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An Optimized Scheme for Enhancing Mobile Ad-Hoc Network Routing Protocol for Transmitting High Density Data

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Abstract: Routing problems in mobile ad-hoc networks have been receiving attention in the last few years. Most of the proposed routing protocols concentrate on finding and maintaining routes in the face of changing topology caused by mobility or other environmental changes. The power aware routing protocols and the topology control algorithms have been developed to address the issue of limited energy reserve of the nodes in ad-hoc networks. In this study, an algorithm has been designed and it has been enhanced with the AODV protocol for transmitting high density data over the ad-hoc network. This enhanced protocol is named as EL-AODV protocol. Enabling the high density data over, ad-hoc networks is more exigent as the links are highly error-prone and go down frequently. The challenge in data transmission over ad-hoc networks is due to the nomadic nature of the host and identifying a dynamic routing protocol that efficiently finds a stable route between mobile nodes. The simulation results show that the pro-posed scheme shows better performance when compared with existing protocol.

Key words: AODV, DSR, stable nodes, energy levels, enhanced AODV, enhanced DSR

INTRODUCTION

Mobile ad-hoc network is an autonomous system of mobile nodes connected by wireless links. Each node operates not only as an end system but also as a router to forward packets. The nodes are free to move about and organize themselves into a network. Mobile ad-hoc networks does not require any fixed infrastructure such as base stations therefore, it is an attractive networking option for connecting mobile devices quickly and spontaneously such as military applications, emergent operations, personal electronic device networking and civilian applications like an ad-hoc meeting or an ad-hoc classroom.

The topology of the network is not under the control but is determined purely by the current geographic location of the nodes and other environmental conditions and the characteristics of the radio transceivers that the nodes possess. The nodes wish to communicate among each other and we assume that they are willing to relay packets in order to facilitate this communication. The problem is to design effective protocols to meet a variety of performance objectives.

Transmission of high density data over ad-hoc network is more challenging than the transmission over other conventional networks due to the changes in the topology that results in a relatively short lifetime of the network paths, high transmission bit error rates during fading periods (Doshi and Brown, 2002). Thus, paths may become frequently. Invalid during connections and this may cause severe ad-hoc degradation in the data quality. In ad-hoc network scenario if there occurs a path failure, switching over to an alternate path may take an unacceptably long period of time causing a temporary disruption of data transmission.

The network topology is not stable as new nodes may unexpectedly join the network or leave and hence, the ad-hoc routing algorithms must minimize the time required in converging after these situations. To overcome the limitations in link-level reliability and the time-varying nature of the network topology, it is proposed to establish stable a path between the source and destination in a single virtual connection.

Several routing algorithms have been proposed to facilitate communication in such dynamically changing network topology. In this study, an algorithm has been developed in order to provide a stable route in which the energy levels all the nodes under that route were maintained above certain specified levels. In addition to that a group of the low mobility nodes under some specified velocity limits has been chosen to participate in the route. So, a stable route can be maintained with some constraints in order to transmit the high density data over the mobile nodes.

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MANET CHARACTERISTICS

The fundamental difference between fixed networks and MANET is that the computers in a MANET are mobile. Due to the mobility of these nodes, there are some characteristics that are only applicable to MANET. Some of the key characteristics are described as (Tang *et al*., 2006):

Dynamic network topologies: Nodes are free to move arbitrarily, meaning that the network topology which is typically multihop may change randomly and rapidly at unpredictable times.

Bandwidth constrained links: Wireless links have significantly lower capacity than their hardwired counterparts. They are also less reliable due to the nature of signal propagation (Su *et al*., 2001).

Energy constrained operation: Devices in a mobile network may rely on batteries or other exhaustible means as their power source. For these nodes, the conservation and efficient use of energy may be the most important system design criteria. The MANET characteristics described previous imply different assumptions for routing algorithms as the routing protocol must be able to adapt to rapid changes in the network topology.

Routing protocols of MANET: There are different criteria for designing and classifying routing protocols for wireless ad-hoc networks. For example what routing information is exchanged when and how the routing information is exchanged when and how routes are computed, etc.

