International Journal of Advance Research In Science And Engineering http://www.ijarse.com
IJARSE, Vol. No.4, Special Issue (01), March 2015 ISSN-2319-8354(E)

COST-EFFECTIVE ROUTE DISCOVERY (CERD) FOR MOBILE AD HOC NETWORKS

Dr. Anuradha Banerjee

Kalyani Govt. Engg. College, Kalyani, Nadia, West Bengal (India)

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 technique to enhance their lifetime and network performance. In this paper, an energy-efficient route discovery technique CERD has been proposed that greatly reduces the number of route-requests flooded into the network and also gives priority to the route-request packets sent from the routers that has communicated with the destination very recently, in single or multi-hop paths. This not only enhances the lifetime of nodes but also decreases the delay in tracking the destination.

Keywords: Ad Hoc Network, Energy Efficiency, Flooding, Node Lifetime, Route Discovery.

I. 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 through out the network to discover a suitable route to the destination. Dynamic source routing (DSR) [5], ad hoc on-demand distance vector routing (AODV) [7], adaptive communication aware routing (ACR) [8], flow-oriented routing protocol (FORP) [9] and associativity-based routing (ABR) [10] 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 relaying on the routing table at each device. Determining source routes require accumulating the address of each router in the route-request message. In FAIR [11], the source node transmits RREQ packets that arrive at the destination through multiple paths. Depending upon the locations, residual energy, velocity etc. various characteristics of the routers, the destination node evaluates performance of the paths by considering their stability and agility. Then communication from source to destination begins through one of the best paths. FORP and ABR are link stability based routing protocols that also rely on the flooding of RREQ packets for route discovery. So, if the number of RREQ packets can be reduced then much lesser number of routers will be involved in the route discovery process in the CERD versions of the above-mentioned routing protocols compared to their ordinary versions. As a result, network throughput or data packet delivery ratio enhances with decrease in energy consumption in nodes.

In order to resolve the issue of reduction of RREQ flooding into the network, as much as possible, our present article proposes a cost-efficient route discovery (CERD) technique for communication in ad hoc networks where the RREQ packets are forwarded only to those downlink neighbours for which it is possible to send the RREQ packet to the destination, 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.

II.OVERVIEW

Each node maintains a cache of nodes with which it has communicated recently. The information stored in cache about each such recently communication destinations, are 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 to all downlink neighbours of a node. On the contrary, CERD imposes a constraint that a node (source/ router) will forward a RREQ packet only to those downlink neighbours for which it is possible to successfully send the route-request to the destination node within the lifetime of those RREQ packets, given a pre-specified location of the destination. Hence, CERD greatly reduces the number of flooded RREQ packets preserving the battery power of network 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.

It 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.

III.COST-EFFICIENT ROUTE DISCOVERY (CERD) TECHNIQUE

The technique of CERD is illustrated in this section based on the following assumptions:-

i) n_s is the source and n_d is the destination node

ii) n_s initiates route discovery at time ts which arrives at a router n_i at time t

iii) The maximum lifetime of a RREQ packet is τ.

iv) A router n_i knows the location of the destination at time t1 where t1 < t

v) Location of any node n_i in the network at time t′ is denoted by an ordered pair $(x_i(t'), y_i(t'))$

vi) Maximum velocity of any node n_i is given by $v_{max}(i)$

vii) Approximate velocity of the wireless signal is given by v_s

A downlink neighbour n_j of n_i receives the RREQ forwarded by n_i destined to n_d, only if it is possible for n_j to send that RREQ to n_d within the entire lifetime of the RREQ packet.

Definition: **Destination Embedding Circle (DEC)**

The circle that embeds all possible positions of the destination n_d during the entire lifetime of the RREQ generated by n_s at time ts, is termed as the destination embedding circle (DEC) as observed by n_i. Its center is $(x_d(t1), y_d(t1))$ and radius is $\{v_{max}(d) \times ((t\text{-}t1)+\tau\text{-}(t\text{-}ts))\}$ i.e. $\{v_{max}(d) \times (\tau\text{-}(t1\text{-}ts))\}$.

