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Performance Metric Comparison of Routing Protocols in Ad Hoc Wireless Multi-Hop Networks Using NS2

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Abstract— **In this paper, we present AntHocNet routing Algorithm for Ad Hoc Wireless Multi-Hop Networks (AHWMNs). AHWMNs are communication networks that consists of mobile wireless nodes placed together with minimal or no prior planning. Establishing and maintaining reliable paths between source and destination in such network is very difficult because of ever changing topology and limited bandwidth resource. Reliability and Efficiency are especially important concerns. Routing algorithms for AHWMNs can be classified as topology-based routing algorithms; position based routing algorithms; and bio-inspired routing protocols.**

AntHocNet is based on Ant Colony Optimization (ACO) technique. To maintain network's performance in case of large no. of nodes and with high mobility, AntHocNet introduce repetitive path sampling by artificial ants while communication session is going on. AntHocNet consists of two phases: reactive and proactive. In reactive phase, multiple paths are setup between source and destination. In proactive phase, ants proactively test existing paths and explore new better path until communication session ends. With set of simulation experiments in Network Simulator (NS2), we also compared its performance with classical approach of AODV and DSR reference algorithms in this research area. The results achieved shows that AntHocNet offers good packet delivery ratio and less average end to end packet delay, especially for TCP traffic, but it needs more routing overhead due to use of more artificial ant packets. This result is visible over a broad range of possible network scenarios and increases for larger & more mobile networks.

***Index Terms*— AHWMN, AODV, DSR, AntHocNet, ACO, Ant, AHWMN routing protocol.**

I. Introduction

Wireless technologies like WiMax, Wi-Fi etc.; in recent years are becoming popular because of mobility and low cost of wireless devices like mobile phones, PDAs, laptop etc. AHWMN is collection of mobile devices which form a network with no pre-existing wiring / infrastructure. All nodes are equal and there is no centralized control. No node as designated router, each node can serve as router for each other and data packets are forwarded from node to node in multi-hop fashion. Routing is task of directing data flow from source to destination while maximizing network performance, which is very difficult in AHWMNs. Due to the mobility of nodes, topology changes frequently and initially efficient & feasible paths can quickly become inefficient and infeasible. Thus routing information has to update regularly which requires more number of control packets. This is problem in AHWMNs since bandwidth of wireless medium is very limited and medium is shared.

Routing protocols are broadly classified as topology based, position based and bio- inspired protocols. Topology based uses existing link details for packet forwarding and classified as Proactive, Reactive and Hybrid routing Protocols. Proactive algorithms maintain routing details about all links present in network even though that links are not currently used for communication. Examples include DSDV and OLSR. If network topology changes frequently significant bandwidth part consumes for maintaining unusual path. Reactive like AODV and DSR maintain paths that are currently used which reduces burden on network. Route discovery delay faced by such protocols. When topology changes frequently, significant amount of traffic generated by such protocol. Hybrid protocol like ZRP combines local proactive and global reactive routing to achieve higher level of scalability and efficiency. This protocol has limitation on topological changes tolerance within given amount of time.

Position based protocols uses physical information of participating nodes and eliminates limitation of topology based protocols. But it is expensive because of GPS. Thus routing in AHWMNs with large number of nodes and with high mobility is difficult task and current routing protocols do not scale well with these scenarios. So Bio-Inspired solves this problem.

Ant Colony Optimization based on ant foraging behavior. Ant moves randomly to search food and while returning they lay down pheromone and other ant reinforce shortest path with more pheromone. Ants are simple autonomous agents that interact via indirect communication called as Stigmergy. This form of communication is local interaction without global information.

AntHocNet based on ideas from ant-based routing. They are based on pheromone trail laying following behavior of ants and ACO. In this, ant like agents continuously sample possible paths and maintain pheromone variables to show Quality of Service. Multiple paths are made available and data packets randomly spread over network following pheromone values.

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II. RELATED WORK

Challenges and application of AHWMNs have made this a very popular research area and lot of routing algorithm have been proposed. A number of different ACO algorithms for adaptive routing have been proposed, which are differed according to how pheromone is updated, how routing table probabilities are calculated, how often and how many ants sent for request.

The first of these were Ant Based Control and Ant Net. Nodes sent Ant agents at regular intervals to randomly choose destination in order to sample the paths, assign a quality to them and to update routing tables. These routing tables contain entry for each destination and neighbor indicating the goodness of going over the neighbor on the way to the destination i.e. Pheromone. Packets are routed stochastically with the probability of links with higher pheromone values.

