Volume 4, No. 4, March-April 2013
ISSN No. 0976-5697
International Journal of Advanced Research in Computer Science
RESEARCH PAPER
Available Online at www.ijarcs.info

Energy Conscious Reliable Routing Protocol (Ecrrp) Based On Fuzzy Logic Towards Clustering In Wireless Ad Hoc Networks

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Abstract: This paper aims to design and develop energy conscious reliable routing protocol based on fuzzy logic towards clustering in wireless ad hoc networks. For the past several decades the clustering problem for wireless ad hoc networks is proposed by several researchers. This research work takes the objective of energy conscious routing since nodes present in the wireless ad hoc networks are battery powered. This paper comprises of fuzzy logic If-Then rules to formulate the objective by using metrics such as delay and residual energy. By using the EC-algorithm along with fuzzy if-then rules, ECRRP is designed and developed. Performance metrics such as average number of clusters, reaffiliation rate and dominant set update are taken into account for comparing the proposed routing protocol with WCA algorithm. Simulations are done using NS2 and the simulated results shows that the proposed ECRRP outperforms WCA.

Keywords: Clustering, Energy conscious, Routing, Mobile Ad hoc Networks, Delay

I. INTRODUCTION

Mobile ad hoc networks (MANETs) are a kind of wireless networks that are decentralized networks in which communication between nodes is deployed without the need of an underlying infrastructure. These mobile nodes have power constraints, limited coverage area, and each node can act as a router in the network [16, 17]. MANETs are mainly suitable for those applications where the deployment of a new fixed infrastructure is purposefully unplanned and practically difficult or impossible as shown in Figure1.

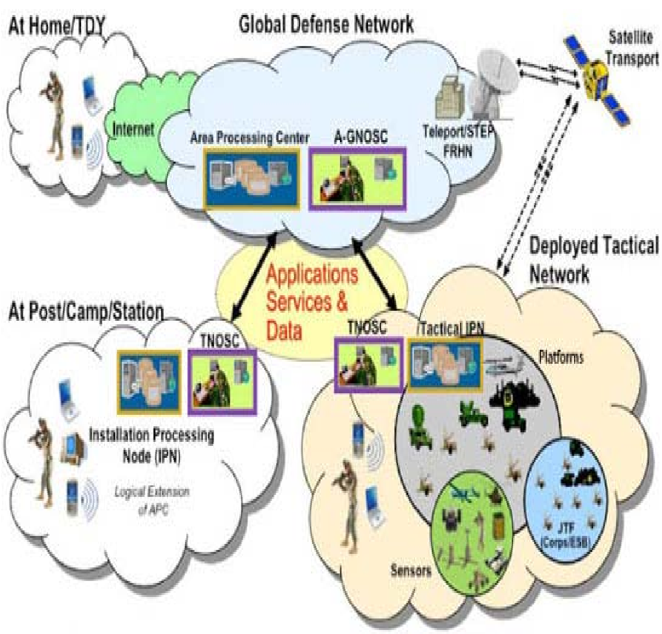

Figure 1. Mobile Ad hoc Network Applications, Services and Data

Thus, MANETs are considered as the most appropriate entrants for disaster scenarios due to their capability of being self-organized, self-repairing, and self-recovery networks. This is due to the fact that communications in disaster scenarios are most likely to be destroyed, non-functioning or severely compromised following a disaster occurrence caused by natural or man-made events.

In disaster response scenarios, rescue teams should take actions quickly and operate efficiently in order to reduce further risks and fatalities.

II. LITERATURE REVIEW

Several real life disaster scenarios have been mocked-up by using this mobility model [5–7]. Several routing protocols for ad hoc networks have been evaluated under the disaster area mobility model [12, 13]. The Ad hoc On-demand Distance Vector (AODV) [11] attained the best performance for the two types of communications evaluated: inter-communications and intra-communications. It was also found that the mobility model for a disaster area can be seen as a combination of different simulation scenarios since different density and mobility of nodes can be found in each tactical area.