n_i will send RREQ packet to n_j if any wireless signal transmitted by n_j at time t can reach the nearest point on the DEC as observed by n_i at time t1, within the time interval $(\tau\text{-}(t1\text{-}ts))$. The distance that can be traveled by the wireless signal within the time interval $(\tau\text{-}(t1\text{-}ts))$ is given by $(v_s \times (\tau\text{-}(t1\text{-}ts)))$. This distance should not be lesser than the distance of n_j from the nearest point on the DEC as observed by n_i at time t1, for receiving the RREQ from n_i. In figure 1, let (h, k) be that particular point on the DEC of n_i, which is closest to n_j. The points $(x_j(t), y_j(t))$, $(x_d(t), y_d(t))$ and (h,k) are collinear. From this condition of collinearity, I obtain the equation (1) and equation (4) is obtained based on the situation that (h,k) is a point on the DEC of n_i. So, its distance from the center of the DEC is equal to radius of the DEC. The situation can be depicted from figure 1.

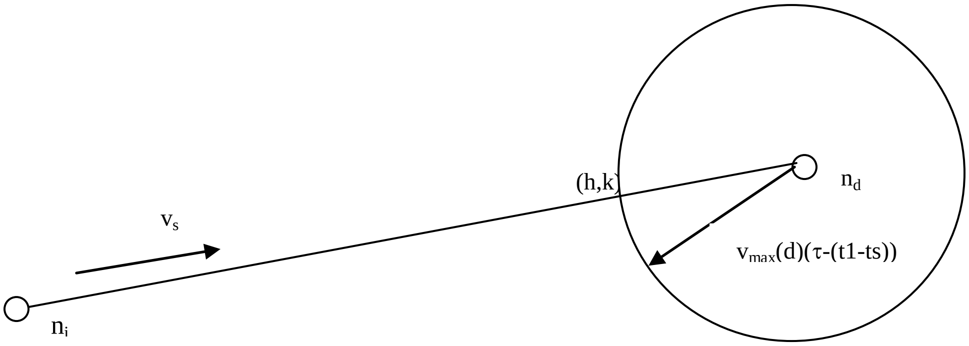

Figure 1: Demonstration of DEC

$(h - x_j(t)) / (x_j(t) - x_d(t)) = (k - y_j(t)) / (y_j(t) - y_d(t))$ (1)

Therefore, $h = x_j(t) + (k - y_j(t)) (x_j(t) - x_d(t)) / (y_j(t) - y_d(t))$ (2)

so, $h = c1\ k + c2$ (3)

where $c1 = (x_j(t) - x_d(t)) / (y_j(t) - y_d(t))$ and $c2 = x_j(t) - c1\ y_j(t))$

$(h - x_d(t))^2 + (k - y_d(t))^2 = v^2_{max}(d)\ (\tau-(t1-ts))^2$ (4)

For simplicity, lets replace $v^2_{max}(d)\ (\tau-(t1-ts))^2$ by a constant c3. Putting h = c1 k + c2 in (5) I get,

$(c1\ k + c2 - x_d(t))^2 + (k - y_d(t))^2 = c3$ (5)

This is a quadratic equation. Solving this equation, following two values (lets denote them as k_1 and k_2) of k are obtained.

$k\_1 = [y_d(t)-c1(c2-x_d(t)) + \surd[\{c1(c2-x_d(t)) - y_d(t)\}^2-(1+c1^2)\{ (c2-x_d(t))^2+y^2_d(t)\}]] / (1+c1^2)$ (6)

$k\_2 = [y_d(t)-c1(c2-x_d(t)) - \surd[\{c1(c2-x_d(t)) - y_d(t)\}^2-(1+c1^2)\{ (c2-x_d(t))^2+y^2_d(t)\}]] / (1+c1^2)$ (7)

Corresponding values of h are denoted as h_1 and h_2 where

h_1 = c1 k_1 + c2 and h_2 = c1 k_2 + c2

Let dist1 and dist2 indicate the distance of the points (h_1, k_1) and (h_2, k_2), respectively, from the center of the DEC in figure 1. Then,

$dist1 = \surd\{(h\_1 - x_d(t))^2 + (k\_1 - y_d(t))^2\}$ and $dist2 = \surd\{(h\_2 - x_d(t))^2 + (k\_2 - y_d(t))^2\}$

Assume that mindist denotes the smaller among dist1 and dist2 (i.e. mindist = dist1 if dist1 < dist2, else mindist = dist2).

If $mindist > (v_s \times (\tau-(t1-ts)))$ then n_i does not forward the RREQ to n_j.

