IJCTA, 9(36), 2016, pp. 121-135
© International Science Press

Improved Cuckoo Search Optimization Based Energy-Delay Aware Routing Algorithm in Manet for Rescue and Emergency Applications

S. Harihara Gopalan* and R. Radhakrishnan**

Abstract : Mobile Ad-hoc network (MANET) is a association of portable nodes as well as some computing devices which can be located subjectively anywhere in the network to achieve a specific task like data transmission and message passing etc for numerous applications. The nodes can transfer information in a specific range and the nodes are accomplished of altering their location often. Owing to these features of MANET nodes, the energy and safety concerns arise. In the preceding works, extremely secured optimal routing systems grounded on Hybrid ACO-MGA and Fuzzy aided ACO procedure have been advanced to amicably resolve such concerns. Nonetheless, these cluster-based protocols progress energy-efficiency at the cost of transmission delay. Likewise, in the Fuzzy Relevance Degree procedure cast-off for cluster head selection, power drain happens when convinced node acts as a cluster head for a long time. Henceforth in this paper, the Improved Cuckoo Search Optimization (ICSO) based Energy-Delay Aware Routing Algorithm is anticipated to resolve the energy and delay issues particularly for the rescue and emergency applications. In this anticipated system, the MANET nodes are optimally grouped with the cluster head selection procedure is done by means of an Improved LEACH (I-LEACH) protocol. Once the CH is elected, the intra and inter-cluster communication is recognized. The energy efficient and delay aware shortest paths are resolute by the ICSO Algorithm. Thus the routing paths are designated with energy efficiency and minimal delay with abridged security threats from diverse attacks. Investigational outcomes display that the anticipated ICSO grounded Energy-Delay aware Routing system offers efficient routing with improved recital in rescue and emergency applications in terms of packet delivery ratio, bandwidth, end to end delay, energy utilization, throughput, network lifetime and consistency.

Keywords : Improved Cuckoo Search Optimization, Improved LEACH, Energy-Delay aware Routing.

1. INTRODUCTION

Efficient collaboration amongst rescue personnel from numerous organizations is a mission critical key section for an effective operation in emergency and rescue circumstances. There are two central preconditions for well-organized collaboration, (1) the incentive to collaborate, which is obviously specified for rescue personnel, and (2) the capability to competently communicate and share information. Mobile ad-hoc networks (MANETs) have the prospective to offer a "best effort" network infrastructure for

* Assistant Professor, Department of Computer Science and Engineering, Sri Ramakrishna Engineering College, Tamilnadu.

** Principal, Sasurie College of Engineering , Tamilnadu.

data sharing in certain scenarios. MANET is an autonomous assortment of nodes mobile users that deals infrastructure-free architecture for communication over a communal wireless medium [1],[2]. MANET nodes have restricted processing speed and power, battery, storage, and communication abilities. One of the most interesting concerns in MANETs is their routing procedures [3], [4], [5]. Routing protocols for ad hoc networks can be separated into two kinds grounded on when and how the routes are discovered: proactive (table-driven) [6] and the reactive (on-demand) [7]. For the table driven routing protocols, reliable and up-to-date routing data are upheld at every mobile host. Henceforth, for the table-driven protocols every mobile host preserves one or more tables comprising routing data to each other mobile host in the network. When a network topology varies, the mobile hosts broadcast the updated messages during the course of the network in order to uphold the routing data about the whole network.

These routing protocols vary in the technique by which the topology data is distributed across the system and in the amount of routing-related tables. An instance of table-driven ad hoc routing protocols is the Destination-Sequenced Distance-Vector (DSDV) routing algorithm [8]. In contrast to the table-driven routing protocols, the reactive routing protocols don't uphold all up-to-date routes at every mobile host. As a substitute, the routes are fashioned whenever they are essential. When a source host needs to direct a datagram to a target, it appeals the route discovery mechanism to discovery the path. An instance is the Ad hoc On-demand Distance Vector Routing (AODV) [9], which is developed DSDV procedure. AODV diminishes the broadcasts rate by generating path on-demand which is opponent to the DSDV which gathers all the routing path. The Dynamic Source Routing protocol (DSR) [10] and Temporally Ordered Routing Algorithm (TORA) [11] are other on-demand routing protocols.