On the other hand, connectivity is a very important issue when designing MANETs [15]. In this kind of network, nodes are mobile; consequently they are continuously entering and leaving the coverage areas formed by other participating nodes. In succession participant nodes as well as the number of nodes in the network are constantly changing. Evolutionary computational approaches are suitable to deal with such variable conditions.

Genetic algorithms (GAs) are widely used as optimization techniques to solve complex problems. Genetic algorithms have been applied to intelligent transportation systems [1,2], website structure mining [8], and wireless sensor networks (WSN) [3,4,10] among other types of ad hoc networks.

A hybrid GA was used by Tzu-Chiang and Yueh-Ming [3], to improve the performance in local and global topology discovery of shared multicast trees. A similar idea was used by Zhou et al. [10], in two-tiered WSN. The use of NS-2 to evaluate the fitness function is very interesting since it allows the designer to model the communication layers and the signal propagation models. Xu et al. [9] included a GA in NS-2 for analyzing topology control in ad hoc wireless networks.

CHEF is a similar approach to that of Gupta et al. [19], but it performs cluster-head election in a distributed manner. Thus, the base station does not need to collect clustering information from all sensor nodes. There are two fuzzy descriptors that are employed in cluster-head election. These are the residual energy of each node and local distance. Local distance is the total distance between the tentative cluster-head and the nodes within a predefined constant competition radius.

III. PROPOSED WORK

A. Mechanism:

Our proposed ECRRP follows a distributed competitive imbalanced clustering mechanism. It builds local decisions for formatting competition radius and electing cluster-heads. For estimating the competition radius for tentative cluster-heads, ECRRP employs both residual energy and delay parameters. Furthermore, ECRRP takes advantage of fuzzy logic to calculate competition radius. ECRRP is also based on a probabilistic sculpt which is employed for selecting tentative cluster-heads. Though, it does not elect the final cluster-heads just by depending on this model. At each and every clustering round, each mobile node generates a random number between 0 and 1. If the random number for a meticulous mobile node is smaller than the predefined threshold T, which is the percentage of the desired tentative cluster-heads, then that mobile node becomes a tentative cluster-head. The competition radius of each tentative cluster-head will change dynamically in ECRRP. This is because ECRRP uses residual energy and delay in order to calculate competition radius. It is rational to reduce the service area of a cluster-head while its residual energy is decreasing. If the competition radius does not change as the residual energy decreases, the mobile node runs out of battery power rapidly.

ECRRP takes this situation into consideration and decreases the competition radius of each tentative cluster-head as its battery power decreases. Radius computation is accomplished by using predefined fuzzy if-then mapping rules to handle the uncertainty. These fuzzy if-then mapping rules are given in section 3.3. In order to evaluate the rules, the Mamdani Method which is one of the most frequently used methods, is used as a fuzzy inference technique. The center of area (COA) method is utilized for defuzzification of the competition radius. In order to calculate cluster-head competition radius, two fuzzy input variables are used. The first one is the delay. The maximum competition radius is a static parameter for a particular for wireless ad hoc networks. The mobile nodes will broadcast the value of this parameter to the entire network. Thus, all the mobile nodes know the maximum competition radius, in advance. Each of the mobile nodes can calculate their relative competition radius according to the value of this parameter. The change of competition radius is according to residual energy and delay.

B. Delay estimation:

There is a significant variation between the end-to-end delay reported by RREQ-RREP measurements and the delay experienced by actual data packets. We address this issue by introducing a DUMMY-RREP phase during route discovery. The source saves the RREP packets it receives in a RREP TABLE and then acquires the RREP for a route from this table to send a stream of DUMMY data packets along the path traversed by this RREP. DUMMY packets efficiently imitate real data packets on a particular path owing to the same size, priority and data rate as real data packets. H is the hop count reported by the RREP. The number of packets comprised in every stream is 2H. The destination computes the average delay Davg of all DUMMY packets received, which is sent through a RREP to the source. The source selects this route and sends data packets only when the average delay reported by this RREP is inside the bound requested by the application. The source performs a linear back-off and sends the DUMMY stream on a different route selected from its RREP TABLE when the delay exceeds the required limit.

