Survey of Swarm Intelligence Inspired Routing Algorithms and Mobile Ad-Hoc Network Routing Protocols

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ABSTRACT—AntHocNet is based on Ant Colony Optimization technique. It is a hybrid algorithm that combines a reactive route setup process with a proactive route maintenance process. The reactive route setup is carried out at the start of a communication session or whenever the source of a current session has no more routing information available for the destination. The proactive route maintenance is run for the entire duration of the session [1]. Its aim is to keep information about existing routes up to date and explore new routes. In this paper survey of AntHocNet with the Ad hoc On demand distance Vector (AODV) routing protocol, TORA (Temporarily Ordered Routing Algorithm), DSDV (Destination Sequence Distance Vector) and Dynamic Source Routing (DSR) protocol is compared. Swarm Intelligence inspired networks are one engineering field which has many concepts in biology and hence the solutions of biology can be used to solve the problems of computer networks.

Keywords: MANET, Ant Based Routing Algorithms, Ant Colony Optimization, Swarm Intelligence.

I. INTRODUCTION

Mobile ad hoc network (MANETs)

Mobile Ad Hoc network (MANETs) is a type of network which is self-organized and multi-hop having mobile nodes operating in a distributed manner without any central infrastructure. MANETs characteristics such as bandwidth constrained, energy constrained, limited physical security and dynamic network topology etc. Randomized change of domain, causes change in topology of networks. Hence the major issue related to MANETs is routing. In MANETs communication is performed via the wireless means and the nodes can perform the roles of both hosts as well as routers for the routing of packets in the network. As a result of limited bandwidth of nodes, the source and destination may have to communicate via intermediate nodes [1]. As in multi-hop routing, the nodes are forwarding packets to each other which require some sort of routing protocol to take the routing decisions. Nodes in these networks carry out both network control and routing duties and thus generate both user and application traffics. The nodes in the network are used to provide connectivity and services that the nodes communicate directly with one another in peer-to-peer fashion [2].

Ant Colony Optimization (ACO)

The Ant colony optimization (ACO) is based on the foraging behavior of ants. When ants search for food, they wander randomly and upon finding food return to their colony while laying a chemical substance called pheromone. Many ants may travel through different routes to the same food source. The ants, which travel the shortest path, reinforce the path with more pheromone that aids other ants to follow. Subsequently more ants are attracted by this pheromone trail, which reinforces the path even more. This behavior quickly identifies the shortest path. Ants are simple autonomous agents that interact via indirect communication known as stigmergy. Stigmergy is an indirect form of communication where individual agents leave signals in the environment and other agents sense them to drive their own behavior. This form of communication is local wherein simple agents interact locally without having any global information. Since these bio-inspired networks are scalable, it will be helpful for further research also [3]. While comparing MANETs and ANTS in Table 1 [3] the conclusion comes that though they have similarities like same physical structure, self-configuration and self-organization but still distinguished from each other
in the route foundation, overhead, motive, routing table information.

![Table 1: Comparison between MANETs and ANTS][3]

Ant based routing algorithms exhibit a number of desirable properties for MANET routing, they work in a distributed way, are highly adaptive, robust, and provide automatic load balancing [4].

**AD HOC ROUTING PROTOCOLS**

A routing protocol for ad hoc networks is composed of a routing algorithm with a set of rules that monitor the operation of the network. Routing protocols of ad-hoc networks are separated in three groups: Table driven - Proactive, on demand driven - Reactive and Hybrid. On demand protocols do not store all paths, but paths are created each time they need to send a data. If source node wants to send a data to destination node then this source node evokes process to search a path. After the path is created, it is maintained by nodes. These are DSR, AODV, ABR, TORA, DYMO and others. In a proactive routing protocol, each node periodically broadcasts its routing table to its neighbors, allowing all nodes to have a consistent network view. Due to the up to date network topology in each node these protocols have the short response time in determining a good route from source to destination. Protocols such as DSDV, WRP fall into this category. A hybrid protocol, such as Zone Routing Protocol (ZRP) combines the advantages of both proactive and reactive protocols. Each node proactively maintains a routing table for nodes within its zone and reactively finds a route to its destination if the destination node lies beyond its zone [5].