Owing to the lowered battery capacity in MANETs energy-aware routing is provided with huge attention in recent years. Similarly, the delay aware routing [12] is also pertains good reception rate. Energy-aware routing is a solution to extend the epoch of energy based nodes in mobile ad hoc networks [13], [14]. [15] As provided in [16], there are commonly two sorts of energy-aware routing constriants: Minimum Energy (ME) routing that selects path based on total energy consumed for packet transmission, and max–min routing that chooses the route which bottleneck residual node energy is the maximum. Communication delay of a packet transversely an ad hoc network is the latency paid by a packet to extent the target from the source. The modules of end-to-end latency of a packet at the network layer are processing delay, packetization delay, transmission delay, queuing delay and the propagation delay [17]. Consequently, the end-to-end delay of a path signifies the amount of delay incurred at every link along the path. Node delay includes the protocol processing time at node i for link (i, j), and link delay is the latency expended by the packet to portable from node i to node j, *i.e*. along link (i, j).

In this paper, ICSO grounded Energy-Delay aware Routing scheme is anticipated to overwhelmed energy, delay and security concerns in the preceding researches. The anticipated system employs the I-LEACH protocol for optimal cluster head assortment in the clustering stage. Then the intra and inter-cluster routing is achieved by means of optimal routes. The energy and delay aware optimized routing is attained by employing an enhanced version of Cuckoo Search Algorithm. The remainder of the paper is organized as follows: section 2 describes the various research methodologies related to this research paper. Section 3 explains the proposed Probability based Swarm Optimized Energy and Delay aware Routing scheme in detail. The experimental results are discussed in section 4 while section 5 makes a conclusion about this research work.

2. RELATED WORKS

In [18], the authors inaugurate a novel metric named as drain rate (DRi) intended by means of weighted moving average technique to precisely extent the energy debauchery rate in a specified node. The authors devise two mechanisms named as minimum drain rate (MDR) and conditional minimum drain rate (CMDR) that outperform energy-conserving protocols simply grounded the on residual energy of nodes.

A novel communication mechanism Random Cast, an extension of RCast [19] is designated in [20], which keeps substantial amount of energy by evading superfluous overhearing and unconditional forwarding of broadcast packets. Its foremost feature is toward decreasing energy spent in dynamic communications in a mobile adhoc network. An energy-efficient routing protocol named as progressive energy efficient routing (PEER) is anticipated in [21]. A link cost metric is advanced that takes into account the energy ingesting intricate with routing signaling packets *i.e*., the energy utilization throughout the route discovery phase. PEER protocol is capable to speed up path setup while adaptively altering the routing path to progress transmission and recital and diminish end-to-end energy utilization.

The device-energy-load-aware relaying outline (DELAR) [22] deeds the feature of device heterogeneity in an ad hoc network. The routing cost metric intricate takes into account the residual energy and congestion status of a node. It demonstrates well-organized in terms of overall energy consumption, packet delivery, and end-to-end delay. Authors in [23] recommend a location-based link stability and energy-aware routing (LAER) protocol for distributed wireless networks. A multi-objective delinquent is consequent which takes into account the dual metric of node energy (drain rate) and link stability [24]. Routes are designated centered on minimizing the energy utilization of mobile nodes and exploiting the link stability. By means of multi-objective replica LAER is able to address applications with diverse QoS restrictions. A flexible energy-efficient (E2) mechanism for substitute ad hoc communications is anticipated in [25]. It offers a balanced usage of node residual energy and decreases the letdown degree of a node. The E2 mechanism is capable to first-rate an energy-optimized route from a set of numerous routes with the least hop count and with the uppermost residual energy. A location grounded on demand routing method, power, and mobility-aware routing (PMAR) system is deliberated in [26]. It takes into account a dual metric connecting both energy and transmission power. PMAR gives considerable energy savings along with improvements in overall network lifetime and decreased delay.

