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Energy Efficient Route Discovery (EERD) for Time-Constrained Communication in Mobile Ad Hoc Network

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Abstract - A mobile ad hoc network is an infrastructure less network, where nodes are free to move independently in any direction. The nodes have limited battery power; hence we require energy-efficient route discovery techniques to enhance node lifetime and network performance. In this paper, we propose an energy efficient route discovery (EERD) scheme that greatly reduces the number of route-requests flooded in the network by controlling their time-to-live attribute. This, in turn, improves the data packet delivery ratio of the underlying routing protocol and reduces the delay in discovering a suitable route to the destination. Also the average node lifetime increases because of reduced message cost.

Keywords - *Ad hoc network, Energy-efficiency, Selective flooding, Time constrained communication, Time-to-live.*

1. Introduction

An ad hoc network is a group of wireless mobile devices or nodes that communicate with each other in a collaborative way over multi-hop wireless links without any stationary infrastructure or centralized management. These networks are deployed mainly in battlefields and disaster situations such as earthquake, floods etc. Many routing protocols have been proposed for ad hoc networks. They can be mainly categorized as proactive and reactive routing protocols. Among proactive routing protocols, destination-sequenced distance vector (DSDV) [1], wireless routing protocol (WRP) [2], global state routing (GSR) [3] and cluster-based gateway switch routing (CGSR) [4] are well known. In all proactive routing protocols the nodes proactively store route information to every other node in the network. In general, the proactive routing protocols suffer from extremely huge storage overhead because they store information both about active and non-active routes. This inculcates the unnecessary complexity of discovering routes to the destinations with which a node rarely communicates. Reactive or on-demand routing protocols are designed to reduce this overhead. In reactive routing protocols, when a source node needs to communicate with a destination, it floods route-request packets throughout the network to discover a suitable route to the destination.

Dynamic source routing (DSR) [5], ad hoc on-demand distance vector routing (AODV) [6,7], adaptive communication aware routing (ACR) [8], flow-oriented routing protocol (FORP) [9, 10] and associativity-based routing (ABR) [11, 12, 13] are well-known among the reactive routing protocols. AODV builds routes using a route-request, route- reply query cycle. When a source node desires to send packets to a destination for which it does not already have a route, it broadcasts a route-request (RREQ) packet across the network. Nodes receiving this packet update their information for the source node and set up pointers backward to the source node in their routing tables. A node receiving the route-request (RREQ) packet sends a route-reply (RREP) if it is either the destination or has a recently established route to the destination with. Dynamic source routing (DSR) is similar to AODV in that it forms a route on-demand when a source node requests one. It uses source routing instead of relying on the routing table at each device. Determining source routes require accumulating the address of each router in the route-request message. Overall it may be noted that for all reactive routing protocols, flooding of RREQ packets inculcates high message cost in the network and if their lifetime can be reduced then a router receiving a RREQ with zero lifetime can discard the packet, instead of forwarding it in ordinary (non-EERD) situations. So, reduction in lifetime of RREQ packets reduces the number of RREQ packets flooded within the network yielding less message contention and collision. As a result, network throughput or data packet delivery ratio enhances with decrease in energy consumption in nodes [14, 15]. .

Time-constrained communication is very common in ad hoc networks where the source node specifies a constraint that certain number of packets needs to be delivered to a specified destination within a certain time limit. This is extremely important from the perspective of emergency situations and ad hoc networks are meant for deployment in this kind of situations such as battlefield, natural calamity etc. In order to resolve the issue of RREQ flooding throughout the network, our present article proposes a energy-efficient route discovery (EERD) technique for time-constrained communication (a specific number of data packets are to be transferred from a given source to a given destination node within a specified time span) in ad hoc networks where the RREQ packets are allowed to remain alive into the network for a much smaller time span depending upon the most recent location of the destination as known to the underlying router or source of the communication. The latest is the known location of the destination the smaller is the number of flooded route-requests. Our proposed technique can be applied with any reactive routing protocol to enhance the performance of the protocol.

