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Comparative Study of AODV, DSR and ARA

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Abstract

Mobile Ad Hoc Networks (MANET) is a self-governing system with no centralized entity controlling the nodes. At the time of communication, nodes rely on many intermediate nodes. Hence the nodes should be more intelligent in the form of a host as well as a router (to forward the nodes). The Ant based routing algorithm uses the principle of ant for searching the food. Ants utilize a specialized form of communication, which is called stigmergy in biology and means indirect communication through the environment. It has been proven that Ant based routing protocol finds the best solution for Ad-hoc network. In this paper the conventional algorithms AODV and DSR are compared with the Ant Based Routing Algorithm (ARA). The simulation is carried out for different network conditions to establish a strong comparison to decide the best. The performance is analysed in terms of Network Throughput, Packet Delivery Ratio, End-to-End delay and Routing Overhead. The simulation results proves that Bio-Inspired algorithms, Ant based routing algorithms offers best performance compared to the conventional routing protocols.

Introduction

Ad-hoc network is gaining popularity because of the characteristics such as decentralized mode of operation, self configuration, high node mobility, rapid deployment. A MANET is an autonomous group of mobile users that communicate over reasonably slow wireless links. The network topology may vary rapidly and unpredictably over time, because the nodes are mobile. These networks are fully distributed, and can work at any place without the aid of any infrastructure. This property makes these networks highly robust. Routing management is challenging task in these situations. The conventional routing protocols performance is well under various situations. But recent the research has proven that the swarm intelligence approach will make the ad-hoc network more useful in the disasters situation. But recent the research has proven that the swarm intelligence approach will make the MANET more useful in various situations. Many desirable characteristics, such as scalability and robustness are exhibited in the biological systems. The Collective behaviours of the nature species (e.g., ants) provide a natural model for the distributive problem-solving, without any extra central control or coordination. These swarms perform complex tasks of global optimization and resource allocation using only local information from the collective of all its elements. Studies have shown that self-organization and stigmergy are very important in the swarm systems.

The Swarm intelligent routing methods will enhance the reliability and timeliness of data transfer within a heterogeneous multi-node wireless communication network.
They will furthermore reduce the overhead in network growth due to their inherently scalable features. The collective decentralized, self-organized behavior of the network exhibits a great deal of global intelligence capable of dynamic near-global optimization of certain tasks. The ant based algorithm uses the principle as behavior of ant for searching the food. While searching for food the ant's secrets the chemical called pheromone. Based on the probability of pheromone ants finds the shortest path. The ants, which travel the shortest path, reinforce the path with more pheromone that aids other ants to follow. This autocatalytic behavior quickly identifies the shortest path. 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. In the 1991 M. Dorigo proposed the ant system for ad-hoc network.

In this paper, mainly three protocols are studied, Ad-Hoc On Demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Ant Based Routing Algorithm (ARA).

Routing Protocol

Routing is difficult since mobility causes frequent network topology changes and requires robust and flexible mechanism to search and maintain routes. Routing protocols must also deal with other constraints such as low bandwidth, limited energy consumption, and high error rates etc. Various routing algorithms have been designed and implemented for mobile nodes. IETF (Internet Engineering Task Force) MANET working group is responsible to analyze the problems in the ad hoc networks and to observe their performance. The IETF had classified the routing protocol into two groups as proactive and reactive routing. In MANET, the reactive routing protocols are mostly preferred as routing table maintenance is not required. In this paper we have explained Ad-hoc On Demand Distance Vector Routing Protocol (AODV) and Dynamic Source Routing (DSR). These conventional routing protocols have some features and draw-

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backs too. The shortcomings can be eliminated considering the bio-inspired approach to the routing in Ad-hoc network.

A. Ad-Hoc On Demand Distance Vector (AODV)

Ad hoc On-Demand Distance Vector (AODV) routing is an on demand, reactive routing protocol for mobile ad hoc networks and other wireless ad-hoc networks. It is jointly developed in Nokia Research Centre of University of California, Santa Barbara and University of Cincinnati by C. Perkins and S. Das [1].