Multicasting over time reservation by means of adaptive control for energy efficacy (MC-TRACE) [27] is an energy-efficient real-time multicast routing procedure for data communication in MANETs. The rudimentary design standards intricate in the energy efficiency multicast routing architecture is the formation and the conservation of an active multicast tree enclosed by a passive mesh within a system. The author anticipated a cross layered architecture multicast routing protocol that takes care of QoS, spatial reuse efficiency and total energy dissipation concurrently. Detecting broken tree branches in a high movement situation whereas by means of a tree-based protocol necessities more attention and it is touched very well by the incorporation of mesh phenomenon into it.

Morteza Maleki et al, [28] anticipated Power-aware Source Routing (PSR) which offers an alteration to DSR protocol by considering node movement and energy depletion as the cause behind link leftover in MANET. Intermediate nodes practices routing-battery cost function which is popular in header of RREQ. These nodes hand-picked the route with least battery cost. Thus this protocol guarantees that no path would be overused and every designated path has minimum battery cost amongst all likely path amongst two nodes. The route finding and upkeep are much difficult when compared to DSR as PSR reflects both movement and energy depletion situations for path inaccuracy. In [29], authors anticipate a cross-layer scheme to choose a stable route, grounded on node's current energy. They measured factors such as current energy of node, its average energy drain-rate and quantified session-duration as the standard for choosing an intermediate node. It iniatiates "make-before-break" mechanism for recognition of an alternate route for the session, when the node's energy gets drained when the session is wide-ranging. The uniqueness of the version of AODV is only local data, there is no additional communication overhead.

LEACH [30] protocol is cast-off for the energy efficient operation. LEACH progresses the life time of the system by redeemable the energy of the nodes and the data trafficking is abridged as the information from the nodes in a group are combined by the cluster head and directs to the base station. Few attacks like Sybil attack, selective forwarding, and hello flooding attack destroys the LEACH's recital by dropping, spoofing, replying or changing the data packets. Groups are dispersed unevenly and alienated randomly. If the cluster head expires information would never extent the base station.

Energy efficient LEACH (EE LEACH) [31] routing protocol is cast-off in wireless sensor network functioning grounded on optimal clustering and effective data ensemble. Gaussian distribution replica is cast-off to shield the network area. After cluster creation, the residual energy in the nodes of the cluster is intended. The node with the uppermost residual energy is designated to be the cluster head. The data aggression is completed by the cluster head before transfer it to the base station. Forwarding nodes are nominated grounded on the residual energy in them to onward the data aggregated by CHs to the base station. This protocol has lesser packet delivery ratio, lesser ingesting of energy. But it lacks to deliver integrity of the information and concealment.

In [32], the authors intend to express a novel meta-heuristic algorithm, entitled Cuckoo Search (CS), for resolving optimization difficulties. This algorithm is grounded on the obligate brood parasitic performance of certain cuckoo species in amalgamation with the Levy flight activities of some birds and fruit flies. It is authorized against test functions and then associates its recital with those of genetic algorithms and particle swarm optimization.

From the literature, it can be seen that furthermost prevailing routing systems considering energy, delay and other QoS factors offers improved recital in MANET. Nonetheless, most systems undergo either in any one of the factors: delay, energy consumption or network lifetime. As this research work is engrossed on rescue and emergency applications where all of these issues must be gratified for redeemable hundreds of life. Henceforth the idea of energy and delay aware is measured in the anticipated routing scheme.

3. PROPOSED METHODOLOGY FOR RESCUE & EMERGENCY APPLICATIONS

In this segment the anticipated routing procedure for rescue and alternative operations is described. So as to demonstrate the features of MANETs cast-off for rescue situations and the application necessities, an instance of a national rescue exercise is cast-off where numerous hundred persons essential to be rescued owing to a train accident in a tunnel. In this rescue operation, numerous teams from diverse organizations contribution and collaboration. The diversity of the teams elaborate and their specialized devices familiarize heterogeneity of devices and outlines on the scene. The devices can range from streaming servers to sensors reading the temperature, so many of them have restricted resources. They are all probable sources of data, but data becomes decayed very fast. Precise to the rescue situation is that personnel is frequently traveling and substitute in teams, and that team members are inclined to cooperate. Team members can nevertheless leave the neighborhood of their colleagues at any time when a condition unknown to the middleware difficulties it. At current, the GPS scheme is engaged to regulate the location of the nodes. Though, this kind of service will still not always be obtainable, since GPS devices will not always effort, *e.g*., in tunnels. It is sensible to consider that numerous nodes have significant information for other nodes, like temperature capacities of the air in diverse regions of the tunnel. Henceforth the MANETs are practical for this purpose in which the routing must be achieved with energy efficiency and least delay inorder to faster the rescue processes.