**SWARM INTELLIGENCE**

Swarm Intelligence (SI) is subfield of Computational Intelligence which provides solution for complex optimization problems which are not easily tackled by other approaches. Swarm Intelligence mainly consists on Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO) and Honeybees paradigms. Swarm Intelligence based approaches are nature and bio inspired. A swarm is defined as a set of (mobile) agents that collectively solve problems. Swarm Intelligence is the property of a system whereby the collective behaviors of (unsophisticated) agents cause sophisticated global patterns to emerge. In the nature animals form into swarms to search food, build nests, to hunt and avoid being hunted etc. The application of the SI paradigms is mostly dependent on the nature of the computational problems. Mostly real hard problems can be simulated by exploitation of SI based algorithmic approaches [8]. The SI based approaches are more promising from other conventional techniques for optimization problems. Due to the nature, architecture, topology and functionality of ad hoc and wireless networks, Swarm Intelligence approaches are most suitable for the routing and energy resources optimization related issues in MANETs and WSNs. Bio inspired, Swarm Intelligence approaches are more promising for ad hoc and wireless sensor networks due to the following prominent aspects i.e.

- Locality of interactions
- Availability of multiple paths,
- Self-organizing behaviors
- Failure backup,
- Ability to adapt in a quick and robust way to topological and traffic changes and component failures,
- Scalable performance robustness to failures,
- Losses internal to the protocol,
- Easiness of design and tuning.
II. EXPERIMENTAL RESULTS FOR MANET PROTOCOLS

2.1 Simulation Environment

The evaluation of performance of MANET’s routing protocols AODV, DSDV, and TORA are based on following metrics.

Simulation environment is as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation Time</td>
<td>100 Seconds</td>
</tr>
<tr>
<td>Pause Time</td>
<td>5 Seconds</td>
</tr>
<tr>
<td>Terrain Area</td>
<td>500m x 400m</td>
</tr>
<tr>
<td>Traffic Type</td>
<td>cbr</td>
</tr>
<tr>
<td>Maximum speed</td>
<td>8 m/s</td>
</tr>
<tr>
<td>No of Node</td>
<td>25, 50, 75, 100</td>
</tr>
</tbody>
</table>

2.2 Analysis and Results Comparison

In this section we evaluate the performance of AODV, DSDV and TORA protocols on the following parameters:

2.2.1 Packet Delivery Ratio / Packet Delivery Fraction (PDR/PDF)

The ratio between the number of packets that are received and the number of packets sent [6].

<table>
<thead>
<tr>
<th>NO. OF NODE</th>
<th>AODV</th>
<th>DSDV</th>
<th>TORA</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>0.9978</td>
<td>0.7877</td>
<td>0.8291</td>
</tr>
<tr>
<td>50</td>
<td>0.9973</td>
<td>0.8353</td>
<td>0.9989</td>
</tr>
<tr>
<td>75</td>
<td>0.9967</td>
<td>0.9147</td>
<td>0.8457</td>
</tr>
<tr>
<td>100</td>
<td>0.9908</td>
<td>0.7775</td>
<td>0.9824</td>
</tr>
</tbody>
</table>

TABLE 1[6]: PDR FOR MANETS ROUTING PROTOCOLS

Figure 1[6]. Comparison of the three protocols of MANETs with respect to PDR.

2.2.2 Routing Overhead (ROH)

The routing overhead measures by the total number of control packets sent divided by the number of data packets delivered successfully.

<table>
<thead>
<tr>
<th>NO. OF NODE</th>
<th>AODV</th>
<th>DSDV</th>
<th>TORA</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>1.002</td>
<td>1.27</td>
<td>1.21</td>
</tr>
<tr>
<td>50</td>
<td>1.002</td>
<td>1.09</td>
<td>1.18</td>
</tr>
<tr>
<td>75</td>
<td>1.003</td>
<td>1.2</td>
<td>1.02</td>
</tr>
</tbody>
</table>

TABLE 3[6]. ROUTING OVERHEAD FOR MANET ROUTING PROTOCOLS

Figure 2 [6]: Comparison of the three protocols of MANETs with respect to Routing Overhead