Some Ant Based routing algorithm for AHWMNs is Ant Colony Based Routing Algorithm (ARA) and Probabilistic Emergent Routing Algorithm (PERA). These algorithms loose much of the pro-active sampling and exploratory behaviour of original Ant Based algorithm in their attempt to limit overhead caused by Ants.

III. ANTHOCNET, AODV AND DSR

AntHocNet is a hybrid adaptive routing algorithm which contains re-active and pro-active components. The algorithm is reactive means it gathers routing information about destinations which are involved in communication session by broadcasting reactive forward ant in order to gather quality of path they followed. It is pro-active means it tries to maintain and improve existing path information while session is going on and helps explore new better paths. Pheromone tables are used to store routing information. Forwarding of control and data packets is done in a stochastic way using pheromone tables. Link failures are handled with local route repair mechanism and by the use of short warning messages.

Dynamic Source Routing (DSR) is a routing protocol for wireless mesh networks. This protocol is truly based on source routing whereby all the routing information is maintained (continually updated) at mobile nodes. It has only two major phases, which are Route Discovery and Route Maintenance. Route Reply would only be generated if the message has reached the intended destination node (route record which is initially contained in Route Request would be inserted into the Route Reply). The DSR protocol is composed of two mechanisms that work together to allow the discovery and maintenance of source routes in the ad hoc network: Route discovery and Route maintenance [5].

The Ad hoc On-Demand Distance Vector (AODV) algorithm enables dynamic, self-starting, multihop routing between participating mobile nodes wishing to establish and maintain an ad hoc network. AODV allows mobile nodes to obtain routes quickly for new destinations, and does not require nodes to maintain routes to destinations that are not in active communication. AODV allows mobile nodes to respond to link breakages and changes in network topology in a timely manner. The operation of AODV is loop-free, and by avoiding the Bellman-Ford "counting to infinity" problem offers quick convergence when the ad-hoc network topology changes. The AODV protocol is composed of two mechanisms that work together to allow the discovery and maintenance of source routes in the ad hoc network: Route Discovery and Route Maintenance [6].

IV. SIMULATION ENVIROMENT

In this section we are particularly described the design and implementation of AntHocNet, AOD and DSR routing protocol using different performance metrics such as packet delivery ratio, average end to end delay. The advantage of simulation in research of different protocol is that, it allows almost perfect experimental control with simulation of a model.

To carry out simulation, we have used Tool Command Language (TCL) scripts to define parameters for different network topology and communication model and used AWKs script to extract data from trace file. We have used GNU Plot tool to plot the graph from the extracted data.

A. Generating Traffic and Mobility Models

To carry out our experiments we have to generate traffic and also have to make mobility models and for this FTP traffic sources are used. The source-destination pairs are spread randomly over the network. Traffic models were generated for 25, 50, 75 and 100 nodes with FTP traffic sources at a rate of 8kbps. (Rate 2.0: in 1 second, 2 packets are generated. The packet size is 512 byte. Therefore the rate is 2 × 512 × 8=8kbps). The packet sending rate in each pair and the number of source-destination pairs is varied to change the offered load in the network.

The mobility model uses here is the random waypoint model in a rectangular terrain area with the field configurations used is 800 *X 4*00 m^2 with 25 nodes, 1500 *X 13*00 m^2 with 50 nodes, 1800 *X 9*00 m^2 with 75 nodes and 3000 *X 15*00 m^2 with 100 nodes. Here, each packet starts its journey from a random source to a random destination. Another random destination is targeted after a pause once the destination is reached. Here for the experimental purpose we keep the varied pause time which affects the relative speeds of the mobiles. We have taken different pause time such as 0, 10, 20s .we also have taken different speeds as 0 m/s, 10 m/s, and 20 m/s. Identical mobility and traffic models generated only once to gather fair results for this project. To generate large number of nodes and their positions and movements including moving directions & speeds we have used a CMU tool called "setdest" in ns-2. Following figure shows one of simulation run's output with 50 nodes.

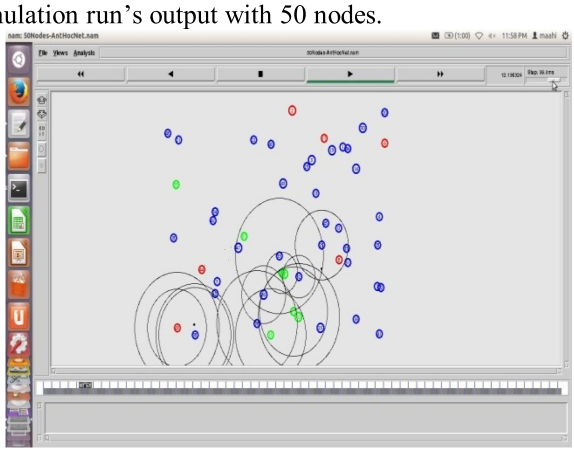

Figure 1: Simulation Setup for AntHocNet

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B. Performance Metrics

We have focuses on two performance metrics such as packet-delivery-ratio (PDR) and Average end-to-end delay of data packets.