The anticipated routing procedure is a cluster grounded routing system. The MANET nodes are grouped inorder to progress scalability in superior networks with greater mobility. The clustering procedure is done by means of an Enhanced LEACH protocol in which the cluster head is designated grounded on residual and extreme energy of the nodes. Then the nodes that are nearby to the cluster head will be shaped into clusters. The inter-cluster and intra-cluster routing is achieved in effect transmission of information. While permitting routing, utmost cluster grounded routing systems deliberates only the energy efficiency although the transmission delay is not measured. In this anticipated method, the Cuckoo search algorithm is engaged for the routing procedure grounded on both the energy and delay. Thus well-organized routing is attained with least energy ingesting and abridged delay. Figure 1 displays the complete flow of the anticipated routing algorithm.

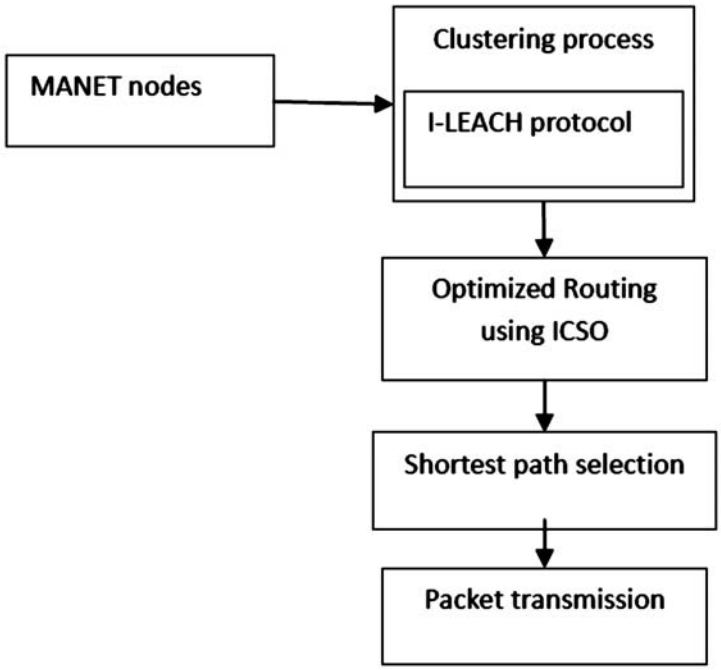

Figure 1: Flow of ICSO based Routing algorithm

3.1. Cluster head selection and cluster formation

The LEACH procedure which is a probabilistic technique can be engaged for the cluster formation and cluster head selection grounded on in MANETs. Nevertheless, the assortment of a node is not completed grounded on sum of energy, which could source difficulty in selection procedure to offer importance to a low power node. If low power node is not cast-off competently, added amount of nodes has to be engaged to form a group. LEACH practices single hop clustering routing and cannot be cast-off for greater networks. Diverse sums of preliminary energy cannot be measured in LEACH meanwhile CH rotation is achieved at respective round. Nodes with little energy, designated as CH could source energy holes and analysis difficulties. To overwhelmed these problems, energy deliberations and second cluster head are delivered giving importance to low power nodes. Thus the Improved LEACH (I-LEACH) has been established.

I-LEACH practices residual and extreme energy of the nodes to designate a head for every round. The anticipated procedure is cast-off to discovery the life time of the nodes in terms of rounds when the anticipated threshold and energy circumstances are measured. The nodes with energy fewer than to that of the (Etr) least energy prerequisite for transmitting and receiving signals is completed to die as it deficiencies energy to do it. Etr is deducted from the energy of the node s(i).e in each round as that much of energy is expended. Complete amount of alive nodes is intended for each round so as to have a trail on the life time of the system.