AODV uses characteristics of DSDV and DSR protocol. It uses route discovery, route maintenance from DSR and hop-by-hop routing, sequence number, beacons from DSDV. For route discovery and route maintenance AODV uses three types of messages, RREQ, RREP, and RERR. Each host acts as specialized router and routes are obtained as a when required. In route discovery phase, the request message is transmitted to all the nodes. The route reply message is received to the source node from destination as a reverse path. In case link failures, nodes transmit the route error message to indicate destination unreachable and routes are quickly re-established. AODV is capable of both unicast and multicast routing. It keeps these routes as long as they are desirable by the sources. Additionally, AODV creates trees which connect multicast group members.

B. Dynamic Source Routing (DSR)

Dynamic Source Routing [2] is reactive protocol which finds route on demand by flooding the network with route request packets. It uses source routing than hop-by-hop routing means node must know complete hop sequence. In source routing the intermediate node doesn't maintain the routing table, packet itself takes routing decision.

The route discovery is performed by flooding route request packets by source nodes. A reply packet will confirm the route for routing the packets. If the route is in the route cache of target node, the route would be used. Otherwise, the node will reverse the route based on the route record in the Route Reply message. The destination node on receiving route request replies through reverse path. In case of route failure, the Route Maintenance Phase is initiated wherein the Route Error packets are generated at that node. Once again route discovery will be started.

This protocol does not use beacon packets to know the presence of neighbors. The drawback of this routing is that overheads are increased and flooding may lead to clogging.

C. Ant Based Routing Algorithm (ARA)

The protocol is based on swarm intelligence and especially on the ant colony based meta heuristic. These approaches try to map the solution capability of swarms to mathematical and engineering problems. The protocol is highly adaptive, efficient and scalable. The main goal in the design of the protocol was to reduce the overhead for routing.

The algorithm (ARA) in [3] describes a routing algorithm for MANETs using ant to setup multiple path, including route discovery and maintenance mechanisms. Route discovery is achieved by flooding forward ants to the destination while establishing reverse links to the source. Routes are maintained primarily by data packets as they flow through the network.

D. Performance Parameters

The performance of these routing protocols can be analyzed for the below mentioned parameters. These parameters will help us to identify which routing protocol is better for various network scenarios.

a. Packet Delivery Ratio

Packet Delivery Ratio is defined as the ratio of the total number of data packets received by the destination node to the number of data packets sent by the source node. This measure tells us how many data packets are successfully delivered at their destinations.

$$\text{Packet Delivery Ratio} = \frac{\text{Total number of packets recived at destination node}}{\text{Total number of data packets sent by source node}} \quad (1)$$

b. Network Throughput

The network throughput represents the numbers of data packets generated by the source node to the number of data packets received in the destination. A routing protocol should try to maximize this value.

$$\text{Network Throughput} = \frac{\text{Total number of packets generated at source node}}{\text{Total number of packets received at destination node}} \quad (2)$$

c. Energy Consumption

This metric measures amount of energy consumed by a node with respect to its initial energy. The percentage energy consumed by all nodes in a scenario is calculated as the average of their individual energy consumption of the nodes.

d. Routing Overhead

The ratio of the bandwidth occupied by the routing/control packets and the total available bandwidth I the network are routing overhead. In wireless ad-hoc networks, nodes often change their location within network. Some stale routes are generated in the routing table which leads to unnecessary routing overhead.

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Simulation

The algorithms are simulated using Network Simulator (NS 2.34) software. NS 2.34 is open source software having substantial support to design routing protocol. To evaluate the performance of these protocols, various network scenarios were considered. For a network with a fixed size, the tests were carried out by varying the number of nodes in the network and simulation time. The parameters selected for the simulation are as shown in the table below.

