A new routing protocol based on AODV in Ad-hoc networks

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Abstract: This paper presents a comparison of several routing protocols of Ad-hoc networks. Of these, AODV is the most suitable in large networks, and here an improvement is proposed for this technique. It is shown that this new protocol can reduce routing overhead and routing delay under a heavy traffic load, while improving throughput and reducing delay, if node movement is not substantial.

I. Introduction

A mobile Ad-hoc network (MANET) enables communication between mobile devices such as laptop computers and wireless handheld devices, and also between mobiles and a wired network. These networks are intended for situations when it is not economically practical or physically possible to deploy the necessary infrastructure, for example in temporary or remote locations such as rescue operations or military applications [1].

In these networks each node must be capable of acting as a router. As a result of the limited radio range of the nodes, a source and destination may have to communicate via a chain of intermediate nodes. Ad-hoc networks do not have a fixed topology, so route construction and maintenance are continual problems in these networks.

Considering that bandwidth is scarce and battery power is limited, it is important to find efficient routing algorithms to create maintain and repair paths with a minimum of overhead [2]. Two classes of protocols, namely proactive and reactive, have been proposed for routing in these networks. With proactive or table-driven protocols, routes are maintained to all possible destinations all the time, whether or not these routes are actually used. Route maintenance in this case can lead to significant overhead because of the amount of update traffic required, especially for large mobile networks. Conversely, reactive or on-demand algorithms create and maintain routes only when they are needed. Many studies have shown that on-demand algorithms are more suitable for ad-hoc networks.

II. Proactive Protocols

With a proactive protocol, each node maintains one or more tables containing routing information to every other node in the network. All nodes update these tables so as to maintain a consistent and up-to-date view of the network. When the network topology changes the nodes propagate update messages throughout the network to update the tables. These protocols differ in the method by which the topology change information is distributed across the network, and the number of routing tables required [3]. Some of the most important protocols in this category are *Destination Sequenced Distance Vector (DSDV), Wireless Routing Protocol (WRP),Global State Routing (GSR), Fisheye State Routing (FSR), Lanmar Routing, Cluster head Gateway Switch Routing (CGSR)* and *Optimized Link State Routing (OLSR)*. The details of these protocols can be found in [4-15].

III. Reactive Protocols

In contrast to table-driven routing protocols, reactive protocols do not maintain up-to-date routing tables at every node, instead the routes are created as and when required. When a source wants to send to a destination, it invokes a route discovery mechanism to find a suitable path to the destination. The route remains valid until the destination is unreachable or until the route is no longer needed. These protocols differ in the way route discovery and route maintenance is done. Some of the most important protocols in this category are *Cluster based Routing Protocol (CBRP), Ad Hoc on Demand Distance Vector Routing (AODV), Dynamic Source Routing Protocol (DSR), Lightweight Mobile Routing (LMR), Temporally Ordered Routing Algorithm (TORA), Associativity Based Routing (ABR), Signal Stability Routing (SSR),Dynamic Load-Aware Routing (DLAR)* and *Location-Aided Routing (LAR)*. The details of these protocols can be found in [16-23].

IV. Comparing of the Protocols

The proactive protocols are compared in Table I, and the reactive protocols in Table II. These comparisons consider the main protocol characteristics in high load networks. In Table I, the route updating column lists how the route tables are updated, and which nodes are sent the update messages. This influences the routing overhead, for example protocols in which update messages are produced by both triggered and periodic means have more overhead than the others. Caching overhead changes according to the number of required tables and the table sizes. Throughput is influenced by factors such as routing overhead and queue length. From Table II, routing overhead with CBRP is lower than the other protocols because CBRP sends request packets only to the cluster heads. In the latest version of DSR, routing overhead is

TABLE I
Comparison of Proactive Routing Protocols

	No. Of Routing Tables	**Route Updating**	**Loop Free**	**Route Optimality**	**Routing Overhead**	**Caching Overhead**	**Throughput**	**Salient Characteristic**
DSDV	*2*	*Periodic, triggered To the Neighbors*	*Y*	*Y*	*High but lower than DBF*	*Medium*	*Low but higher than DBF*	*Loop freedom*
WRP	*4*	*Periodic, triggered To the Neighbors*	*Y*	*Y*	*High*	*High*	*Low*	*Loop freedom, fast convergence*
GSR	*4*	*Periodic To the Neighbors*	*Y*	*Y*	*High and lower than DSDV, WRP*	*Rather high*	*Low but higher than DBF*	*Loop freedom, using LS*
FSR	*3*	*Different Periods to the Neighbors*	*Y*	*Y*	*Lower than GSR*	*Rather high*	*Higher than GSR*	*Overhead reduction, delay increasing*
CGSR	*2*	*Periodic to the Neighbors, Cluster heads*	*Y*	*Y*	*Lower than DSDV*	*Medium and lower than DSDV*	*Higher than DSDV*	*Hierarchical Structure*
Lanmar	*5*	*Periodic To the Neighbors*	*Y*	*Y*	*Lower than FSR*	*Medium and lower than FSR*	*Medium*	*Overhead Reduction*
OLSR	*4*	*Periodic, Triggered in the network*	*Y*	*Y*	*Lower than GSR, LS*	*High*	*Medium*	*Overhead Reduction*