The flow chart in Figure 2 briefly entitles the employed of I-LEACH protocol. When the network arrives the setup stage, Ep, the probability by means of energy concerns is intended by consuming Emax, Cp and Ep, then the average energy of all the nodes are intended. Then the threshold value is calculated. An amount is haphazardly picked in the range 0 to 1. If the amount selected is fewer than the threshold value and the consistent node is allocated to be cluster head if its energy is added than that of the average energy. The energy essential for data transmission is presumed from the energy of the node in each round. When the energy drops below the least value, it is acknowledged to be dead. A graph is strategized for totality of alive nodes in every round. Thus the cluster head can be designated. This selection procedure benefits in choosing the optimal node as the cluster head and grounded on this head node, the adjacent nodes are clustered organized to practice clusters.

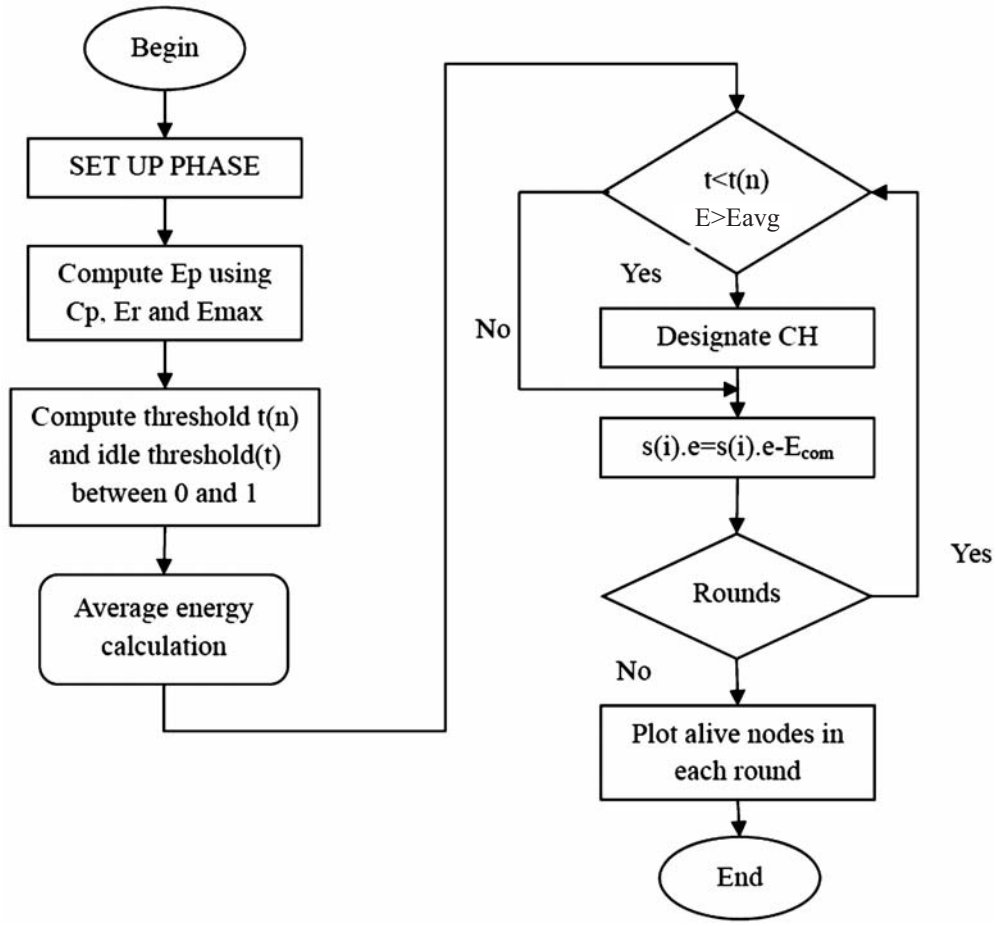

Figure 2: Proposed I-LEACH algorithm

Algorithm 1: I-LEACH

1. **Initialization :** N = ($n1$, $n2$, $n3$…,nn), E = ($e1$,$e2$,$e3$….,en), r = number of rounds, Ech = Energy of cluster head,$e0$ = preliminary energy of every node, Eavg = Average energy of all nodes in specific cluster., Ep = Probability by means of energy considerations, Er = reaming energy, Et r = energy essential for transmitting and receiving data Emax = Maximum energy of a node, TDMA = Time division multiple access
2. **Inputs :** Er, Emax, n, r, $e0$,
3. **Outputs:** CH, graph plotting alive nodes.
4. $\mathrm{E}_{\mathrm{avg}} = \sum_{j=1}^{n} en$
5. $i = 1$ to r
6. if ($ni \in$ N) then
7. $e0(i)$ = P*((Emax-Eused)/Emax)
8. $$t(n) = \frac{e0(i)}{1 - e0(i) \bmod \left(r.\,\mathrm{round}\left(\frac{1}{e0(i)}\right)\right.}$$
9. t = random number (0–1)
10. if(($t < t(n)$) && ($ei >$ Eavg)) then
11. CH ← ni

12. $s(i).e = s(i).e$– Etr //used to send information through TDMA

13. end if

14. $i = i + 1$

15. goto step 6

16. plot total alive nodes for each round

17. end if

In the given algorithm, Lines 1, 2 & 3 designates about diverse factors cast-off in preparing the code, inputs and outputs of the scheme. Line 4 designates about average energy used, which is cast-off later to associate the energy with other nodes and originate a subsequent cluster head that is cast-off to send data to destination by means of TDMA method. Line 5 designates about energy restrictions cast-off to regulate probabilistic value that is used to attain threshold in later stage. Line 6 designates end terms of a loop procedure for max amount of rounds. In line 7, the preliminary energy of every node is set. Line 8 deliberates threshold value that is cast-off to