2. Overview

Each node maintains a cache of nodes with which it has communicated recently. The information stored in cache is identification number of the destination, its maximum velocity, geographical location in terms of latitude and longitude at the time of communication and timestamp of the communication. These are supplied by the destination node embedded within its route-reply message. Ordinary flooding of RREQ packets floods them in all directions. On the contrary, EERD imposes an upper limit on the time-to-live attribute of the RREQ packets depending upon the most recent location of the destination known to the source/ current router and the timing constraints enforced by the source of the communication session, which is, in most of the cases, much lesser than the life span of an ordinary RREQ packet. Hence the routers can discard RREQ packets much earlier reducing cost of messages in the network and energy consumption in nodes. The improvement is very much noticeable because in ad hoc networks generally the nodes communicate with a fixed set of nodes. For example, a school boy generally communicates with a fixed set of teachers, class-friend and family members; a business person generally communicates with a fixed set of clients and colleagues etc. So, very often a recent location of the destination node is known to the source or routers. The benefit is highest if a recent location of the destination is known to the source. In that case, source computes the time-to-live field of RREQ and embeds the information within the route-request packet itself. Then it is selectively forwarded to certain downlink neighbours for which it is possible to abide by the time-to-live constraint. The neighbours of the source repeat the process. The advantage of EERD is minimum in the situation where a recent location of the destination is known only to an uplink neighbour of the destination and to none of its predecessors.

2.1 Energy Efficient Route Discovery (EERD)

In order to illustrate EERD, we need to define and analyze the following concepts:

i) Ordinary Average Time-to-live (ORD_AVG_TTL) – It specifies the average time duration for which a RREQ packet can stay alive in the network under ordinary situations considering maximum allowable number of hops in the network. Here it is assumed that a node can travel at most H number of hops where H is the hop count in the network.

ii) EERD Maximum Time-to-live (EERD_MAX_TTL) – It specifies the maximum time duration for which a RREQ may be allowed by EERD to stay alive in the network.

2.2 Evaluation of ORD_AVG_TTL

Since H is the hop count of the network and a RREQ packet can traverse at most R_{max} (R_{max} and R_{min} , denote the maximum and minimum radio-ranges in the network) distance in each hop, maximum possible distance traveled by a route-request packet is HR_{max}. So, the maximum time t1_max spent in wireless movement of route-request packets is given by,

$$t1\_max = HR_{max} / v_s \quad (1)$$

where v_s is speed of the wireless signal.

Maximum number of routers in a path is given by (H-1). Please note that waiting times are also involved in this respect. In worst case the newly arrived route-request packet is stored in the last position of message queue of each router in the communication path from source to destination. As a result, it has to wait for completion of forwarding of at most (Q_{max} -1) number of pending messages in the message queue of a router where Q_{max} is the maximum possible number of storage spaces in message queue of any node in the network. The maximum time required for forwarding each of those messages is $(\tau_{max}+\phi)$ (w+1) where τ_{max} is the maximum time required by a node to forward a message. After a node forwards a packet it expects the acknowledgement within ϕ unit time duration. If acknowledgement does not arrive within this time duration then a message can be present at most w number of times. So, a message can be forwarded at most (w+1) number of times. The evaluation here corresponds to the situation where each message is transmitted (w+1) number of times. Then the newly arrived route-request packet may also have to be forwarded at most (w+1) number of times with time duration corresponding to each transmission being $(\tau_{max}+\phi)$. This worst case situation may prevail in all of those (H-1) routers. Hence the total waiting time t2_max is,

$$t2\_max = \{(\tau_{max}+\phi)\ (w+1)(Q_{max} - 1) + (\tau_{max}+\phi)(w+1)\}(H-1)$$

$$\text{i.e., } t2\_max = (\tau_{max}+\phi)\ (w+1)\ Q_{max}\ (H-1) \qquad (2)$$

Let ORD_MAX_TTL and ORD_MIN_TTL indicate the maximum and minimum time duration for which a RREQ packet can stay alive in the network under ordinary situations corresponding to the traversal of H number of hops in the network.