Proactive vs. reactive routing: Proactive schemes determine the routes to various nodes in the network in advance so that the route is already present whenever needed. Route discovery overheads are large in such schemes as one has to discover all the routes. Examples of such schemes are the conventional routing schemes, Destination Sequenced Distance Vector (DSDV) (Tang *et al*., 2006). Reactive schemes determine the route when needed. Therefore, they have smaller route discovery overheads. Examples of such are as follows:

Single path vs. multi path: There are several criteria for comparing single-path routing and multi-path routing in ad-hoc networks. First, the overhead of route discovery in multi-path routing is much more than that of single-path routing (Perkins *et al*., 2003). On the other hand, the frequency of route discovery is much less in a network which uses multi-path routing since, the system can still operate even if one or a few of the multiple paths between a source and a destination fail. Second, it is commonly believed that using multi-path routing results in a higher throughput.

Table driven vs. source initiated: In table driven routing protocols, up-to-date routing information from each node to every other node in the network is maintained on each node of the network. The changes in network topology are then propagated in the entire network by means of updates.

Destination Sequenced Distance Vector Routing (DSDV) and Wireless Routing Protocol (WRP) are two schemes classified under the table driven routing protocols head. The routing protocols classified under source initiated on-demand routing, create routes only when desired by the source node (Broch *et al*., 1998). When a node requires a route to a certain destination, it initiates what is called as the route discovery process. Examples include DSR and AODV.

The proposed scheme has been incorporated in the AODV (Perkins *et al*., 2003) routing process and the performance of this scheme was verified by simulation. The simulation results shows that this new scheme shows better performance compared with ordinary AODV protocol based on various performance metrics.

SELECTION OF SUITABLE PROTOCOL

To select a suitable routing protocol, an analysis has been done by considering the various advantages, disadvantages and the suitability of few existing protocols. The suitable protocol is identified and chosen based on the experimental results produced by some of the researchers. The three protocols that has been analyzed for this purpose are Dynamic Source Routing (DSR) protocol, Destination Sequenced Distance Vector (DSDV) protocol and Ad-hoc on demand Distance Vector (AODV) routing protocol (Broch *et al*., 1998; Qin and Kunz, 2004).

DSR protocol makes uses of source routing and route cache where the sender knows the complete hop-by-hop route to the destination. DSDV protocol maintains a complete list of routes to the destination. AODV discovers routes on an on demand basis and builds a route table based on the number of required broadcasts with one entry per destination that guarantees loop free routes by sequence numbers indicating the freshness of the route. The AODV protocol relies on routing table entries to propagate a Route reply (RREP) back to the source and subsequently route data packets to the destination. 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 Route Error (RERR) packets when the next hop links breaks which in turn forwards the RERR to its own set of predecessors thus, erasing all routs using the broken link. AODV maintains a timer-based state in each node, regarding utilization of individual routing table entries which expires if not used recently.

Based on the survey analysis made on the previous mentioned three protocols on various performance metrics, AODV shows better performance in terms of packet delivery ratio and end-to-end delay as compared to DSR and DSDV and it is chosen as the suitable routing protocol for transmitting the high density data over mobile ad-hoc network.

ENERGY LEVEL CONCEPT FOR STABLE ROUTES

As high density data has to be transmitted much importance has to be given for the selection of the reliable and stable route for a distortion less transmission. A more stable route to transmit the high density data can be achieved by enhancing the routing protocol used. An algorithm was developed based on the energy levels and a table was created called as Energy Level Association Table (ELAT).

This ELAT has been created based on the various threshold levels of the residual energy available in the nodes that participate in the routing process. In addition to that for the provision of the stable routes, the reliability of the nodes are considered by assuming the fact that low mobility nodes may be available in the network topology that was formed during the particular period of time (Tang *et al*., 2006).