approximate cluster head of a node. Line 9 deliberates a random amount among 0 to1 and associates it with threshold value to regulate cluster head. In line 10, it is tested if the haphazard amount picked is fewer than threshold and node has sufficient energy to transmit information. Line 11 designates the assignment of primary cluster head. Line 12 defines about decreasing the Etr from energy of the node. Line13 and 14 increases the procedure to subsequent round, line 15 initiates the complete procedure again from line 8. Line 16 specifies the plotting of a graph amongst alive nodes and amount of nodes. Then the groups are molded dependent upon the cluster head with alike nodes are clustered underneath every cluster head.

3.2. Improved Cuckoo Search Optimization based Routing algorithm

The suggested Improved cuckoo search procedure grounded routing system offers energy and delay aware routing. The cuckoo search is an optimization procedure which is cast-off to enhance the Quality of Service (QoS) factors like network life time, energy level, throughput, bandwidth, delay, shortest path distance and packet delivery ratio. These species replicate by laying their eggs in the host birds' nest. Host birds position provides certain reproductive method of cuckoo birds, if a host bird recognize cuckoo eggs available its nest it will either toss away those alien eggs or desert its nest and make a new nest somewhere else. Cuckoo search optimization (CSO) is concerned on certain reproduction behavior, and is beneficial for numerous optimization difficulties. It pertains huge improved method than meta-heuristic algorithms.

CSO targets a novel and potentially enhances solutions (cuckoos) to substitute a not-so-good solution in the nests [33]. Fairly a amount of species engage the obligate brood parasitism by laying their eggs in the nests of other host birds (nodes). Some host birds can engage direct conflict with the intruding cuckoos. If a host bird discovers the eggs are not their own, they will either throw these alien eggs away or simply abandon its nest and build a new nest elsewhere. Some species of cuckoo can even mimic the color and pattern of the host bird's egg, so that the probability of the egg being noticed is abridged. They select a nest with eggs just rested for increasing the probabilities of hatching of their eggs. The flight performance of these birds displays a Levy flight distribution. The current CS procedure decreases the likelihood of their eggs being unrestricted and thus upsurges their reproductively. By exhausting the cuckoo search, the optimal energy and delay aware routing can be attained. Though the CSO has convinced problems in defining the factors P_a (fraction of worst routes), and step size α.

