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Performance Comparison of IACO,AODV Networking Routing Protocols

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Abstract- There are several standard protocols for Mobile Ad hoc Networks (MANET) that have been developed for devices with higher computing features. The Efficient routing protocols can provide significant benefits to mobile ad hoc networks, in terms of both performance and reliability. Many routing protocols for such networks have been proposed so far. Amongst the most popular ones are Ad hoc On-demand Distance Vector (AODV), Improved Ant Colony Optimization (IACO). In this paper we present our observations regarding the performance comparison of the above protocols in mobile ad hoc networks (MANETs). We perform extensive simulations, using NS-2 simulator. The Average end-to-end delay and the Packet Delivery Ratio have been considered as the two performance parameters

Key Words: AODV, MANET Routing, NS-2, IACO.

1. INTRODUCTION

Mobile Ad Hoc Networks are wireless networks which do not require any infrastructure support for transferring data packet between two nodes [1]. In these networks nodes also work as a router that is they also route packet for other nodes. Nodes are free to move, independent of each other, topology of such networks keep on changing dynamically which makes routing much difficult. Therefore routing is one of the most concerns areas in these networks. Normal routing protocol which works well in fixed networks does not show same performance in Mobile Ad Hoc Networks. In these networks routing protocols should be more dynamic so that they quickly respond to topological changes [2].

Wireless technologies are becoming important in the world of communications. It is mainly due to three reasons: mobility, low cost and good bandwidth. MANETs are self-organized networks. MANET networks [1] do not have infrastructure or any access point. Communication in an ad-hoc network does not require existence of a central base station or a fixed network infrastructure. Each node of an adhoc network is both a host and a router. This is a feature that makes difficult the communication between the participants of the network. Moreover, the allocation of IP addresses to build routes where the information will travel from a source node to a destination node is so difficult. A number of algorithms have been proposed, and can be categorized as either proactive or reactive protocols. The former ones are constantly scanning the network to build and maintain routes from and to every node, even if there are no packets to be sent. The main idea behind this behavior is to have always a path available on which to send an eventual flow of data packets. They are efficient if routes are frequently used. The latter ones, on the other hand, use an on-demand approach. They establish a multihop path between a pair of nodes only if there are packets to be

transmitted. Thus, saving bandwidth and reducing overhead. They are efficient if routes are sporadically used.

There is a lot of work done on evaluating performances of various MANET routing protocols for constant bit rate traffic but there is very little work done for variable bit rate traffic. In our paper we have evaluated performances of most widely used MANET routing protocols namely AODV, DSDV, DSR and OLSR, TORA, IACO for VBR in MANET using NS-2 which is a discrete event simulator developed at Berkeley University. Our study has shown that IACO has performed better than AODV in terms of Delivery Ratio and average end-to-end delay.

The rest of this paper is organized as follows. In section 2 we briefly describe the routing protocols that we evaluate. In section 3 we discuss the most important previous studies on the subject and explain our work. Section 4 presents the Simulation environment used for evaluation of the said protocols. In Section 5 we present our simulation results and observations. Finally, section 6 concludes the paper.

2. WIRELESS AD HOC ROUTING PROTOCOLS

In this section we briefly describe the protocols that we investigate. A detailed discussion and comparison of most popular wireless ad hoc routing algorithms is available.

AODV Protocol

AODV (Ad hoc On-demand Distance Vector) [7] is a proactive protocol. In this protocol, the nodes use the sequence numbers to avoid loops and take the path information as updated as possible. When a source node wants to transmit information to a destination node, it sends a RREQ (Route Request) packet in broadcast mode to request a route. If a node sees that it is in the destination field of a RREQ, first it checks that this packet has not been received yet by means of a RREQ register. If it was not registered, it sends the message back and increases the number of hops and creates the route reverse replying with a RREP (Route Reply) packet to confirm the path. For the maintenance of the routes can be used 2 methods:

a) ACK messages in MAC level or b) HELLO messages in network

The AODV algorithm is an improvement of DSDV protocol described above. It reduces number of broadcast by creating routes on demand basis, as against DSDV that maintains routes to each known destination [4] [5] [6]. When source requires sending data to a destination and if

route to that destination is not known then it initiates route discovery. AODV allows nodes to respond to link breakages and changes in network topology in a timely manner. Routes, which are not in use for long time, are deleted from the table. Also AODV uses Destination Sequence Numbers to avoid loop formation and Count to Infinity Problem.

