Survey of AI Techniques in MANET Routing

K. RAJYALAXMI[1], M. ANUSHA[2], N. VENKATADRI[3]
[1] *Research Scholar, Computer Science & Engineering, KL University, Andhra Pradesh, India*
[2] *Associate professor, Computer Science & Engineering, KL University, Andhra Pradesh, India*
[3] *Lecturer, Department of Computer Science, Dr. LHR. Govt. Degree College, Andhra Pradesh, India*

Abstract— MANET is a self-configuring network of one or more devices connected by wireless links. Nodes in MANET can communicate directly or indirectly (through intermediate nodes) to transmit data among the nodes. So many routing protocols have been developed to accomplish routing in mobile ad hoc networks but still there is a scope for research in MANET routing. This kind of network is more prone to security attacks due to lack of central administration, open medium and many other factors, due to this some researchers using artificial intelligence techniques in MANET routing to provide security and shortest path routing. In this paper, we presented literature review on AI techniques implementation in mobile ad hoc network routing protocols. In the literature we observed most of the researchers implemented AI techniques in AODV routing protocol. We use AI techniques in collaboration with Temporally Ordered Routing Algorithm (TORA) to improve various performance metrics.

Indexed Terms— MANET, AODV, TORA

I. INTRODUCTION

In wireless & mobile networks, MANET (Mobile Ad-hoc Network) provides promising solutions to actual problems. It is a collaborative collection of different wireless nodes that make a short-term network without the assistance of any self-contained infrastructure or central administration. The nodes in the network can join and leave at any time and change positions within the network. In this network nodes can directly communicate with any other node laying in their radio ranges [1]. Each and every node in the network is able to act as both host and router [1].

MANET consists of different characteristics like dynamic topology, bandwidth-limited connections, energy constraints, and limited protection at the physical level. Because of its great adaptability, it is widely used in various sets of applications like military operations, emergency or disaster relief operations, business meetings, and mine site operations. By Nature, these types of networks are fit for the case where either no stable infrastructure exists or arranging a network is not possible. The figure (1) shows the basic architecture of MANET [2].

For diffusion of information packets, some kind of protocol is required to form the routing decisions. Routing protocols can be categorized into three types as shown in figure [2][3].

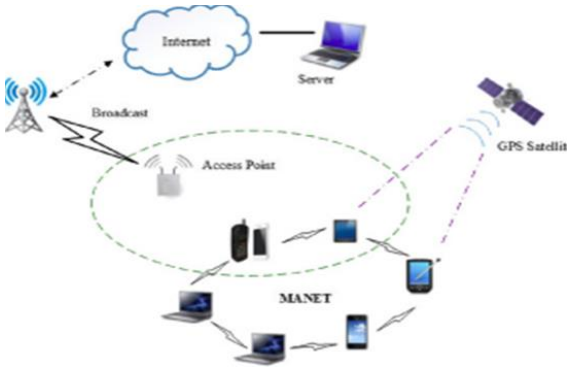

Figure 1: Basic Architecture of MANET

- Proactive Protocols: These are also named as table-driven routing protocols. To transmit data from one node to a different node these protocols use pre-calculated routes. Every node in the network required to maintain a routing table containing the routing data of every other node. Routing tables will be reorganized periodically as the network topology is changed this leads to routing overhead and wastage of memory.

- Reactive Protocols: These are also named as on-demand routing protocols. A path finding method is formed only when one node needs to transmits some data to another node. In this, every node not required to record information regarding each further node in the network. These protocols take more latency for the route set-up process.

Hybrid Protocols: These protocols combine the characteristics of proactive protocols and reactive protocols.