C. Fuzzy If-Then Rules:

The below Table I. represents the fuzzy if-then rule chart.

Tab;e: 1 Fuzzy If-Then Rules

Delay	Residual Energy	Competition Radius
Less	Low	Very small
Less	Medium	Small
Less	High	Rather small
Average	Low	Medium small
Average	Medium	Medium
Average	High	Medium large
Far	Low	Rather large
Far	Medium	Large
Far	High	Very large

D. EC-Algorithm:

T ← Probability to become Cluster Head Node
NodeState ← clustermember
Clustermembers ← empty
Myclusterhead ← this
betentativehead ← true
μ ← (0,1)
If μ<T then
Calculate CompetitionRadius using Fuzzy if-then mapping rules
CandidateCHMessage(ID, CompetitionRadius, ResidualEnergy)
On receiving CandidateCHMessage from node N
If this.ResidualEnergy < n.ResidualEnergy then
Betentativehead ←FALSE
Advertise QuitElectionMessage(ID)

End if
End if
If betentativehead = True then
Advertise CHMessage(ID)
Nodestate ← clusterhead
On receiving joinCHMessage(ID) from node N
Add N to the clustermembers list
EXIT
Else
On receiving all CHMessages
Myclusterhead ←the closest cluster-head
Send joinCHMessage(ID) to the closest cluster-head
EXIT
End if

IV. SIMULATION SETTINGS AND PERFORMANCE METRICS

A. *Simulation Settings and Parameters:*

We use NS2 to simulate our proposed technique. In our simulation, the channel capacity of mobile hosts is set to the same value: 2 Mbps. We use the distributed coordination function (DCF) of IEEE 802.11 for wireless LANs as the MAC layer protocol. It has the functionality to notify the network layer about link breakage. In our simulation, we keep the number of mobile nodes as 150. The mobile nodes move in a 1000 meter x 1000 meter square region for 50 seconds simulation time. We assume each node moves independently with the same average speed. All nodes have the same transmission range of 250 meters. In our simulation, the speed is 10 m/s. The simulated traffic is Constant Bit Rate (CBR). Our simulation settings and parameters are summarized in Table 2.

Table: 2 Table Type Styles

No. of Nodes	150
No. of Flows	2
Area Size	1000 X 1000
Mac	802.11
Radio Range	10m to 20m
Simulation Time	50 sec
Traffic Source	CBR
Packet Size	512 KB
Mobility Model	Random Way Point
Speed	0.5 m/s
Rate	250 Kb.

B. *Performance metrics:*

a. Number of Dominant Set Updates
b. Number of Reaffiliations
c. Number of Clusters