1. Packet-delivery-ratio (PDR): The Ratio of the number of data packets delivered to the destinations to those generated by the FTP Sources.

PDR = Receive Packet/Sent Packet * 100. The higher the value gives the use the better results. This metric characterizes both the completeness and correctness of the routing protocol also reliability of routing protocol by giving its effectiveness.

2. Average end-to-end delay: This is the average time delay for data packets from source to destination. This metric describes the packet delivery time: the lower the end-to-end delay the better the application performance.

V. SIMULATION RESULT AND DISCUSSION

Even though AntHocNet, AODV and DSR share a similar on demand behavior but differences in the protocol mechanism can lead to significant performance differentials. The performance differentials are analyzed using packet delivery ratio, average end to end delay with respect to varying speed and pause time and number of nodes.

Table-I: Packet Delivery Ratio & Average End to End Delay Analysis for varying Speed

Speed	*AntHocNet*	
	PDR	*AvgE2EDelay*
10	99.1517	0.314897
20	98.8501	0.248200
30	98.7535	0.302999
40	98.7160	0.305099
50	97.6594	0.252537
AODV		
10	96.8320	0.374107
20	95.4214	0.315393
30	96.3987	0.252742
40	95.9038	0.235423
50	94.7703	0.267025
DSR		
10	99.2390	0.617388
20	98.4795	0.687139
30	98.5981	0.728255
40	98.1368	0.865398
50	97.8600	0.853582

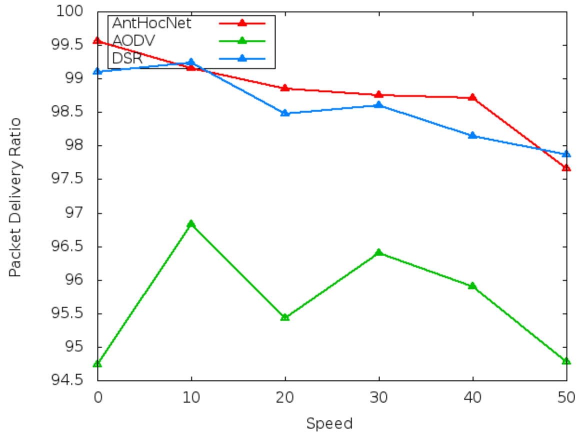

Figure 2: Packet Delivery Ratio vs. Speed

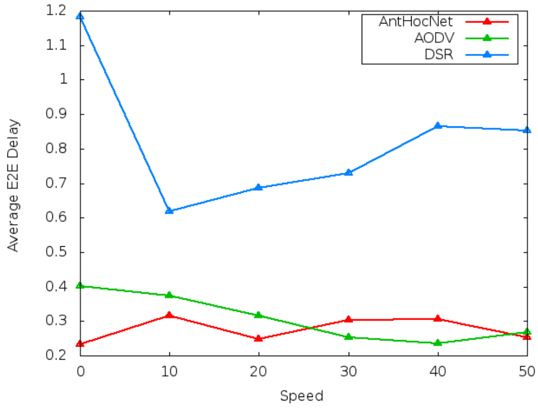

Figure 3: Average End to End Delay vs. Speed

Table-II: Packet Delivery Ratio & Average End to End Delay Analysis for varying Pause Time

Pause Time	*AntHocNet*	
	PDR	*AvgE2EDelay*
0	99.2378	0.378616
10	98.8579	0.369318
20	99.0092	0.455298
30	98.8364	0.429715
40	99.2901	0.455298
AODV		
0	97.2574	0.367465
10	96.1378	0.378596
20	96.8084	0.398710
30	96.5486	0.400270
40	97.8248	0.485887
DSR		
0	99.0694	0.653547
10	99.1826	0.787164
20	98.8482	0.712663
30	98.9917	0.954393
40	99.4305	0.718797

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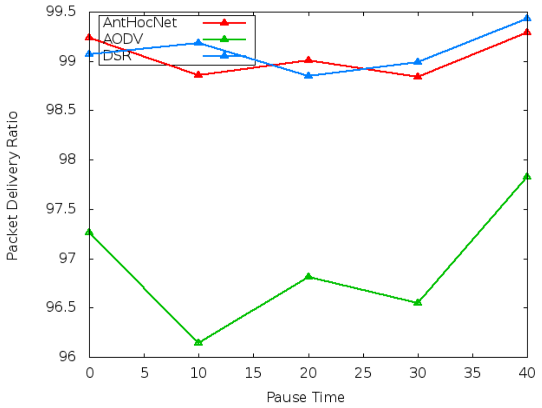