IV . SIMULATION RESULTS

Simulation of the mobile network has been carried out using ns-2 [12] 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 cost effective route discovery. Number of nodes has been taken as 20, 50, 100, 300 and 500 in different independent simulation studies. Speed of a node is chosen as 5m/s, 10 m/s, 25 m/s, 35 m/s and 50 m/s in different simulation runs. Transmission range varied between 10m and 50m. Used network area is 500m ×500m. 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 CERD embedded versions CERD-AODV, CERD-ABR and CERD-FAIR respectively. In order to maintain uniformity of the implementation platform, I 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.

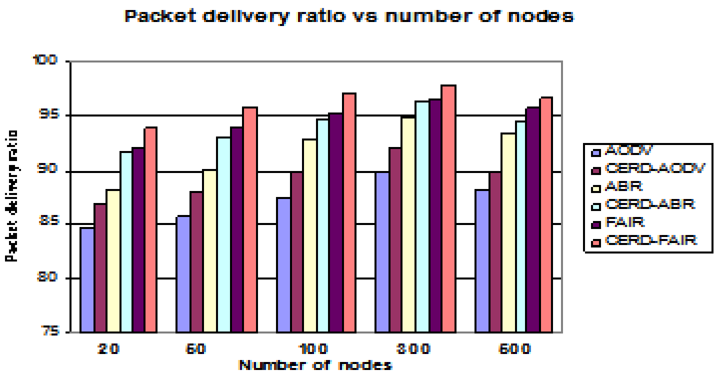

Figure 2: Data packet delivery ratio vs number of nodes

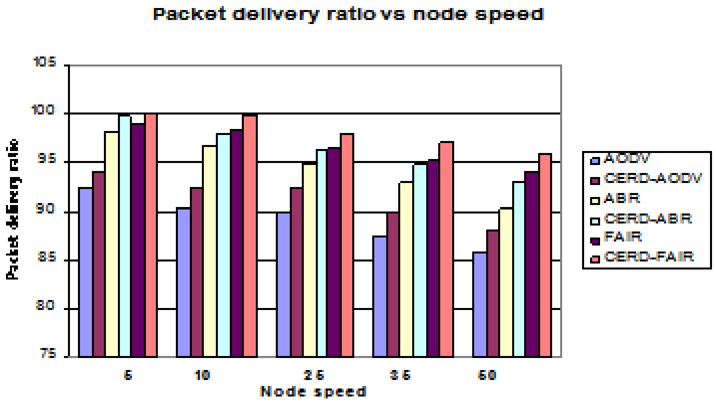

Figure 3: Data packet delivery ratio vs node speed

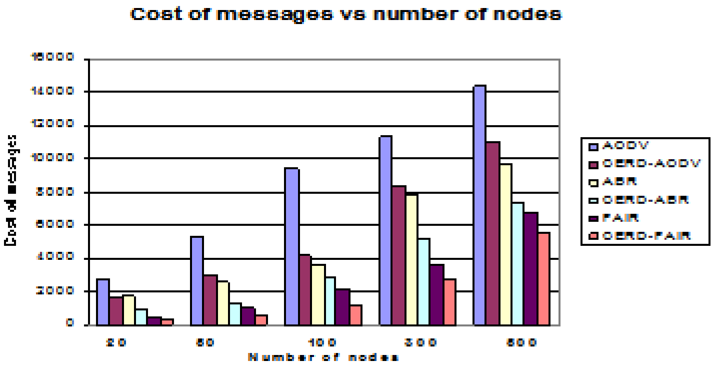

Figure 4: Cost of messages vs number of nodes

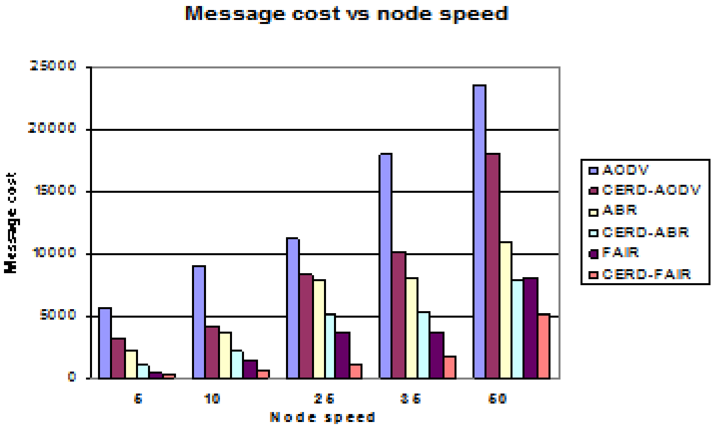

Figure 5: Cost of messages vs node speed

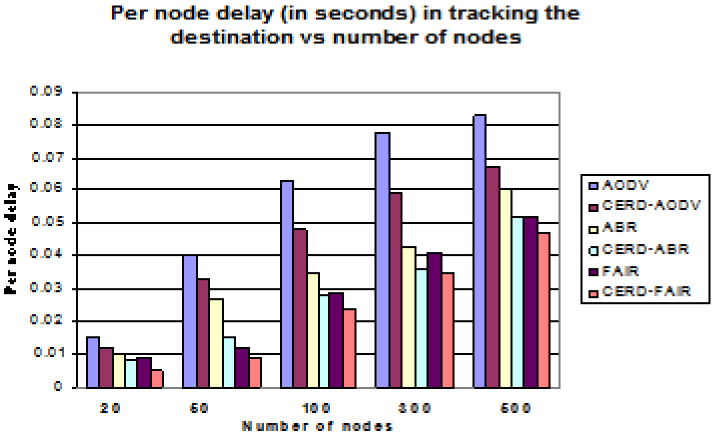

Figure 6: Per node delay vs number of nodes

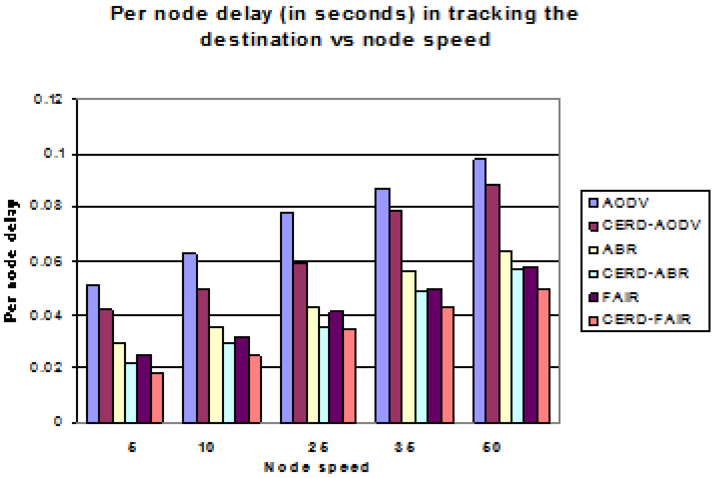

Figure 7: Per node delay vs node speed

Figure 2 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 by colliding. Figure 4 shows that for all the protocols cost of messages increase with increase in number of nodes. This is quite self-explanatory. From figure 6 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. Figures 3, 5 and 7 are concerned with the influence of node speed on these metrics. As the node speed increases, many new links form and older ones break increasing the network congestion and message collision. Colliding messages are unable to reach their respective destinations; hence they need to be retransmitted. This causes additional delay in the process and injects some more messages. As a result, packet delivery ratio decreases with increased cost and delay.

CERD 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 within the lifetime of RREQ packet generated by the source of the communication session. This increases the node lifetime and reduces the packet collision. As a rate, data packet delivery ratio of CERD embedded versions of the above-mentioned protocols also increase compared to the ordinary versions of those. The improvements are evident from figures 2, 3, 4 and 5. As far as delay in tracking the destination is concerned, CERD embedded versions show significant improvement. The reason is that RREQ packets in CERD 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 CERD facility.

Please note that the improvement produced by CERD-AODV over ordinary AODV is more than those produced by CERD-ABR over ordinary ABR and CERD-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 CERD-AODV over AODV is more than that produced by CERD-ABR over ABR and CERD-FAIR over FAIR.

V.CONCLUSION

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.

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] Anuradha Banerjee, Paramartha Dutta, Fuzzy Controlled Adaptive and Intelligent Route (FAIR) Selection in Mobile Ad Hoc Networks, European Journal of Scientific Research, vol. 45 no. 3, September 2010

[12] www.isi.edu/nsnam/ns/