An important feature of AODV is the maintenance of timer based states in each node, regarding utilization of individual routing table entries. A routing table entry is expired if not used recently. A set of predecessor nodes is maintained for each routing table entry, indicating the set of neighboring nodes which use that entry to route data packets. These nodes are notified with RERR packets when the next-hop link breaks. Each predecessor node, in turn forwards the RERR to its own set of predecessors, thus effectively erasing all routes using the broken link. Route error propagation in AODV can be visualized conceptually as a tree whose root is the node at the point of failure and all sources using the failed link as the leaves [5][6].

IACO

IACO (Improved Ant Colony Optimization) is a metaheuristic in which a colony of artificial ants cooperates in finding good solutions to discrete optimization problems. Each ant of the colony exploits the problem graph to search for optimal solutions. An 'artificial ant', unlike natural counterparts, has a memory in which it can store information about the path it follows. Every ant has a start state and one or more terminating conditions. The next move is selected by a probabilistic decision rule that is a function of locally available pheromone trails, heuristic values as well as the ant's memory. Ant can update the pheromone trail associated with the link it follows. Once it has built a solution, it can retrace the same path backward and update the pheromone trails.

AntNet is a multipath routing algorithm for mobile adhoc networks that combines both proactive and reactive components. It is based on AntNet [2], designed for wired networks, with some modifications to be used on ad-hoc networks. For example, it does not maintain routes to all possible destinations at all times, but only for the open data sessions. This is done in a Reactive Route Setup phase, where reactive forward ants are sent by the source node to find multiple paths towards the destination node. Backward ants are used to actually setup the route. While the data session is open, paths are monitored, maintained and improved proactively using different agents, called proactive forward ants. The algorithm reacts to link failures with either a local route repair or by warning preceding nodes on the paths. The packets used in the network can be divided into three different classes:

1. Data packets represent the information that the end-users exchange with each other. In anti-routing, data packets do not maintain any routing information but use the information stored at routing tables for traveling from the source to the destination node.

2. Forward and Backward ants are control packets used to update the routing tables and distribute information about the traffic load in the network.

3. Neighbor Control packets are used to maintain a list of available nodes to which forward packets. Actually, they are HELLO messages broadcasted periodically from each node to all its neighbors.

There are two types of mobile agents: Forward Ants and Backward Ants. Forward Ants gather information. On a regular time base, every router sends one Forward Ant with a random destination over the network. This Forward Ant is forwarded by some intermediate routers to its final destination, in a way that balances between exploitation of known good paths and the exploration of new, possibly better, paths. This is accomplished by the exploration probability parameter. As Forward Ants pass through the network, they save information about the intermediate routers on an internal stack.

The other kind of mobile agents are the Backward Ants. Backward Ants are created out of Forward Ants, once they have reached their destination. They inherit all the information on the internal stack of a Forward Ant. The Backward Ant follows exactly the same path as the Forward Ant, but in the opposite direction. In all the intermediate routers, the information of the Backward Ant is compared to the corresponding entry in the statistical model. The result of this comparison is used to adapt the probabilities in the routing table, as well as the statistical model itself. Once the Backward Ant arrives in the starting router, it is discarded (after adapting the routing table and the statistical model).

Backward Ants have a higher priority than data packets. The sooner they are processed, the sooner the extra information is taken into account. Forward Ants cannot have a higher priority. They need to suffer the same network delay as the data packets to be able to measure the network congestion.