The factors P_a, Levy flights λ and α presented in the CSO support the procedure to catch globally and locally enhanced solutions, correspondingly. The parameters P_a, and α are very significant factors in fine tuning of solution vectors, and can be possibly cast-off in regulating convergence rate of algorithm. The outmoded CSO procedure practices stable value for both P_a, and α. These values are set in the initialization step and cannot be altered throughout novel generations. The foremost disadvantage of this technique appears in the amount of iterations to discovery an optimal solution. If the value of P_a is lesser and the

value of α is great, the recital of the procedure will be poor and leads to significant upsurge in amount of repetitions. If the value of P_a is huge and the value of α is small, the speed of convergence is great but it may be incapable to discovery best solutions. The key difference amongst the ICSO and CSO is in the method of adjusting P_a, and α. To progress the recital of the CSO procedure and remove the problems caused from considering fixed values of P_a, and α, the ICS procedure practices variables P_a, and α. In the primary generations, the values of P_a, and α must be big sufficient to apply the procedure to upsurge the variety of solution vectors. Nevertheless, these values should be reduced in concluding generations to outcome in an improved fine-tuning of routing solutions. The values of P_a, and α are energetically altered with the amount of generation and uttered in the subsequent equations

$$p_a(gn) = \frac{\left(a_{max} - p_{a_{min}}\right)}{p} \times gn \tag{1}$$

$$\alpha(gn) = \alpha_{max} \exp(c.\, gn) \tag{2}$$

Where $c = \frac{\ln\left(\frac{\acute{a}_{min}}{\acute{a}_{max}}\right)}{\square}$; NI and gn are the amount of complete iterations and the present iteration, correspondingly.

By expending ICSO procedure, the fitness of the global best solution progresses (discover the optimal energy & delay aware route). The paths also transfer about in the search space in close proximity to the global best and not discovering the rest of search space.

The optimal path is grounded on trails

$$E_{Tx} = E_{elec}\, k + \varepsilon_{amp}\, kd^2 \tag{3}$$

$$E_{Rx} = E_{Rx-elec}\, k \tag{4}$$

Where E_{Tx} and E_{Rx} are broadcast and reception of energy in the paths. Here '*k*' is the message length and '*d*' is the transmission distance. Thus energy debauchery diverges linearly with message length and as a square for transmission distance. The optimal trail will be at an optimum network lifetime, smallest delay, high packet delivery ratio, greater bandwidth and energy deliberation than other paths. The factors are intended grounded on the weight basis.

$$F_i = W_i\, D + W_2\, E + W_3\, P + W_4\, NL \tag{5}$$

Where W → weight values, D → minimum delay, E → improved energy, Pàpacket length and NL → network lifetime

$$x_i^{(t+1)} = x_i^{(t)} + \alpha \text{ Leavy } (\lambda) \tag{6}$$

Where α > → step size which should be associated to the scales of the delinquent of interests. In more cases, can practice α = 1. The above equation is fundamentally the stochastic equation for random walk. The product ⊕ means entry wise multiplications. Grounded on the alterations from CSO, the ICSO offers optimal routing with energy and delay concerns. Thus the routing in MANET converts well-organized by means of the anticipated algorithm. The subsequent algorithm obviously defines the ICSO grounded routing.

Algorithm 2: ICSO based Routing

Initialize each path weight = 0

Begin

Objective function $f(x)$, $x = (x_1,..., x_d)^T$

Generate initial population of n number of paths x_i, ($i = 1, 2, ..., n$) using (4)

While $e(t <$ MaxGeneration) //termination criterion

Get a cuckoo randomly by Levy flights

Evaluate the quality/fitness of paths F_i

Compute objective function using (5) which considers energy and delay of paths

Find high transmission paths with shortest distance using (3)

Choose a path among n (say x_i) randomly

If ($F_{x_{i+1}} > F_{x_i}$)

Replace x_i by the new path x_{i+1};

Else

Keep path x_i

End if

A fraction (P_a) of worse paths are abandoned and new ones are built using (1);

Keep the best paths with high transmission (low energy and less delay);

Rank the paths and find the current best

End while

Postprocess results and visualization

Update best path as optimal path

End

The optimal path designated by means of this ICSO procedure gratifies the simple QoS factors specifically energy and delay sideways with packet delivery ratio, network lifetime and load conditions. Thus the routing system improves the rescue operation throughout emergency situations with minimum delay in data sharing and long lasting system for continuous application.