ALGORITHM FOR NODE ENERGY LEVEL

The algorithm used for maintaining the residual node energy level for the maintenance of the stable route is given as:

Algorithm:

```
if ( node energy Nen is ≥50%)
 {
    {
    create energy level association table
    }
      if ((Nen = 70%) and (N en >70%))
    {
Enter Nen = 70 in ELAT - (1)
    }
 else if ((Nen = 60%) and (Nen >60%))
    {
Enter Nen = 60 in ELAT - (2)
   }
 else if ((Nen = 50%) and (N en >50%))
      {
Enter Nen ≥50 in ELAT - (3)
      }
         }
 else
    {
    Eliminate the node
    }
```

In this algorithm, three different threshold levels for the residual energy of the individual nodes are fixed as 70, 60 and 50% of the maximum level of the energy in that node. In fact, it is considered that the maximum energy level is almost same in all the nodes. Whenever, a stable route has to be established, the algorithm verifies the residual energy level of the nodes. If the energy level of some of the nodes are ≥70% of the maximum energy level of the node, these nodes are listed in the energy level association table ELAT-(1).

Similarly, the ELAT-(2) and ELAT-(3) are created for the energy levels of 60 and 50%, respectively. In addition to this, a list of low mobility nodes which are moving at a speed less than a specified speed are also included in all the three ELATs.

Thus, a route is established using the nodes which have the energy level of >50% level. First preference is given to the nodes with energy level of ≥70% Then, the second preference is given to the nodes with energy level of ≥60%. Then, the third preference is given to the nodes with energy level of ≥50%.

It is assumed here that if the nodes participate in the stable route for high density data transmission, the energy level of these nodes may reduce to about 10% which fixed as the minimum threshold energy level needed for the node for its survival. If the energy level of the nodes are <50%, the nodes should not be included as at any time the node energy may fall down to a level less than the fixed threshold level.

This new routing concept is used as an additional routing metric along with the existing routing metrics of the AODV routing protocol. Energy level association incorporated as a routing metric reduces data loss by avoiding the nodes and the corresponding routes that are not stable. Along with the hop count and freshness of the route, residual energy level is used to predict the route life-time and hence a stable route is chosen.

Route discovery and route maintenance: Whenever a node needs to find a route to another node, it broadcasts a Route request (RREQ) message to all its neighbors. The RREQ message is flooded through the network until it reaches that destination. On its way through the network, the RREQ message initiates the creation of a temporary energy level packet in the nodes, it passes upto the destination. After this, the destination unicast a Route Reply (RREP) message back to the source through all its possible routes. The RREP message collects the energy level information of the nodes during its RREP process and it delivers the information to the source for proper route selection in order to provide a stable route from source to destination. The source then creates a energy level association tables based on the different energy levels of the nodes as mentioned in the algorithm. The source then identifies the best possible route from source to destination based on the energy level of the nodes. First, it identifies the nodes which have the energy level of ≥70% and selects that route for data transmission. If the energy level of the nodes are not available with ≥70% then it identifies the nodes which have ≥60% and selects that route. If the energy level of the nodes are not available with ≥60% then it identifies the nodes which have ≥50% and selects that route. If the source identifies that there is no route with the desired energy levels then it waits for a small time and once again it broadcasts the RREQ message to all its neighbors.

SIMULATION STUDY AND PERFORMANCE ANALYSIS

The performance analysis of EL-AODV was carried out using NS-2 simulator. Table 1 shows the parameters used for the simulation. The simulation was run for 10 rounds and the average values obtained by this simulation have been analyzed. The performance metrics obtained were packet delivery ratio, end-to-end delay and normalized routing overhead. The performance analysis of both AODV and EL-AODV based on the pause time and the number of nodes was carried out. In all the cases, the performance of EL-AODV was found to be better than AODV.

Figure 1 shows the variations of packet delivery ratio as the number of nodes increases. As the stable route is maintained, EL-AODV gives better packet delivery ratio and also almost a constant value. The AODV shows comparatively low packet delivery ratio when the number of nodes are <60 and the packet delivery ratio increases slowly as the number of nodes increases.