V. RESULTS AND DISCUSSIONS

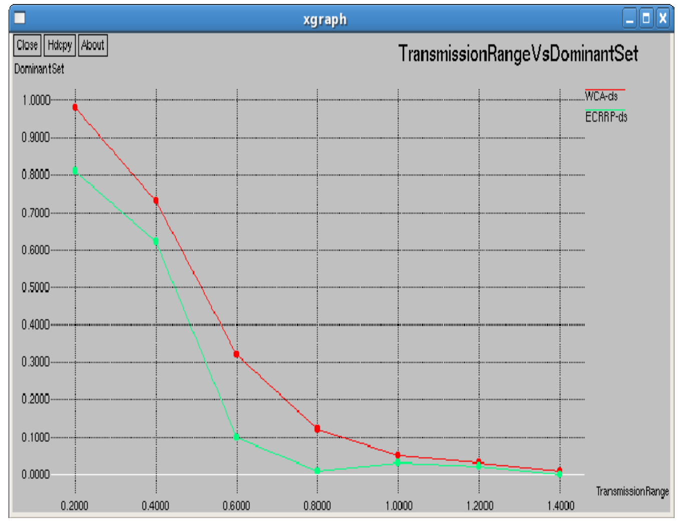

Figure 2. Transmission Range Vs Dominant Set

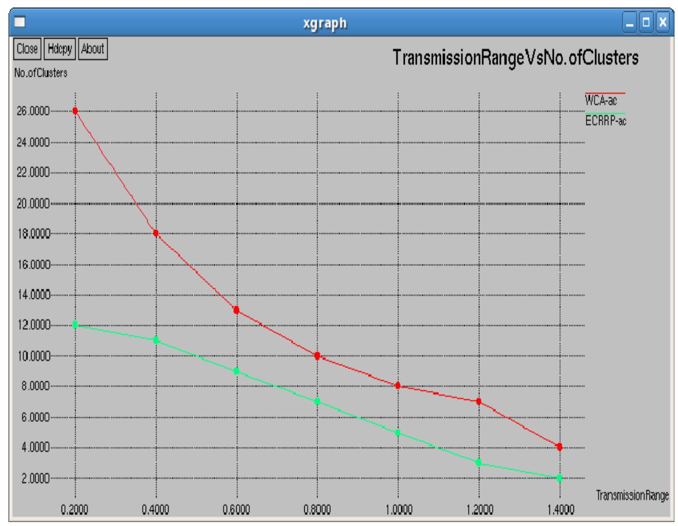

Figure 3. Transmission Range Vs Number of Clusters

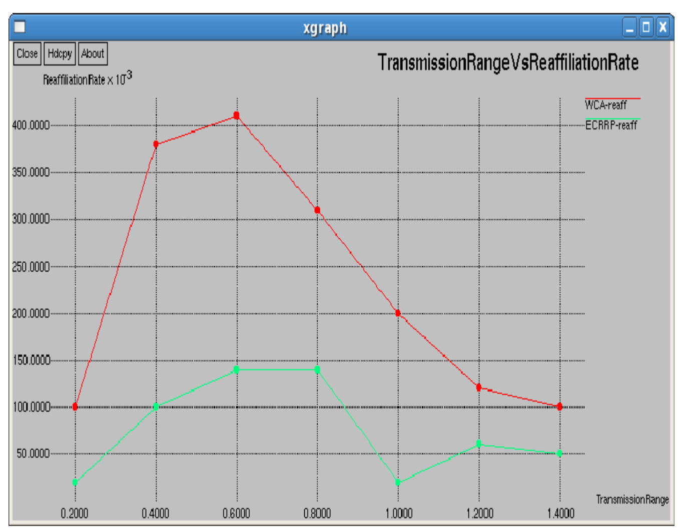

Figure 4. Transmission Range Vs Reaffiliation Range

The Figure 2 shows the performance comparison between WCA and the proposed protocol ECRRP in Transmission Range versus Dominant Set aspect. It can be observed that the proposed ECRRP attains reduced dominant set when compared with WCA. From the Figure 3 it can be seen that WCA urge to form more number of clusters than that of our proposed ECRRP. Also in Figure 4 it is clearly observed that reaffiliation rate of the cluster nodes is reduced in ECRRP than the WCA routing protocol.

VI. CONCLUSIONS

This paper presented energy conscious reliable routing protocol (ECRRP) based on fuzzy logic towards clustering in wireless ad hoc networks. This work comprises of fuzzy logic If-Then rules to formulate the objective by using metrics such as delay and residual energy. By using the EC-algorithm along with fuzzy if-then rules, ECRRP is designed and developed. Performance metrics such as average number of clusters, reaffiliation rate and dominant set update are taken into account for comparing the proposed routing protocol with WCA algorithm. Simulations are done using NS2 and the simulated results shows that the proposed ECRRP outperforms WCA.

VII. ACKNOWLEDGMENT

The first author covey his sincere gratitude to the Management of Dr.N.G.P.Arts and Science College for providing career opportunity as Assistant Professor in the Department of Computer Technology of Dr.N.G.P.Arts and Science College. The second author thanks the Management of Dr.N.G.P.Arts and Science College for providing career opportunity as Head of the Department for the Department of Computer Technology of Dr.N.G.P.Arts and Science College.

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