So, ORD_MAX_TTL = t1_max + t2_max

i.e,

$$ORD\_MAX\_TTL = HR_{max} / v_s + (\tau_{max}+\phi)\ (w+1)Q_{max}\ (H-1) \qquad (3)$$

As far the evaluation of ORD_MIN_TTL is concerned, it corresponds to the situation where a message traverses R_{min} distance in each hop and at most H number of hops is permitted. No waiting time is involved in any node.

$$\text{So, } ORD\_MIN\_TTL = HR_{min} / v_s \qquad (4)$$

For simplicity we assume that both ORD_MIN_TTL and ORD_MAX_TTL are equally likely. Therefore,

$$ORD\_AVG\_TTL=(ORD\_MAX\_TTL+ORD\_MIN\_TTL)/2 \qquad (5)$$

2.3 Evaluation of EERD_MAX_TTL

The evaluation is based on certain constraints and basic assumptions mentioned below:

Constraints and primitive assumptions:

n_s and n_d are source and destination nodes, respectively, in a communication session where the timing constraint is that q number of packets are to be delivered from source to destination within time t2. All nodes are equipped with clocks which are synchronized throughout the network. The RREQ packet transmitted by n_s arrives at a router n_b at timestamp t1. Then the time left for the remaining route discovery and message packet transfer process, is (t2-t1). Two different cases can take place here – one is that n_b knows a recent location of the destination and the other is that n_b is unaware of any recent location of the destination.

Case-1: n_b knows about a recent location of destination n_d

Latest communication between n_b and n_d took place at time t and at that time, the geographical positions of these two nodes were $(x_b(t), y_b(t))$ and $(x_d(t), y_d(t))$ respectively. Within the time interval (t2-t1), maximum time span will be available for route discovery provided the time allotted for message packet transfer from n_s to n_d, through n_b, is minimum. Let, t_x be the time duration required for route discovery from n_b to n_d and t_f be the time span required for message transfer from n_s to n_d.

$$\text{So, } t_x+t_f = t2 - t1 \qquad (6)$$

The time required for message transfer from n_s to n_d, through n_b will be minimum if n_b and n_d continue to move to another at maximum relative velocity i.e. $(v_{max}(b)+v_{max}(d))$ where $v_{max}(i)$ indicates the maximum possible velocity of any node n_i in the network. Assume that after transmission of j number of message packets the nodes n_b and n_d become closest and during the transfer of those j numbers of packets, the nodes were coming close to one another at maximum relative velocity. After they come to the closest position, their distance does not increase any more. Actual message packet transfer from n_b to n_d begins at time $(t1+t_x)$. Let $t_p(i)$ (where $1 \le i \le j$) indicate the time required by the i-th message packet to travel from n_b to n_d. So,

$$t_p(1) = [\sqrt{\{(x_b(t)-x_d(t))^2+(y_b(t)-y_d(t))^2\}} - (v_{max}(b)+v_{max}(d))\ (t1+t_x-t)] / v_s \qquad (7)$$

where v_s is the speed of the wireless signal.

For each i s.t. $1<i \le j$, $t_p(i)$ is related to $t_p(i-1)$ as follows (based on the assumption that n_b and n_d continuously come close to one another during message packet transfer also with maximum possible relative velocity):

$$t_p(i) = t_p(i-1)\{1 - (v_{max}(b)+v_{max}(d)) / v_s\} \qquad (8)$$

Hence the total time required by first j number of message packets from n_b to n_d is denoted by z(j) and defined as follows:

$$z(j) = t_p(1) + t_p(2) + t_p(3) + \ldots + t_p(j) \qquad (9)$$

i.e. $z(j)=t_p(1)+t_p(1)\{1-(v_{max}(b)+v_{max}(d))/v_s\}+ t_p(1)\{1-2(v_{max}(b)+v_{max}(d)) /v_s\}+\ldots+t_p(1)\{1-(j-1)(v_{max}(b)+v_{max}(d)) / v_s\}$ i.e. $z(j) = t_p(1) [j - \{ (v_{max}(b)+v_{max}(d)) / v_s \} (1+2+3+\ldots+(j-1))]$

So, $z(j) = t_p(1) [j - \{ (v_{max}(b)+v_{max}(d)) / v_s \}j(j-1)/2]$ (10)