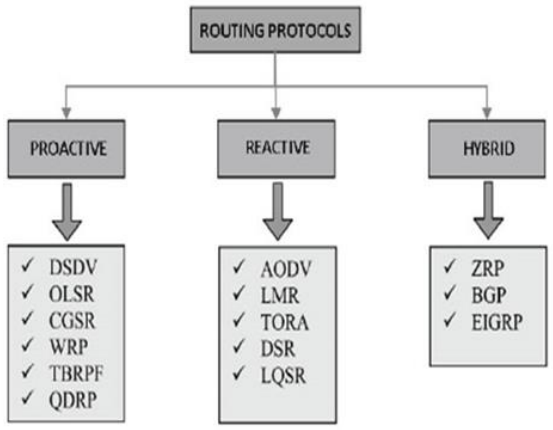

Figure 1. Types of Routing Protocols [2]

- AI Techniques in MANET

ACO:

Ant Colony Optimization (ACO) algorithms is a Swarm Intelligence based technique used for developing routing algorithms for ad hoc networks. To solve the computational problems the probabilistic approach ACO is used. It depends on the action of real ants. Ants have the nature of finding the optimal path to the food source from their colony [4]. They communicate using a evaporative chemical substance called as a pheromone [5]. Generally an isolated ant makes a random move. While moving, it discharges a quantity of pheromones on its trail. If they find food then new ants are expected to follow this trail and supplement it. After a while, pheromone diffuses. Subsequently longer paths possess limited pheromone concentration than shorter paths. Eventually, all the ants go along with the shortest path because of its highest pheromone concentration.

- Network Routing Using ACO

In Mobile ad hoc network routing is a toughest job due to its peculiar network such as traffic load and network topology may modify arbitrarily and in a time-variant nature. The multi-agent quality of ACO rule is best suitable for the diffused type of network routing. The given network can be rendered as a construction graph where the vertices are set of routers and the links are association between routers in that network. Currently network path-finding problem is just finding a set of cost effective path between nodes present in the corresponding graph representation [6].

- Description of Reactive Protocol-AODV

AODV (Ad hoc on Demand Distance Vector Routing Protocol) is one of the most frequently used protocol in the mobile ad-hoc network. It is reactive on-demand protocol, in which nodes keeps data regarding only those paths that are especially required. The major variation betwixt AODV and some other reactive routing protocol is that it utilizes a destination sequence number to find out the originality of routing information and to preclude routing loops. It employs mesh system topology. The communication paradigm of mesh topology is decentralized; each node can instantly communicate with some other node inside its radio scope. It uses a traditional routing table with one entry per destination. This is differing from DSR, which can preserve multiple route cache records for each target node. It brings down control messages and modulates the energy intake of the devices that use the protocol; the routing protocol is stored on each node to reduce the use of bandwidth [7]. Figure 3 shows the example of AODV routing protocol [8].This routing protocol has two main phases: Route discovery and Route maintenance.

- Route Discovery: When a node discovers that there is no forthcoming path to its goal node then the origin node starts the route discovery procedure by sending a route request packet (RREQ). Originating node broadcasts RREQ to all its neighbours in the network. The RREQ in any case passes along the network before it reaches the target node. The in-between node upon receiving RREQ, generate a reverse routing path to the originating node, and it makes an entry for the originating node in its routing table [9]. Nodes react to the RREQ that possess a path to the goal node by sending a RREP message to the originator node. RREQ essential job is to found a backward path so that the destination node can return to the source using RREP via unicast. Route communication will modify the routing tables of middle nodes.

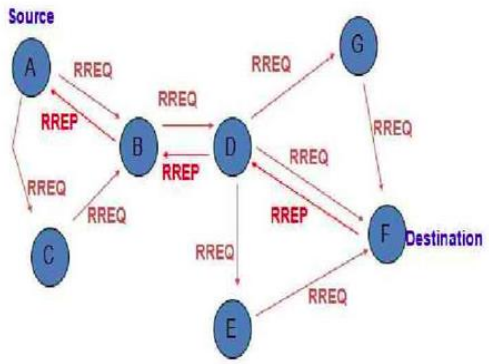

Figure 3: Example of AODV Protocol with RREQ, and RREP messages

Route Maintenance: The originating node dispatches HELLO messages sporadically to goal nodes to check its route activeness. If HELLO is not received from a neighbour within a specific amount of time, the route error packet(RERR) is returned to the origin node and other round of RREQ query is broad casted.