Table I: Simulation parameter

Simulator	NS 2.34
Number of nodes	10/20/30/40/50
Network Size	1000 X 1000
Max. Speed	10 m/s
Simulation Time	100 s – 1000 s
Routing Protocol	AODV, DSR, ARA
Traffic Pattern	CBR

We wanted to simulate the AODV, DSR and ARA algorithm for the above mentioned simulation parameter. The NAM editor is used to imagine the actual scenario of packet transmission for the protocol. The fig. 1 explains node placement in NAM window, an animator window showing packet transmission, packet drop and communication, route discovery and packet transmission using AODV protocol. The route discovery and packet transmission for DSR is shown in fig. 2. The ARA simulation screenshot showing energy of each node, throughput, PDF and NRL for 10 nodes is shown in fig 3.

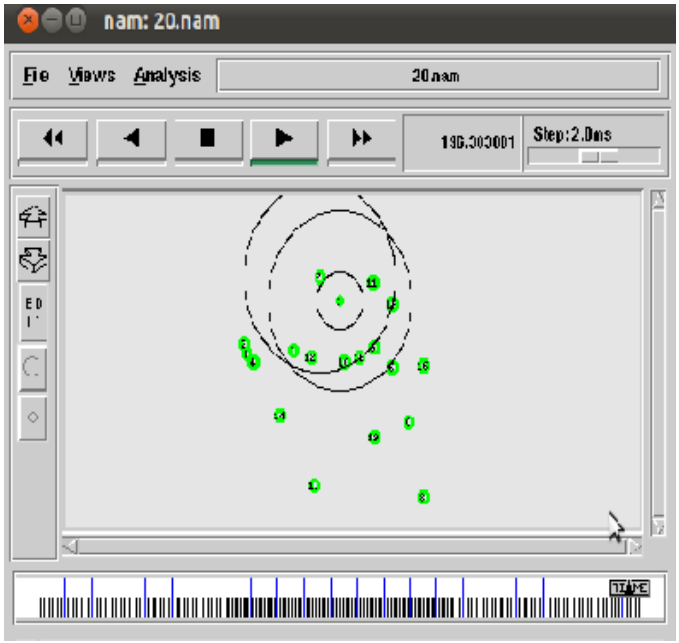

Fig. 1. Packet transmission scenario in AODV

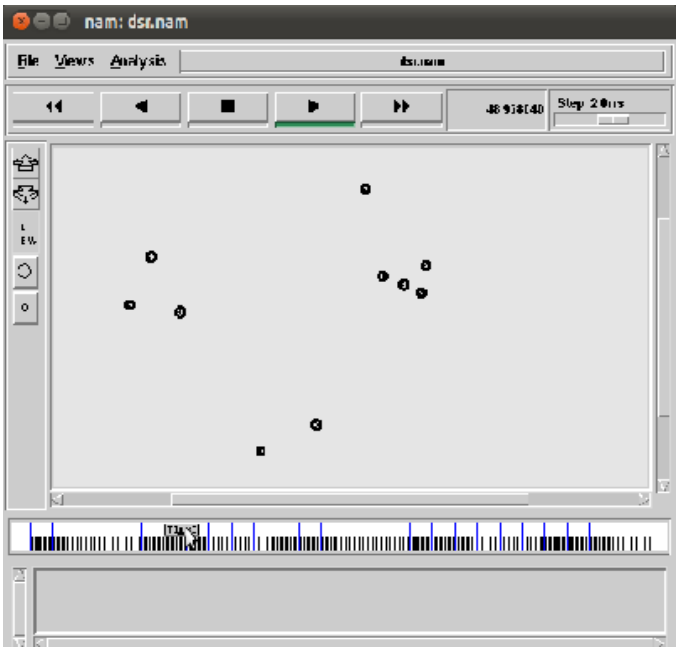

Fig. 2. Packet transmission scenario in DSR