Figure 2 shows the variations of end-to-end delay as the pause time increases. It is observed that the end-to- end delay produced by EL-AODV is less when the pause time is <150 sec and it slowly increases. But the AODV protocol produces more end-to-end delay compared with EL-AODV. In both cases, the end-to-end delay increases as the pause time increases because the

Table 1: Simulation parameters

Parameters	Values
Simulation time	300 sec
Simulation area	700×700 m
Bandwidth	2 Mbps
Number of nodes	100
Radio range	200 m
Data	512 data packets
Speed of packets	20 packets sec^{-1}
Mobility model	Random way point

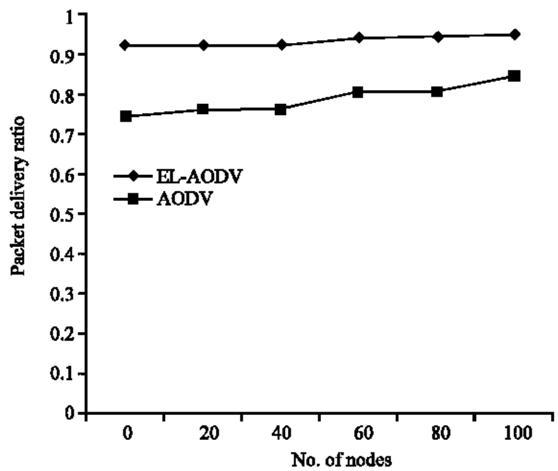

Fig. 1: Packet delivery ratio vs. number of nodes

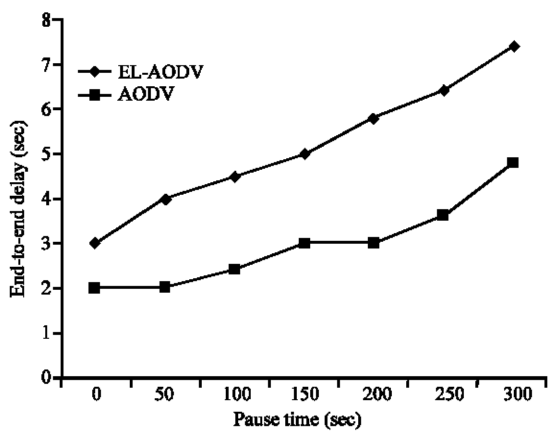

Fig. 2: End-to-end delay vs. pause time

nodes that participate in the established route should deliver a voluminous of data. The end-to-end delay is enormous in the case of AODV protocol when compared with that of EL-AODV protocol. Figure 3 shows the variations of normalized routing overhead as the pause time increases. The routing over head is more for EL-AODV during the initial stages because it has to carry out the energy level information of different nodes participating in the route selection process. But the routing over head reduces slowly as the pause time

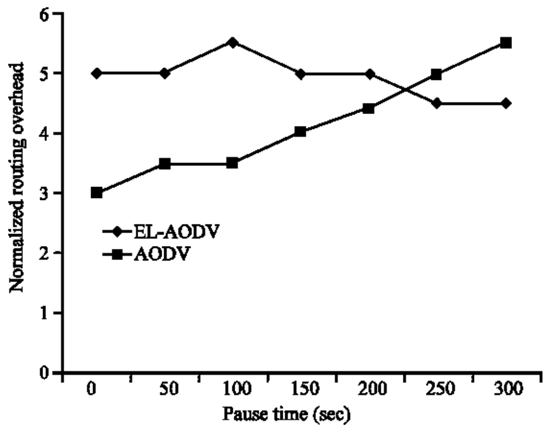

Fig. 3: Normalizaion routing overhead vs. pause time

increases. On the other hand, the routing over head for AODV is less in the initial stages and it increases as the pause time increases.

CONCLUSION

In order to provide, a high density data transmission in a mobile ad-hoc network, the network should provide a stable route. As there should not be any breakage of the routes established, much care has to be taken on maintenance of the residual energy level of the nodes participating in the network connection established. As the existing protocols are not very suitable for this, some enhancement is needed for the existing protocols.

In this study, an enhancement has been provided for the AODV protocol and the performance of the enhanced AODV protocol namely EL-AODV was analyzed. The simulation results shows that the EL-AODV performs better than the existing AODV protocol. As the stable route is maintained for a prolonged time, this concept provides a better data transmission for high density data over mobile ad-hoc networking environment. Some future study can be extended based on this concept in which by predicting the mobility of the nodes and by knowing the velocity of the various nodes under movement more stable routes can be identified (Su *et al*., 2001). Moreover if some of the nodes are stationary for a long time then that nodes can be specially used for the transmission of low density traffic.

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