TABLE II
Comparison of Reactive Routing Protocols

	Metrics	**Route reconstruction**	**Periodic beaconing**	**Loop free**	**Multipath**	**Routing Overhead**	**Caching Overhead**	**Throughput**	**Salient Characteristic**
CBRP	*Speed, Shortness*	*Locally*	***Y***	*N*	*N*	*Lower than DSR*	*Medium*	*Higher than AODV*	*High speed of data transmission*
AODV	*Freshness, Speed*	*By source*	*N*	*Y*	*N*	*Higher than DSR*	*Lower than DSR*	*Higher than DSR*	*No periodic transmission, Delay in link failure*
DSR	*Shortness*	*By source*	*N*	*Y*	*Y*	*High*	*High*	*Low*	*No periodic transmission*
LMR	*Speed, Shortness*	*Locally*	*N*	*Y*	*Y*	*Rather high*	*Medium*	*Low*	*High delay in network partitioning*
TORA	*Speed*	*Locally*	*N*	*N*	*Y*	*High*	*Medium*	*Low*	*High routing overhead*
ABR	*Stability, Nodes load Shortness*	*Locally*	*Y*	*Y*	*N*	*Rather high*	*High*	*Rather high*	*Less delay, Using of multiple metrics*
SSR	*Link stability*	*By source*	*Y*	*Y*	*N*	*High*	*Medium*	*Rather high*	*High delay in route discovery*
DLAR	*Intermediate Nodes load*	*By source*	*N*	*Y*	*N*	*High*	*Medium*	*Rather high*	*Less congestion*
LAR	*Speed*	*Locally*	*N*	*Y*	*N*	*Rather low*	*Medium*	*Rather high*	*Less routing overhead*

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reduced by immediately sending request packets through the neighbors when no route exists. Note that CBRP does need to keep and update cluster information, which creates some routing and caching overhead. In high load conditions, DSR throughput is reduced because there is no metric for recognizing stale routes, which may cause data packets to be dropped.

The most important protocols, and those which dominate recent literature, are AODV, DSR, OLSR, FSR, ABR, TORA, and LANMAR. From Tables 1 and 2 and the above discussion, it is clear that proactive tables are not suitable for Ad-hoc networks because of the network resource requirements and the significant overhead generated by node movement. Among the popular on-demand protocols, AODV is selected here because it is simple, has low processing complexity, needs low storage capacity and requires few network resources. The selected route in this protocol is the one with lowest delay, so network congestion will be reduced. Compared with DSR, which has received much attention recently, AODV has less end-to-end delay and greater throughput in high load networks (which are of most interest).

The following protocols are not suitable for high load networks. DSR is not suitable because of the high data packet delay and low throughput due to failure of data packets in these networks, TORA because of its high routing overhead, routing loops and low convergence, and ABR because of the complexity of route discovery, the routing delay, and high storage requirements.

V. Description of AODV

Each AODV node builds and maintains routing table entries containing the destination sequence number, next hop node in the shortest path to the destination, and the distance to the destination. A destination sequence number is created by the destination for any route information it sends to the requesting nodes. Using sequence numbers eliminates looping and indicates the age of routing information. AODV is based on the distance vector algorithm, but unlike other proactive distance vector algorithms, does not use periodic or triggered updates to disseminate routing information. With AODV, route requests are made only when needed and nodes are not required to maintain routes to destinations that are not actively used in communications. Routing tables are built using route discovery and maintained using route maintenance, as described below.