Advantages

- Lower overhead
- Low storage requirement

Disadvantages

- High delay of the route set-up process
- Employ flooding

- Related work

In [10] the authors proposed an enrichment of AODV protocol, entitled EAODV, which is capable to avert black hole attacks. Using A* heuristic search algorithm the EAODV can obtain a shortest route of routing discovery. The hop count value and approximate time to reach the goal node are utilized to calculate heuristic equation. To form a secure value one-way hash function is used and then forwards to all adjacent nodes. To run EAODV in various running time with or without black hole nodes the observations were conducted in NS2. This latest protocol exhibits better outcomes in terms of Packet loss and Average End-to-End delay.

In [11], the authors proposed intelligent routing with some modifications to the AODV, Secure Shortest Path AODV(SSP-AODV). This modified version is used to make AODV more secure and to prevent black hole attacks. The two techniques named A* heuristic search algorithm and Floyd Warshall's algorithms are used to optimize the routing process. These two algorithms use the value of hop count and estimate time as input. The preventing technique SSP-AODV has two phases: finding the shortest path and checking for the secure path. Three performance indicators are used to measure the performance of the proposed algorithm, original AODV and black hole AODV. The experimental outcomes exhibits that SSP-AODV is able to enhance the performance of the network in the two metrics while securing from black hole attacks.

A hybrid optimization method was proposed in [12] for MANET routing. AODV protocol is developed with the proposed optimization method using Ant Colony Optimization (ACO) and Cuckoo Search (CS).

A hybrid optimization method using Ant Colony Optimization (ACO) and Cuckoo Search (CS) is proposed by [3] authors for the optimization of MANET routing. Ad hoc On-demand Distance Vector Routing (AODV) protocol is built with the proposed optimization algorithm. ACO routing approaches are useful to manage the most challenging MANETs environments. It is shown that the proposed hybrid algorithm routing (ACO with CS) performs better in terms of throughput, average end-to-end delay, total cached replies sent and route acquisition time in comparison to the existing algorithms.

For movable multi-hop ad-hoc networks the authors in [13] offered a new on-demand power-balanced routing algorithm for movable multi-hop ad-hoc networks. This algorithm is obtained from ant colony-based Meta heuristic of swarm intelligence. These approaches attempt to plot the solution effectiveness of swarms to arithmetical and engineering problems. The planned protocol attains steeper convergence of packet delivery rates; as the ants locate the paths quicker than actual with battery accuse decay. The proposed routing protocol is highly adaptive, resourceful and scalable. The simulation outcomes illustrate that the proposed algorithm is clearly dissimilar from prevailing algorithms.

In [7] the authors proposed SEAL-AODV algorithm improves the conventional AODV routing protocol based on the QoS metrics such as networks throughput and end-to-end delay as compared to existing meta-heuristics-based routing algorithm. The optimal path selection is done on the basis of multiple metrics such as hop count, residual energy and routing load. The hop count ensures the shortest path; routing load ensures the less congestion whereas residual energy ensures that the route remains valid for a longer duration. The proposed technique performed well other than all the protocols.

A subterranean insect-based routing convention for MANETs has been proposed in [14]. The fundamental thought of the ACO meta-heuristic is taken from the nourishment seeking conduct of genuine ants. The ACO used to find the briefest route between source node and destination node on the outline and handle combinatorial upgrade issues through meta-heuristic ACO. MANETs encounter the evil impacts of the benefit confinements in essentialness, computational breaking points and data transfer limit. AdHocNet is blend estimation, containing both receptive and proactive parts. ACO based computations have particular to grant adaptable and creative solution for network routing. Subterranean insect colony computations are very flexible to the developing environments.