- 1) *Construct ant solutions:* This procedure manages a colony of ants that concurrently and asynchronously visit adjacent states of the considered problem by moving through neighboring nodes of the solution space of the problem's construction graph.

- 2) *Update pheromones:* It is the process by which pheromone trails are modified. The trail value can either increase, as ants deposit pheromone on the components or connections they use, or decrease, due to pheromone evaporation. Net increase/decrease in pheromone value at a given location on trail is determined by difference of deposition and evaporation.

- 3) *Daemon actions:* This procedure is used to implement centralized actions which cannot be performed by single ants.

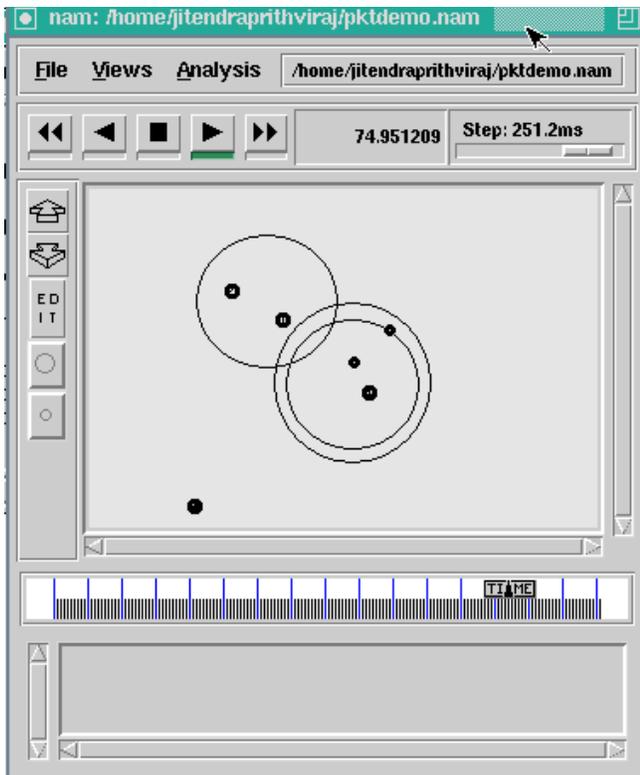
3. PREVIOUS WORK

In this section we analyse the most relevant previous studies concerning ad hoc routing performance comparisons. The authors in [6] use constant bit rate (CBR) for their analysis. Most of the previous work is limited on performing simulations for ad hoc networks with a CBR. Our work differs in that we use variable bit rate (VBR). We observe and comment on the behaviour of each protocol.

4. SIMULATION ENVIRONMENT

We have used network simulator ns2.31 for simulation, most widely used network simulator and freely downloadable.

The following simulations are done to measure the performance of the MANET routing protocols. The parameters used and their performance in the MANET protocols are explained below. At the very onset, a visual representation of the AODV Protocol was observed. This gave a clear picture of the behavior of wireless protocols. It is because in case of wireless protocols, the nodes are not stationary and they are continuously moving. Each node has its own specific radio range, which is indicated by the circles in the Fig. 1 below.



A. Throughput

Trace files are post-processed to calculate the delay of each transmitted packet during the simulation. Average delay is calculated dividing the total delay by the number of packets arrived at destination. Minimum and maximum values are also written in the file. In the configuration file, this test is just called delay. At the very onset, the performance of the two commonly used MANET protocols viz. AODV and IACO were considered. Three and five sources were taken to have a better picture of the performance with respect to the parameter used. It is to be noted that the Average-end-to-end delay was computed by varying the time.

(I) Throughput of AODV

The Average Throughput [kbps] = 986
 StartTime=46.70 and Stop Time=90.00 for AODV.

(II) Throughput of IACO

Improved AntNet has Average Throughput [kbps] = 952.35, StartTime=1.10 and StopTime=2.21

Improved Ant Colony Optimization was now compared with AODV. We got a slight advantage in AntNet protocol. In this case, throughput was considered in each of the two protocols. It was observed that AntNet is relatively consistent and stable as compared to the other MANET protocols. Furthermore, it is to be noted that the Average-End-to-End Delay has been computed against the Offered Traffic.