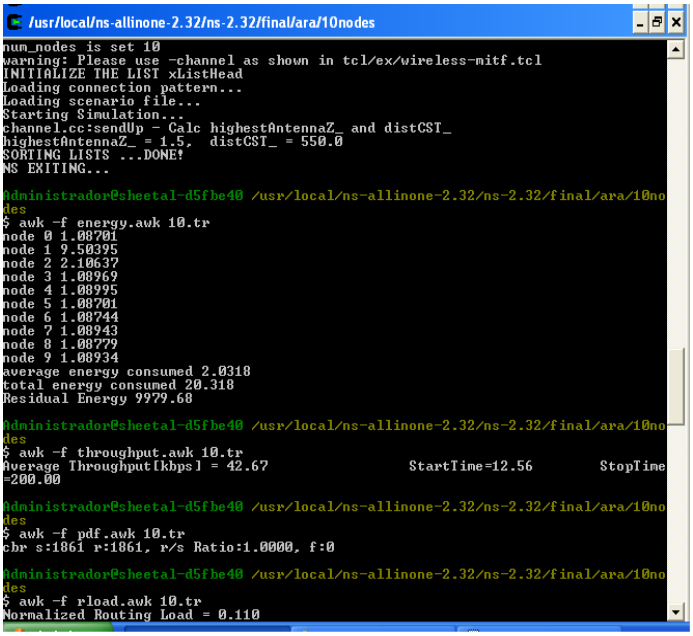

Fig. 3. Simulation screen and parameters for ARA

Result

After the simulation of AODV, DSR and ARA protocol for different simulation time, with varying node size for the mentioned table 1 simulation environment against through-

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put, Packet Delivery Ratio, routing overload and energy consumption is calculated.

Throughput comparison for 10 nodes and 50 nodes is shown in fig 4 and fig 5 respectively. ARA offers best throughput for all the network conditions irrespective of simulation conditions. Throughput increases as pause time increases.

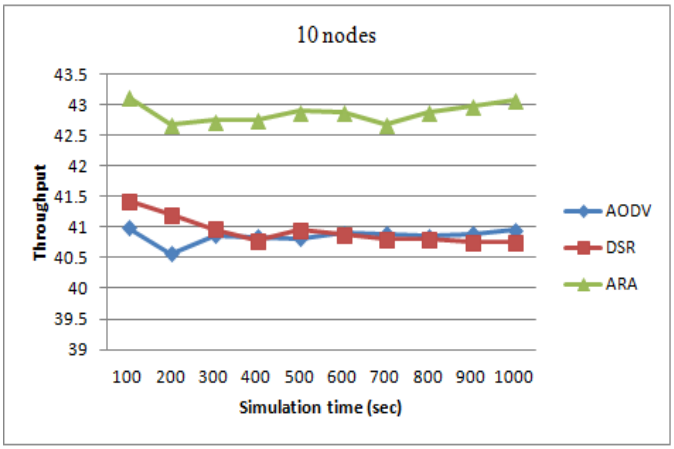

Fig. 4. Throughput for 10 nodes

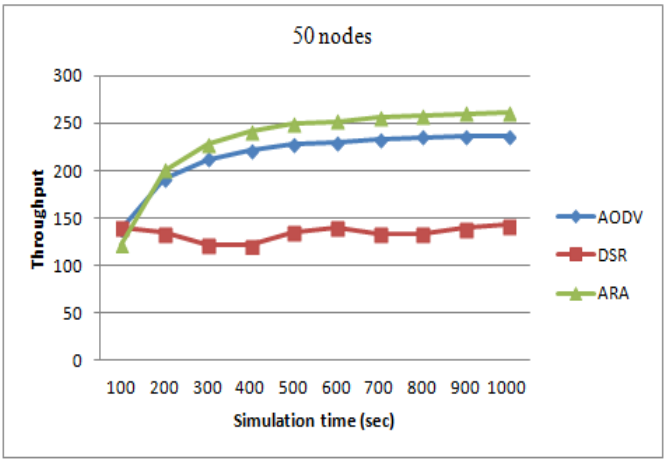

Fig. 5. Throughput for 50 nodes

Under the same simulation environment, Packet Delivery Ratio is calculated and comparative results for 20 and 30 nodes are shown fig 6 and 7 below.