In [15] the authors proposed CSO-AODV protocol, to deal through performance assessment of QoS in MANET. This protocol attains QoS by together finding route reply from various routes utilizing best fitness value calculation is accomplished. Thus, it assures QoS condition during path discovery method. The performance measurement of proposed protocol is performed by network simulation and the outcomes are compared through ACO, PSO and normal AODV protocol. Later simulation, the results are checked out by three conditions i.e. mobility, scalability and congestion. For these conditions, the results study specifies that proposed protocol is used, and the outcomes be able to give stringent QoS to multiple applications.

In[16] the authors proposed a new approach, termed E-AODV, to detect and avoid black hole attacks in smart meter networks. The performance of E-AODV is extensively evaluated compared with the default AODV in an actual sub- urban neighborhood topology. Simulations are conducted by changing the position of malicious meter and ART. Simulation results verify that for each position of malicious meter, E- AODV significantly improves the PDR and throughput while the delay is slightly increased in comparison with AODV. Furthermore, the performance is assessed based on ART. Results indicate that ART has no effect on PDR when E-AODV is considered, but it considerately impacts PDR in AODV. It also shows that average throughput and end-to-end delay can be additionally enhanced via fixing the ART for E-AODV.

In [17] the authors proposed algorithm EASA RA considers the residual energy while selecting path during route discovery. Basic Ant Routing Algorithm utilizes forward Ant (FANT) and backward Ant (BANT) to set up the path. Simulation of the proposed algorithm EASARA was performed in a sparse to dense environment and the results are compared with another algorithm SAR. It was found that EASARA provides a better throughput and lower delay and is able to provide a better packet delivery with an increase in number of nodes. For a denser network environment the proposed one is more appropriate algorithm.

To impart QoS routing in MANETs with Emergent Intelligence (EI), in[18] the authors projected a new scheme. This scheme uses Emergent Intelligence in the agents; the trust cost and node trustworthiness; multi-QoS circumstances, such as bandwidth, delay, packet loss rate and cost required in favor of application for finding a best QoS path. The proposed method rapidly determines the possible QoS routes from originating to goal node. Lastly examine the proposed outcomes with the outcomes attained by the authors in [19] and it clearly exhibits its progress in the quality of service in MANET with end to end delay, packet loss, and QoS.

To find out appropriate and finest path in a network, ACO algorithm makes use of mobile agents like ants. In [20] the proposed hybrid model of PSO with ACO. To find the paths between two nodes in a network ACO acts like an input to the Particle Swarm Optimization (PSO) approach to determine the routes

among two nodes in a network. The proposed algorithm has less total link delay and least communication rate in compared with conventional ACO.

Proposed Work

A Algorithm*

In Artificial Intelligence, A* heuristic search algorithm is one among the best optimization search algorithms. In order to reach the goal node from an initial node in a shortest way, this algorithm has been used. This algorithm makes use of details about path cost and also uses heuristic values to obtain the solution, as this is an informed search algorithm. It accomplishes optimality and completeness. It has an objective function F(n) that calculates the estimated cost of cheapest solution to 'n'. The cost F(n)[11] is mathematically represented in equation 1.

$$F(n)=G(n)+H(n) \quad (1)$$

The value of G(n) is the movement cost to the present node 'n' from the initial node and the value, and H(n) is the cost to reach the goal node from the present node 'n' .

Advantages of A* Algorithm

- Best algorithm than other search algorithms
- It is a complete and optimal algorithm
- It can solve very complex problems

We use A* algorithm to improve the performance of MANET on-demand routing protocol. In SSPAODV protocol [16], three performance indicators such as average end-to-end delay, packet delivery ratio, and packet loss are used to measure the performance of the proposed algorithm. We use other parameters like throughput, energy, penalty for node availability, path length, and congestion to measure the performance of the proposed protocol.

II. CONCLUSION

In this paper we gathered literature review on artificial intelligence techniques in mobile ad hoc network routing. Many of the authors used AI techniques in Ad hoc On-Demand Distance Vector protocol to provide security and shortest path routing. In future, we use AI techniques with Temporally Ordered Routing Algorithm (TORA) to improve its performance.

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