B. Packet Delivery Ratio

Packet Delivery Ratio trace files are post-processed to calculate the delivery ratio of data packets. That is, the relation between sent packets and received packets. As usual, the performance of the two commonly used MANET protocols viz. AODV and IACO were considered. Three and five sources were taken and the Packet Delivery Ratio was computed by varying the time.

It is to be observed that the Packet Delivery Ratio gradually increases as the time elapses. Infact, it converges to hundred percent in all the cases. Furthermore, it is to be observed that the Packet Delivery Ratio of IACO is relatively more at the starting as compared to that of AODV for both the cases viz. three sources as well as five sources. We got a slight advantage in AntNet protocol. Three sources were again considered in each of the three protocols. It was observed that Improved Ant Net is relatively consistent and stable as compared to the other two MANET protocols.

It is observed that for all the two protocols, the Packet Delivery Ratio decreases with the increase in error rate, or correspondingly the packet loss. Furthermore, it was observed that when the packet loss is less, IACO gives the best Packet Delivery Ratio. But as error rate increases,

AODV tends to give a better Packet Delivery Ratio. Even in this case, two sources were considered in all the above three MANET protocols.

5. Conclusions

We have presented a detailed performance comparison of important routing protocols for mobile ad hoc wireless networks. AODV and IACO are reactive protocol. Both reactive protocols performed well in high mobility scenarios. High mobility result in highly dynamic topology i.e. frequent route failures and changes. Both proactive protocols fail to respond fast enough to changing topology. Both AODV and IACO use reactive approach to route discovery, but with different mechanism. AODV uses routing tables, one route per destination, sequence number to maintain route.

The general observation from simulation is that IACO has performed well compared to all other protocols in terms of terms of Average throughput. The performance of Improved Ant Colony Routing Algorithm is comparable to the shortest path algorithm for static topology but is dependent on the buffer size at the nodes. In Improved AntNet, a high ant generation rate leads to removal of congestion in the network. This causes Improved AntNet to perform better compared to AODV.

A reactive approach should be done instead of the proactive one used. Some simulations at the end with flooding techniques indicated that better results can be achieved in this way.

6. Future Work

Though ad-hoc networks are currently studied, more research has to be done to deploy this technology in a large scale to the market. Not only about routing issues, but also about security risks, social acceptance, and selfishness. If a user declines to route packets for other hosts, and he only wants to use the network as transport for himself, other hosts will not get service.

Research should be done to avoid this. Furthermore, security risks should be taken in account. For instance, a host, like a laptop or a PDA, can be compromised by malware; thus affecting communications between nodes. Due to the distributed routing, a node failure will not be critical, but has to be studied. Perhaps IACO, implemented in the ns2 .31, is a great candidate to act as a routing agent. However, real experiments should be done with real laptops and PDAs devices.

Further simulations could also be done using another simulator. Both OMNET and Cygwin are good candidates and have commercial support. Another possible extension is the separation of the data and control routing tables. In the current implementation the probabilities continuously vary. For data packets it's better if the

probabilities only change from time to time when something essential changes in the network. A solution is to separate the data and control routing tables with the ants only updating the control routing table. Now and then this control routing table is mapped on the data routing table according to some rules set by the network operator. For example, when the system notices that the probabilities constantly alternate between 2 paths (like e.g. in Fig. 4 after the link failure), these means 2 parallel paths to the destination exist. To get a maximal throughput, the probabilities of the 2 interfaces on these paths in the data routing table preferably get a value of 50%. A possible rule for this phenomenon would be: 'If a link between 2 mappings reaches a probability of at least 60%, this link belongs to a good route.

Spread the total probability over the good routes. Improved ACO can also be applied in other domains. Possibilities are e.g. a BGP like protocol based on IACO or the application of ACO in peer-to-peer networks. An example of the latter is, an anonymous file sharing system.

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