Figure 4: Packet Delivery Ratio vs. Pause Time

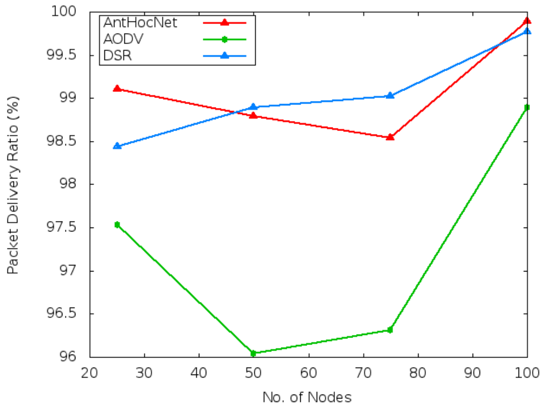

Figure 6: Packet Delivery Ratio vs. Number of Nodes

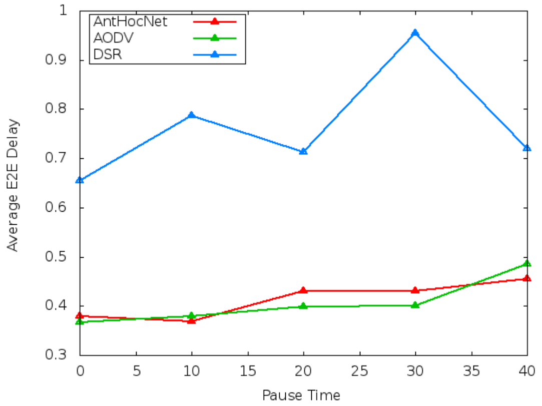

Figure 5: Average End to End Delay vs. Pause Time

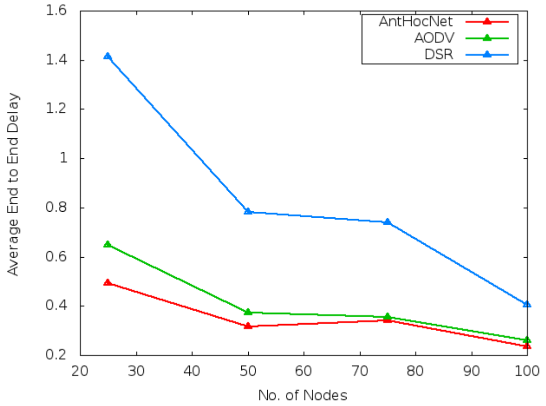

Figure 7: Average End to End Delay vs. Number of Nodes

Table-III: Packet Delivery Ratio & Average End to End Delay Analysis for varying No. of Nodes

No. of Nodes	***AntHocNet***	
	PDR	***AvgE2EDelay***
25	99.0994	0.492230
50	98.7923	0.314897
75	98.5419	0.340903
100	99.8939	0.233660
AODV		
25	97.5325	0.648266
50	96.0374	0.374107
75	96.3173	0.355305
100	98.8955	0.260895
DSR		
25	98.4433	1.412710
50	98.8869	0.782366
75	99.0212	0.741078
100	99.7728	0.403695

Figure 2, 4, and 6 shows comparison of packet delivery ratio for varying speed, pause time and number of nodes respectively. AntHocNet is relatively higher, consistent and stable as compared to the DSR and AODV.

Figure 3, 5, and 7 shows comparison of average end to end delay for varying speed, pause time and number of nodes respectively. AntHocNet has lowest end to end delay compared to DSR and AODV. Thus AntHocNet is consistent and stable as compared to AODV and DSR.

VI. CONCLUSION

Scalability of AntHocNet in comparison with classical routing algorithm AODV and DSR is demonstrated by simulation results. AntHocNet performs better in terms of packet delivery ratio at high rates, at large number of nodes, and with high mobility. Its performance is inferior to DSR at low rates and at less number of nodes in terms of packet delivery ratio but superior than DSR & AODV in many scenarios in terms of average end to end delay. From this it is concluded that AntHocNet is suggested for large-scale, high data rate networks with high mobility. As number of nodes increases or at high rates also, the AODV's and DSR's performance either decreases or very low whereas AntHocNet's performance either constant or increases with either increase in number of nodes or at high data rates.

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