Let ψ denote the minimum possible geographical distance between two nodes in the network.
So, ψ is the distance between n_b and n_d after transferring first j number of data packets and it continues to be the distance between them during transfer of subsequent message packets.
Hence, $[\sqrt{\{(x_b(t)-x_d(t))^2+(y_b(t)-y_d(t))^2\}} - (v_{max}(b)+v_{max}(d)) (t1+t_x+z(j)-t)] = \psi$ (11)

For simplification, assume that the constants c1 and c2 are defined as,
$c1 = \sqrt{\{(x_b(t)-x_d(t))^2+(y_b(t)-y_d(t))^2\}}$ and $c2 = (v_{max}(b)+v_{max}(d))$

Placing these constants in (11) we get,
$c1 - c2 (t1+t_x+z(j)-t)] = \psi$ (12)

After transmission of first j number of packets, remaining (q-j) number of packets is to be transferred and for each of them, the required transfer time is (ψ/v_s). Considering all those (q-j) number of packets, the total required transfer time is $(q-j) (\psi/v_s)$. So, the total transfer time t_f for all message packets taken together, is given by,

$t_f = z(j) + (q-j) (\psi/v_s)$ (13)

From (6) we get $t_f = t2 - t1 - t_x$

So, $t2 - t1 - t_x = z(j) + (q-j) (\psi/v_s)$

i.e. $t_x + z(j) = t2 - t1 - (q-j) (\psi/v_s)$ (14)

Putting this value of $(t_x + z(j))$ in (12) we get,

$c1 - c2 (t1+t2 - t1 - (q-j) (\psi/v_s) - t) = \psi$

i.e. $c1 - c2 (t2 - t) + c2 (q-j) (\psi/v_s) = \psi$ (15)

Assuming that $c3 = c1 - c2 (t2 - t)$, from (15) we get,

$c3 + c2 (q-j) (\psi/v_s) = \psi$

i.e. $j = q + (c3 - \psi) v_s / (c2 \psi)$ (16)

If an acceptable value of j (j≥1; if j is a fraction more than 1, then j is replaced by $\lfloor j \rfloor$; all other values of j less than 1 are unacceptable) is obtained, then putting this value of j in (10), z(j) can be computed. Let this value be denoted by a constant c4. Therefore, from (14),

$t_x + c4 = t2 - t1 - (q-j) (\psi/v_s)$ (17)

So, $t_x = t2 - t1 - (q-j) (\psi/v_s) - c4$

Therefore, EERD_MAX_TTL = $t2 - t1 - (q-j) (\psi/v_s) - c4$

On the other hand, if no acceptable value of j is obtained then case 2 is applicable.

Case-2: n_b does not know about a recent location of destination n_d

Here it is impossible to estimate that after transmission of how many packets the nodes n_b and n_d will come to the closest position. Therefore, to compute the maximum possible time allotted for route discovery abiding by the timing constraints, it is assumed that the two involved nodes are closest right from the beginning of message packet transmission. So, the time required for transmitting each packet is (ψ/v_s). Since q number of packets are to be transmitted total time t_f required for message packet transmission, is $(q\ \psi/v_s)$. From (1), the time t_x available for RREQ forwarding, is $\{t2 - t1 - (q\psi/v_s)\}$. Therefore, EERD_MAX_TTL = $\{t2 - t1 - (q\psi/v_s)\}$.

Note: It may happen for a very large value of t2 that EERD_MAX_TTL is greater than or equal to ORD_AVG_TTL. In that case, the time-to-live attribute of RREQ packets looses importance, it is set to a negative value (-99 in our simulations) and instead of this attribute, forwarding by routers is controlled by hop count of the message. If the RREQ message has already traversed H hops, then it is dropped by the underlying router. Otherwise, the improvement caused by EERD is given by (ORD_AVG_TTL – EERD_MAX_TTL) which is greater than or equal to 0.