V.1- Route Discovery

When a node needs to send a packet to a destination to which it does not have a routing entry, it broadcasts a route request (RREQ) packet. To prevent unnecessary broadcasts of RREQs the source node uses an expanding ring search. In an expanding ring search, the source node initially uses a time-to-live (TTL)-Start in the RREQ packet IP header and sets a timeout for receiving a reply (RREP). Upon timeout the source retransmits a RREQ with TTL incremented by TTL-increment. This continues until TTL reaches a specified maximum. The source will retransmit the RREQ with the highest TTL if it does not receive any reply within the timeout period. A node receiving a RREQ establishes a reverse path to the sources of the RREQ in their routing table, and either replies to the RREQ if they already have an entry for the destination or forwards the RREQ If there is no routing information to the destination in its routing table, finally the destination will reply. Nodes receiving a RREP setup a path to the destination and in this way, desirable routes are discovered.

V.2- Route maintenance

An existing routing entry may be invalidated if it is unused within a specified time interval, or if the next hop node is no longer reachable. In that case, the invalidation is propagated to neighbors that have used this node as their next hop. Each time a route is used to forward a data packet, its route expiry time is updated. When a node detects that a route to a neighbor is no longer valid, it removes the invalid entry and sends a route error message to the neighbors that are using the route. The nodes receiving route error messages repeat this procedure. Finally, the source requests a new route if it still needs the route.

VI. Improved AODV

The overhead required with AODV is a major drawback of this protocol, especially in high load networks. The overhead mainly consists of route request and reply packets. In the route discovery process, each intermediate node gathers a limited amount of routing information, which will mean AODV often relies on route discovery broadcasts. In this paper, we reduce the routing overhead by using source routes in the route request and reply packets, so that the nodes have more routing information and routing tables can be used more often. The use of source routes in DSR causes problems, especially in large networks, because of stale routes used in data transmission, which cause packet loss and the pollution of routing tables in other nodes [10]. However, AODV uses sequence numbers, which means stale routes, can be recognized and removed from the routing tables if they don’t need to be updated. So the probability of stale route existence will become less. Furthermore, the use of stale routes will not pollute other routing tables, because source routes are not used in the data packets as they are used in DSR.

The use of source routes in route request and reply packets can cause scalability problems in very large networks. Improved AODV can reduce routing overhead and delay of routing because source nodes have large amount of information about network routes so they mostly send their packet through the routes, cached in routing table instead of propagating route request packets which can cause both

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higher overhead and higher route discovery delay. If a source sends a route request packet it must wait till it receives the route reply packet that causes the route discovery delay to increase. However, due to node movements, the initially discovered routes which were optimal lose their optimality because of the changing in nodes distances and the end-to-end delay will increase. This will be encountered less in low speed networks. The use of invalid routes due to high speed of movement will result in dropped data packets and reduced throughput if they are used before updating that will occur more in high speed networks. In the next section, we evaluate the proposed protocol for two cases, high speed and low speed, and compare it with conventional AODV.

VII. Simulation Environment

The simulated network consists of 50 nodes randomly placed, initially on a 1000m*1000m field. Each node moves in the region according to a given mobility model. Each wireless channel has 2 Mb/s bandwidth and a circular radio range of 250 m radius. No multiple-access contention or interference is modeled and each link uses the entire channel bandwidth when transmitting packets. The routing protocol is modeled as an independent routing module, one at each node. The link layer protocol is used to detect link failures. Since no link layer details are modeled, a link layer event is generated automatically whenever a link fails or reappears.

Nodes are constantly moving according to a model similar to Brownian model. In this model nodes change their speed and direction at discrete time intervals, each node chooses V? [0, Vmax] and ? ? [-π, π] and moves with velocity vector (V. Sin?, V. Cos?) during that interval. If this movement would cause a node to exceed the field boundary, it is reflected into the field. The parameters used in this model are Vmax=20m/s for high speed, Vmax=2m/s for low speed and time interval = 0.1 s

The simulated traffic is constant bit rate (CBR) with 10 – 50 connections. In each connection, the source sends 128 bytes data packets at an average rate of 2 pkt/sec.

Node buffer capacity is assumed to be unlimited. Packet delay in the buffer queues is calculated according to

$$T=1 / (\mu c - \lambda),$$

where $1/\mu$ is the average packet size in bits, c is the channel capacity, λ is the average packet transmission rate on each link in pkt/sec (λ for each link is calculated separately through simulation), and T is the queuing delay and packet transmission delay.

The AODV parameters are as follows:

Active route time-out = 0.1s

Maximum number of RREQ retransmission = 3

In the expanding ring:

TTL-Start = 1 hop, TTL-increment=2 hops, Max-TTL=7 hops

Time between retransmission requests is calculated according to the above formula and the value of TTL in the expanding ring.

