Topology-Hiding multipath Protocol (TOHIP)	Robust against various attacks	Delay in finding the routing path due to the route request phase
Divya Sharma *et al.*[3]	Ad Hoc on demand distance vector routing(AODV)	Stability of the route selected by the AODV routing protocol is better which increases the power conservation, network life time, and energy efficient.	Overhead problem, since the data packers are delivered to too many unintentional nodes, Reliability of data delivering is also potentially low.
Gurpreet Singh *et al.*[4]	Orientation Based Ant Colony	This algorithm has the highest pheromone value	Less efficiency with respect to security and

	Algorithm	to avoid local minima problem.	routing.
V.R. Budyal *et al.*[5]	Adaptive neuro-fuzzy inference system	Reduced end to end delay and control overhead during the data packet transmission over the selected route, improvement in the packet delivery ratio as well as the path success ratio	This method is not applicable for multiple any cast routes for different QoS requirements.
Somayeh Taheri *et al.*[6]	Anonymous group-based routing	Focused more on the privacy aspect of the route selected for the communication in network	Unfeasible to search for the optimal route when more than one leader emerges in the network, Impractical for sub mesh group communication
Gurpreet Singh *et al.*[7]	Ant colony algorithms	Appropriate for finding the adaptive route in volatile network	Because they are redundant and have no central control, swarm systems are inefficient.
Shubhajeet Chatterjee *et al.*[8]	Dynamic Source Routing	Data packet transmission with high packet delivery ratio, low end to end delay and low routing overhead is achieved. More, energy efficient.	Calculation efforts of the individual nodes are very high.
Rajashekhar *et al.*[9]	Neighbor node selection	Multi caste routing scheme is provided by making use of the multiple paths as redundant paths.	The requirement of information exchange between the nodes increases the computational overhead. Complexity of the signal receiver is also increased.
B. Nancharaiah *et al.*[10]	Hybrid routing intelligent algorithm model (Ant colony	Optimal route for communication of mobile nodes in network is	Unable to handle the scattering problems, optimization problems

	optimization algorithm + particle swarm optimization)	selected with the ability to perform superiorly than ant colony optimization algorithm	and non-coordinate systems.
Anahit Martirosyan et al [11]	Energy-aware and quality of service-based routing	Multiple QoS are utilized	Much computational effort
Sachin Tripathi, Ajay Kumar Yadav et al. [12]	Traffic load balanced multicast routing protocol	Reduced number of disjoint routes	Not using the better search algorithm

IV. RESEARCH GAPS AND ISSUES

Due to the random nature of mobile nodes in MANET, battery power and channel bandwidth are limited. Moreover, battery power limitation, unpredictability of mobile nodes and variation in signal strength of the nodes in MANET creates link or node vulnerability and instability during the data transmission. If the proper path for the transmission is not selected, the problems such as packet loss, delay, and jitter may occur in the MANET in the course of data packet transmission which significantly affects the performance of the network. Delay signifies the time for the data packets to reach the estimation due to the unavailability of the network resources. Jitter signifies the difference in end to end delay of the data packets travelling from source to destination. Packet loss signifies the drop in the transit rate of the network. In [4], ant colony algorithm was used to find the routing path for the mobile nodes. But the ant colony algorithm search for the optimal path without any initialized search direction, which ascends the local optima convergence problem. Moreover, the objective of finding the multipath in ant colony algorithm does not consider the multiple constraints like, distance, energy and delay within the algorithm [4].

In [10], hybrid routing algorithm was designed by combining ant colony and PSO algorithm for routing in MANETs. Here, serial hybridization was proposed to find the feasible path for the data transmission without mainly considering the End-to-end delay, power consumption, and communication cost when routing a packet from a source to a destination. Even though these methods [4, 10] considered the optimization algorithms for finding the multi-paths, one of the serious problems of current MANETs is the topology exposure problem which aims to derive the network topology from the routing information to be transmitted among the nodes. In order to alleviate these problem, in [1, 2], topology hiding multi-path routing was proposed to handle topology exposure problem in MANET. These works make use of route request phase additionally to hide the network topology when sending the data packets. Also, these topology hiding routing protocols [1, 2] produces the multiple number of disjoint paths without considering any QoS parameters as like [4, 10]. So, the current research gap presented in the literature is the handling of QoS parameters using optimization algorithm with the proper topology hiding mechanism.

V. CONCLUSION

In this paper, a range of literature on the topic of MANET routing protocols was identified and reviewed. The existing routing protocols of the MANET's are broadly classified into four major categories and distinctive literature deliberating the advantages and disadvantages are provided in this paper. Furthermore, the Comparative study of various routing protocols has been presented in the form of table. This review focuses upon protocols such as topology-hiding protocol, Ad-hoc On-demand Distance Vector (AODV) protocol, Ant colony algorithms and hybrid routing intelligent algorithm. Several shortcomings exists in different routing protocols and the current research gap is to handle the QoS parameters with topology hiding mechanism as there is trade off between security and QoS.

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