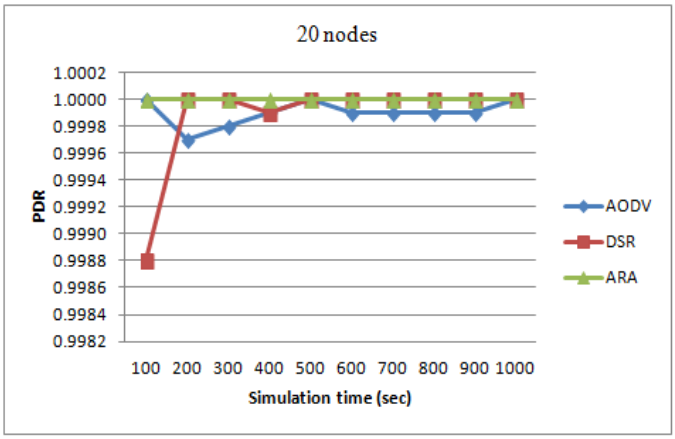

Fig. 6. PDR for 20 nodes

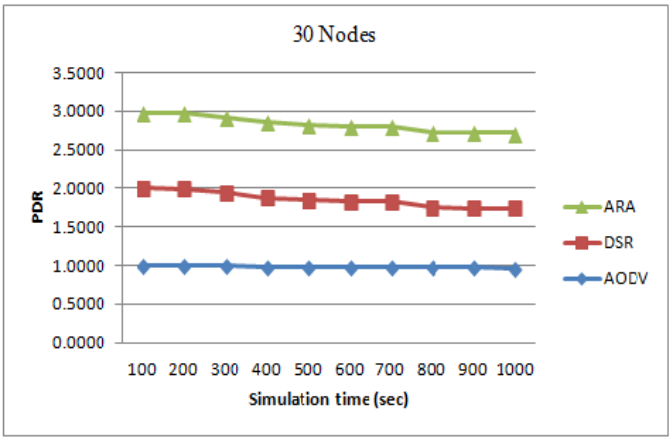

Fig. 7. PDR for 30 nodes

In small network scenarios, all the three protocol offers maximum PDR. ARA provides comparatively highest PDR over AODV, DSR for all network size and simulation times.

All the three protocols are simulated and compared for routing overhead to prove effectiveness of Ant routing algorithms in MANET.