Simulation time = 90s

VIII. Simulation Results

The simulation results for high speed vehicle are presented in our previous paper [24] and for low speed node will be discussed here. Figure 1 gives the number of routing packets versus the number of connections. Each hop transmission of a packet is considered as one transmission. Note that there is no performance improvement until 15 connections. As the number of connections increases, a considerable reduction in routing overhead is achieved.

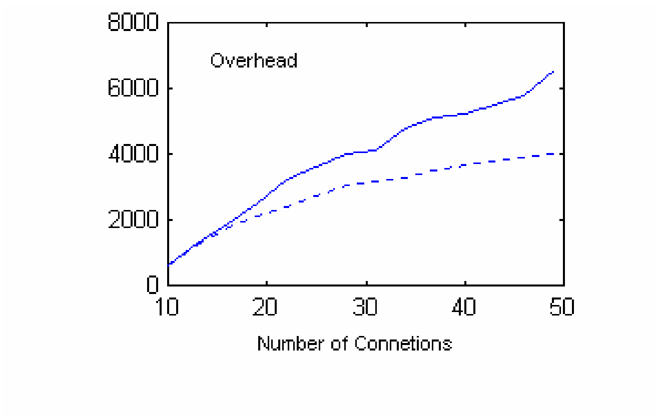

Fig.1 : Routing Overhead for low speed

Figure 2 shows the corresponding routing delays, which is the route discovery latency. Similar to the overhead, routing delay is improved in high load conditions. This is because delays due to route request transmissions are avoided.

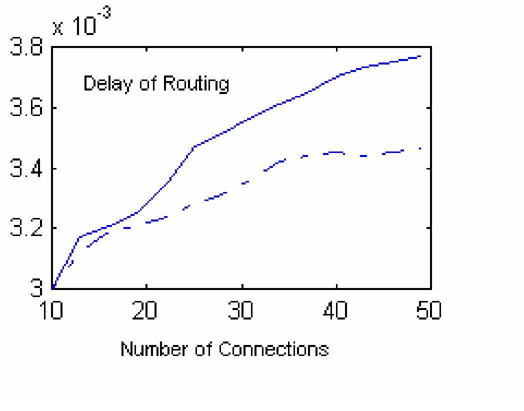

Fig.2 : Delay of Routing for low speed

Figures 3 and 4 show the end-to-end delay and throughput. Throughput is measured as the number or data packets, which are successfully received in destination in a given time interval. As shown in Fig. 3, there is little improvement until the load is high. This improvement is not significant because of the data packet failure delay and the lost of route optimality, both due to nodes movement.

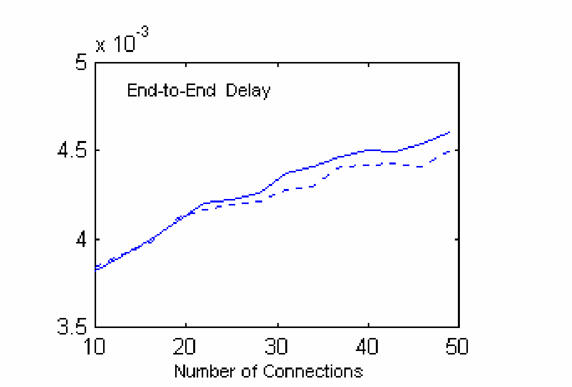

Fig. 3: End-to-end delay for low speed

In [24], in high speed conditions, there is no improvement in throughput while in the low speed case, Fig. 4, shows an improvement in higher load situations, i.e. 20 connections or more. This improvement is the result of a reduction in routing delay, which decreases the packet delay in node queues. This also reduces data packet failure due to long delays.

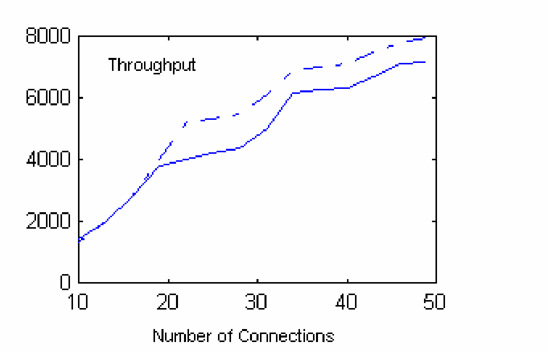

Fig.4 : Throughput for low speed

IX. Conclusions

In this paper we have compared routing protocols in Ad-hoc networks. An improvement to AODV was presented. Performance results showed that using source routes in the route discovery process can reduce routing overhead and routing delay in high load networks with no desirable effects on end-to-end delay and throughput in high speed networks and even a little improvement in low speed networks.

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