2.4 Improvement of EERD in terms of message cost

Let, on an average, the number of downlink neighbours of a node is α, and once a router receives a RREQ packet, it takes at least t_R amount of time to broadcast it within its own radio-range. So, t_R is given by,

$t_R = R_{min} / v_s$

So, the maximum number of hops a RREQ packet can travel under EERD is denoted by h_max and defined by,

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$h\_max = t_x/t_R$

The significance of these symbols are mentioned earlier in this section.
It is quite clear that $h\_max \leq H$, because under no circumstances a RREQ packet can travel more than H hops.
So the maximum number of RREQ packets in EERD is denoted by RREQ_COST_EERD and defined by,

$$RREQ\_COST\_EERD = \alpha+\alpha^2+\alpha^3+\ldots+\alpha^{h\_max}$$

$$\text{i.e. } RREQ\_COST\_EERD = \alpha(\alpha^{h\_max}-1)/(\alpha-1)$$

Under ordinary situations, the number of RREQ packets is denoted by RREQ_COST_ORD and defined by,

$$RREQ\_COST\_ORD = \alpha+\alpha^2+\alpha^3+\ldots+\alpha^H$$

$$\text{i.e. } RREQ\_COST\_EERD = \alpha(\alpha^H-1)/(\alpha-1)$$

Without any loss of generality, let's assume that $h\_max = H - k$ where $k \geq 0$

Hence, the improvement IMV_EERD_COST caused by EERD in terms of message cost, is (RREQ_COST_ORD – RREQ_COST_EERD).

$$\text{i.e. } IMV\_EERD\_COST = \{\alpha^{H+1}/(\alpha-1)\}(1 - \alpha^{-k})$$

2.5 Selective RREQ Message Flooding

A router can n_b can selectively forward a packet provided it knows a recent location (say at time t) of destination n_d. Also assume that n_b is aware of geographical locations at time t of some of its neighbours. So, if the value of EERD_MAX_TTL corresponding to router n_b is lesser than the value of EERD_MAX_TTL corresponding to some neighbours of n_b, then n_b wont forward that RREQ to those neighbours. This is called selective flooding of RREQ packets in EERD embedded versions of routing protocols.

Note: During computation of IMV_EERD_COST the selective flooding facility of EERD was not considered. If selective flooding is availed then IMV_EERD_COST would have increased even more.

3. Simulation Results

Simulation of the mobile network has been carried out using ns-2 [15] simulator on 800 MHz Pentium IV processor, 40 GB hard disk capacity and Red Hat Linux version 6.2 Operating System. Graphs appear in figures 2 to 7 showing emphatic improvements in favor of limited area route discovery. Number of nodes has been taken as 20, 50, 100, 200, 400 and 700 in six different independent simulation studies. Speed of a node is chosen random between 5m/s and 35m/s in various simulation runs. Transmission range varied between 10m and 50m. Used network area is 2000m ×2000m. Used traffic type is constant bit rate. Mobility models used in various runs are random waypoint, random walk and Gaussian. Performance of the protocols AODV, ABR and FAIR are compared with their EERD embedded versions EERD-AODV, EERD-ABR and EERD-FAIR respectively.

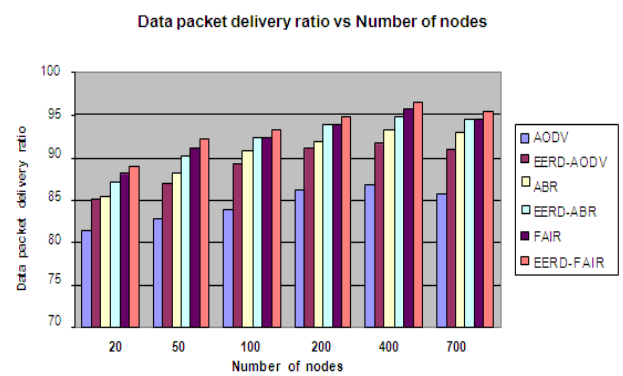

Figure 1: Graphical illustration of data packet delivery ratio vs number of nodes