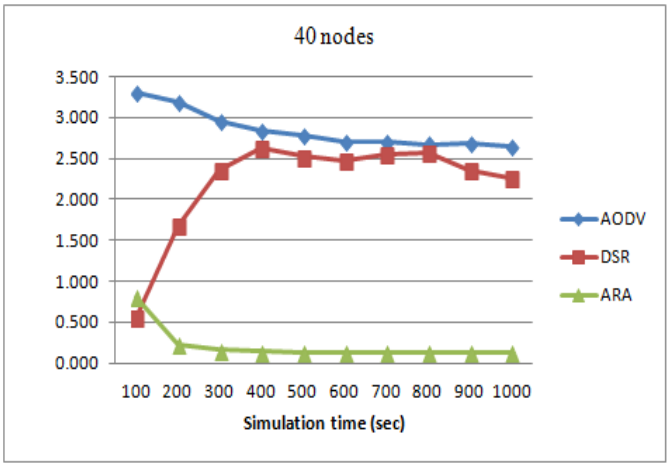

Fig. 8. NRL for 40 nodes

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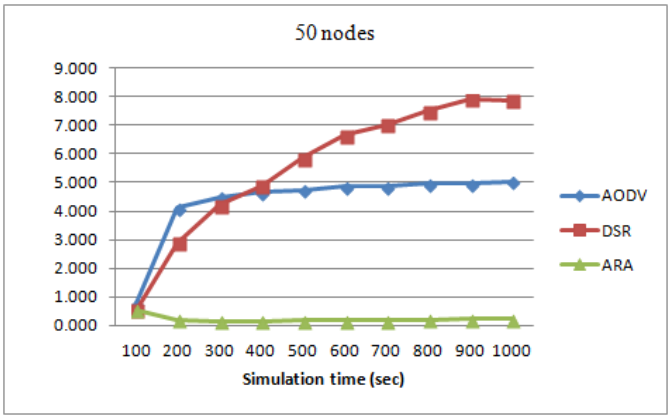

Fig. 9. NRL for 50 nodes

Ideally routing load should be as small as possible. ARA again proved to be the best as an ant agent itself carries the control packets.

Considering various network conditions, ARA is more reliable protocol in terms of energy consumption. The fig 10 and 11 below explains the energy consumption for 40 nodes and 50 nodes.

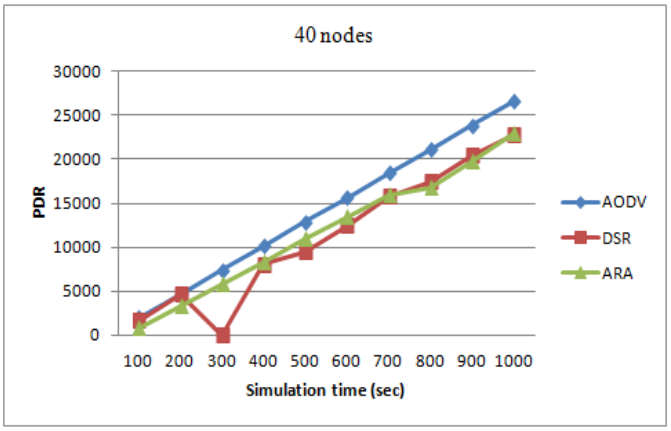

Fig. 10. Energy consumption for 40 nodes

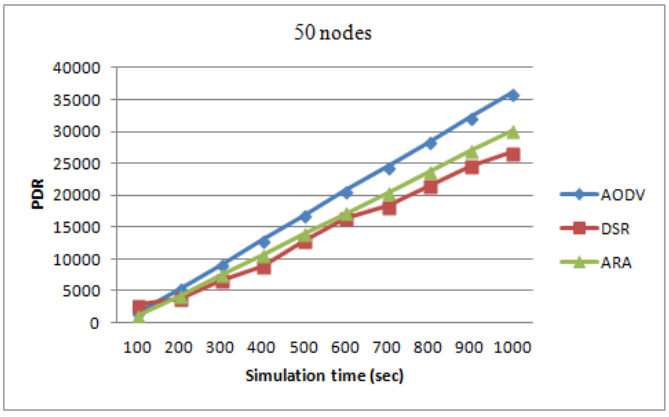

Fig. 11. Energy consumption for 50 nodes

The energy consumption of ARA can still be improved using Energy Aware ARA protocol. The ARA is modified in order to achieve limited energy consumption constraints.

Conclusion

Mobile Ad-hoc Networks are self-organizing and self configuring networks. Routing is difficult since mobility causes frequent network topology changes and requires robust and flexible mechanism to search and maintain routes. Routing protocol should deal with low bandwidth and energy consumption. The ant based routing algorithm uses principle of ant searching for food and specialized form of communication called stigmergy. In this paper we have made the comparison of thee MANET protocols, AODV, DSR and ARA. The ARA proved to be more prominent for all network size and pause time. The bandwidth and energy consumption constraints are drastically solved using ARA. The performance of ARA is far better over AODV and DSR considering the other network parameters.

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Biographies

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