2.2.3 Throughput

Throughput is the total of all bits (or packets) successfully delivered to individual destinations over total-time / total time (or over bits-total / total time) and result is found as per KB/Sec [6].
2.2.3 END TO END DELAY

The figures 4 and 5 show the end to end delay of routing protocols in different physical characteristics. Considering both the scenarios, it is observed that DSR has lower delay while TORA suffers higher delay in other case. One of the factors responsible for the poor performance of TORA is related to its formation of temporary loops within the network and collisions held, thus the links to neighbour nodes are broken. Besides, in response to link failures, TORA sends more updated packets, whereas an acknowledgment of the retransmitted update packet might not be received, resulting in a serious congestion of the network. The value of TORA is fluctuating and nearly constant at 0.00030sec and AODV has 0.00004sec while DSR is close to AODV has value 0.00003sec. DSR suffers with higher delay of 4sec due to reactive approach, where the data packets keep on waiting in buffers until a route is discovered route to the destination and also route information is included in the packet header, causing an increase in the packet length, and thereby an increase in the delay and TORA has lower delay 0.09sec. The above observation reveals that as end to end delay is less, packets takes less time to transverse the network [7].

III Experimental Results for Swarm Intelligence

In a range of simulation experiments, we compare AntHocNet to AODV (with local repair), a state-of-the-art MANET routing algorithm and various standard. In Subsection 3.1, it describes the simulation environment, and in Subsection 3.2 presents and analyses the results.

3.1. Simulation environment

In this paper [11], the number of nodes and the size of the simulation area are varied, while keeping the average node density constant (7:5). The experiments with 100, 500, 1000 and 1500 nodes in square areas with sides of, respectively, 1500, 3500, 5000 and 6000 m. Data traffic consists of 20 CBR sources sending four 512-byte packets per second. Nodes move according to the RWP model, with a minimum speed of 0 m/s, a maximum speed of 10 m/s and a pause time of 30 s. The radio propagation range of the nodes is 250 m, and the data rate is 2 Mbit/s. The path loss model is a free space model. At the MAC layer, the 802.11b DCF model is used. Each simulation is run for 500 s. A simple, reactive approach as AODV is expected to be equally effective. In these tests the performances of AntHocNet and AODV were comparable, but when the environment became more difficult (more mobility, more sparseness, longer paths), there was an increasing performance gap in favour of AntHocNet [11].
In the sparse scenario of 100 nodes in 3000 x 1000m². Node mobility is increased by either increasing the maximum node speed or decreasing the node pause time (the lower the pause time, the higher the node mobility). Figures 5–8 show the delivery ratio, average delay and average jitter of AntHocNet and AODV under different node speeds. AntHocNet outperforms AODV clearly for delivery ratio and jitter, and the differences increase for higher speeds.

**Figure 6 [11].** Delivery ratio under various speed values for RWP mobility.

**Figure 7 [11].** Average packet delay under various speed values for RWP mobility.

**Figure 8 [11].** Average delay jitter under various speed values for RWP mobility.

**Figure 9 [11].** Delivery ratio under various pause times for RWP mobility.

Some proactive algorithms keep on searching the best path from the source and destination even if no data packet is available for sending from source to destination. Some of the algorithms are reactive and nodes come into action only when a packet is received for transmission from source to destination. These proactive and reactive algorithms are having their own limitations and are not found suitable for routing in Mobile Ad Hoc Network mainly when real time applications QoS is to be ensured. Hybrid routing algorithms are proposed which contain advantages of proactive and reactive algorithms [10].

**IV. CONCLUSION**

It was observed that by using ideas taken from the simple behaviour of swarm intelligence, optimization and innovations in routing protocols can be done, that help to outperform the standard MANET routing
protocols like AODV, DSDV, DSR and TORA. Depending on application needs the presented protocols provide also customizing and tuning capabilities that can make them suitable for a wide range of MANET applications. In this paper we have compared different Manet protocols in section (II) where AODV performs better than others in PDR, ROH and throughput. As observed in section (III) where swarm intelligence protocol i.e. AntHocNet outperforms AODV especially for parameters with delivery ratio and jitter in a higher density node of networks. With these observation, it is conclusive that swarm intelligence protocol perform better than the Manet protocols for a specific network of nodes.

REFERENCES