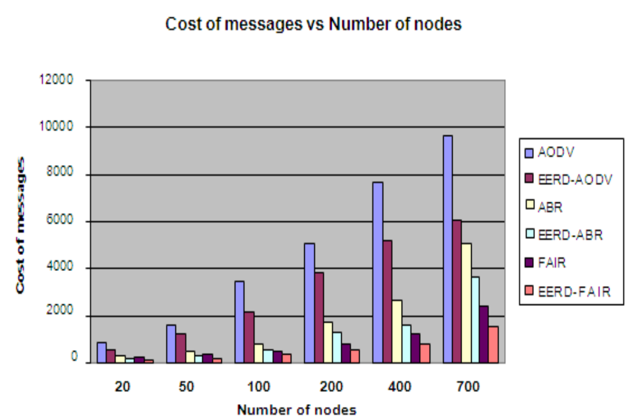

Figure 2: Graphical illustration of cost of messages vs number of nodes

In order to maintain uniformity of the implementation platform, we have used ns-2 simulator for all the above-mentioned communication protocols. The simulation matrices are data packet delivery ratio (total no. of data packets delivered×100/total no. of data packets transmitted), message overhead (total number of message packets transmitted including data and control packets) and per node delay in seconds in tracking destination (total delay in tracking the destination in different communication sessions / total number of nodes). Simulation time was 1000 sec. for each run.

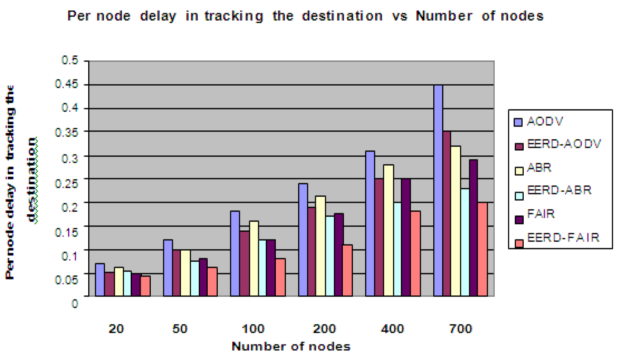

Figure 3: Graphical illustration of per node delay in tracking the destination vs number of nodes

Figure 1 shows that the initially the data packet delivery ratio improves for all the protocols with increase in number of nodes and then it starts reducing. The reason is that the network connectivity improves with increase in number of nodes, until the network gets saturated or overloaded with nodes. When the overloading occurs, cost of messages become very huge and the packets hinder one another from reaching their destinations again by colliding. Figure 2 shows that for all the protocols cost of messages increase with increase in number of nodes. This is quite self-explanatory. From Figure 3 it may be seen that as the number of nodes increase, the delay in tracking the destination also increases. The reason is that more number of communications is initiated with increased number of nodes and due to better network connectivity more destinations can be tracked now which are far apart. Also the phenomenon of more packet collision increases the delay in tracking destinations.

EERD greatly reduces the injection of route-request packets to a great extent since an intermediate node that has recently communicated with the destination, broadcasts the route-request only to those downlink neighbors from which it is possible to drive the RREQ to the actual destination abiding by the timing constraints. This increases the node lifetime and reduces the packet collision. As a rate, data packet delivery ratio of EERD embedded versions of the above-mentioned protocols also increase compared to the ordinary versions of those. The improvements are evident from Figures 1, 2 and Table 1. As far as delay in tracking the destination is concerned, EERD embedded versions show significant improvement. The reason is that RREQ packets in EERD embedded versions face much less hindrances due to lesser amount of packet collisions compared to the ordinary versions of those protocols. Therefore, those RREQ packets are driven to their respective destinations much sooner in protocols with EERD facility.

Please note that the improvement produced by EERD-AODV over ordinary AODV is more than those produced by EERD-ABR over ordinary ABR and EERD-FAIR over ordinary FAIR. The reason is that in AODV, among all discovered routes from source to destination, the one with minimum hop count is elected for communication, without considering stability of the links (stability is expressed mainly in terms of relative velocities between the two nodes forming a link). On the other hand, in ABR, the route with maximum number of stable links is elected as optimal. FAIR is even more conscious on link stability as well as agility. Hence, the phenomenon of link breakage is more frequent in AODV than ABR as well as FAIR. In order to repair the broken link, more RREQ messages are injected into the neighborhood of the broken link in case of ABR and FAIR whereas in AODV a new route discovery session is initiated altogether which requires generation of a huge number of RREQ packets once again. Actually, link breakage in all protocols increases message overhead decreasing the network throughput with different intensity determined by the logic of the protocol itself. Note that, the phenomenon like route discovery and link repair are less devastating in ABR and FAIR than in AODV. So, performance enhancement of EERD-AODV over AODV is more than that produced by EERD-ABR over ABR and EERD-FAIR over FAIR.

Table 1: Simulation Parameters

Network space	$1000m \times 1000m$
Simulation time	500 second
No. of nodes	50,60,70,80,90,100
Traffic model	CBR
Primary energy of each node	1-10J
Sleep power	0.01 watt
Packet size	512 bytes
Medium access protocol	IEEE 802.11
Speed of mobile nodes	0-25 m/s

Also it is noticeable from the above figures that the improvement produced by EERD embedded protocols over their ordinary versions increase with the number of nodes. The reason is that, as the number of nodes increase, the number of RREQ packets in the network also increase due to the initiation of an increased number of communication sessions. This, in turn, generates packet contention and collusion raising the number of link breakages by reducing the lifetime of nodes (as more communication sessions are initiated, the average forwarding load on the nodes increase and automatically this will reduce their lifetime). A huge number of nodes with exhausted battery may hamper network connectivity which is detected as broken link problem. As a result, more RREQ packets are injected into the network to repair those links making the problem more severe. So, the improvements produced by EERD embedded versions are more noticeable with increase in number of nodes.

4. Conclusions

The concept of energy-efficient route discovery presented in this paper greatly reduce message overhead of the network. As a result, data packet delivery ratio increases along with the lifetime of network nodes. Maximum benefit can be obtained if the source node knows about a recent location of the destination which is very much possible from the point of view of ad hoc networks.

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References

[1] Charles E. Perkins, "Highly dynamic destination-sequenced distance vector routing for mobile computers", ACM Computing and Communications Review, vol. 14, issue 4, pp. 234 – 244.
[2] Shree Murthy, J.J. Garcia-Luna-Aceves," An efficient routing protocol for wireless networks", Mobile Networks and Applications (Kluwer Academic Publishers), pp. 183-197, 1996.
[3] Tsu Wei Chen and Mario Gerla, "Global State Routing: A new routing scheme for ad hoc wireless networks", Proceedings of IEEE International Conference on Communications, 1998.
[4] C.C. Chiang, H.K. Wu, W. Liu, M. Gerla, "Routing in clustered multi-hop mobile networks with fading channel", Proceedings of IEEE SICON, 1997.
[5] David B. Johnson, David A. Maltz, "Dynamic source routing in ad hoc networks", Mobile Computing, pp. 153-181.
[6] Bin Hu, Hamid Gharavi, "DSR-based directional routing protocol for ad hoc networks", Proceedings of IEEE GlobeComm 2008.
[7] Ian D. Chakeres et. Al, "AODV routing protocol implementation design", Proceedings of WWAN, March 2005.
[8] Tetsuro Ueda et. Al., "ACR: An adaptive communication aware routing through maximally zone-disjoint shortest paths in ad hoc wireless networks with directional antenna", Journal of Wireless Communications and Mobile Computing, 2007.
[9] W. Su and M. Gerla, "IPv6 flow handoff in ad hoc wireless networks using mobility prediction", Proceedings of IEEE GlobeComm 1997, pp. 271-275.
[10] Chai Keong Toh, "Associativity-based routing for ad hoc networks using mobility prediction", IEEE International Phoenix Conference on Computers and Communications (IPCCC'96).
[11] S. Singh, M. Woo and C.S. Raghavendra, "Power aware routing in mobile ad hoc networks", Proceedings of Mobicom 1998, Dallas, Texas, Oct. 1998.
[12] C.K. Toh,"Maximum battery life routing to support ubiquitous mobile computing in wireless ad hoc networks", IEEE Communications Magazine, June 2001.
[13] Mahammed Tarique, Kemel E. Tepe and Mahammed Naserian, "Energy saving dynamic source routing for ad hoc wireless networks", Proceedings of WIOPT 2005.
[14] Khalid Kaabneh et. Al, "An effective location-based power conservation scheme for mobile ad hoc networks", American Journal of Applied Sciences, vol. 6, pp. 1708-1713.
[15] Dhiraj Nitnaware and Ajay Verma, "Energy constraint node cache based routing protocol for ad hoc networks", International Journal of Wireless and Mobile Networks, vol.2, no. 1, February 2010.

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