4. EXPERIMENTAL RESULTS

Table 1

Simulation Parameters

Parameter	*Values*
No. of Nodes	100
Area Size	1100 X 1100 m
Mac	802.11
Radio Range	250m
Simulation Time	60 sec
Traffic Source	CBR
Packet Size	80 bytes

In this segment, the recital of the suggested ICSO grounded EDA routing procedure is estimated and associated with prevailing systems. The prevailing techniques explicitly AODV, ACO grounded routing and our preceding works specifically Hybrid ACO-MGA and Fuzzy aided ACO methods are associated with the anticipated ICSO grounded routing system. The trials are showed by means of NS-2 simulator. The imitation settings are specified in Table 1.

Performance Evaluation

End-to-end delay

The average time occupied by a packet to transfer from source to target across the system is well-known as End to End delay.

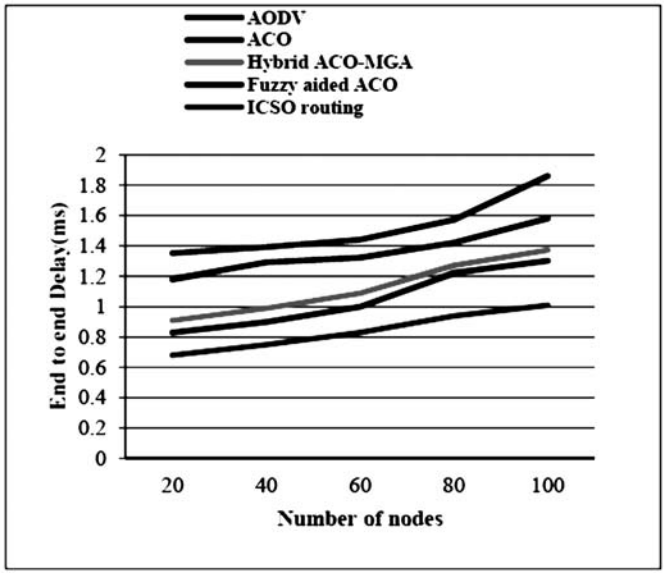

Figure 3: End-to-end delay comparison

Figure 3 displays the contrast of end to end delay recital for AODV, ACO, Hybrid ACO-MGA, Fuzzy aided ACO and suggested ICSO grounded routing. The nodes are changing from 20 to 100 and end to end delay is planned for such nodes in milliseconds (ms). From the graph it is vibrant that the ICSO grounded routing because of the consumption of delay factor in the assortment of optimal path outdoes the other replicas with least end to end delay.

Bandwidth

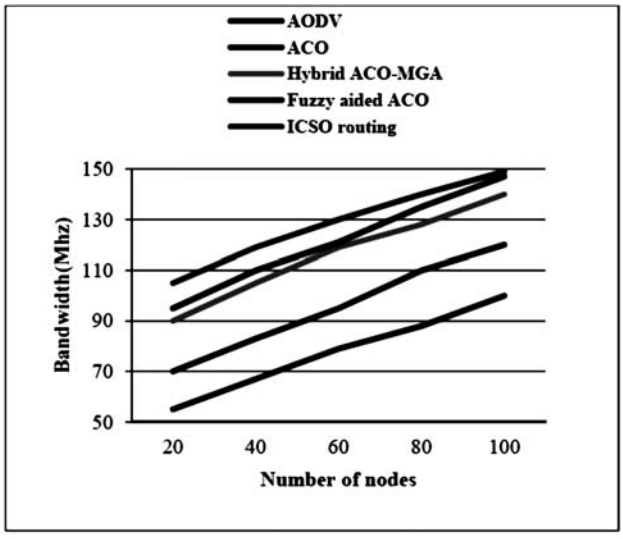

Figure 4: Bandwidth comparison

The network recital is entitled improved when it has advanced bandwidth range.

Figure 4 displays the contrast of bandwidth recital for AODV, ACO, Hybrid ACO-MGA, Fuzzy assisted ACO and anticipated ICSO grounded routing. The nodes are fluctuating from 20 to 100 and bandwidth is designed for such nodes in Mhz. From the graph it is perfect that the ICSO grounded routing outdoes the other replicas with advanced bandwidth.

Throughput

The amount in which the data packets are effectively transferred over the system or communication links is distinct as throughput. It is dignified in bits per second (bit/s or bps). It is also quantified by units of data administered over a specified time slot.

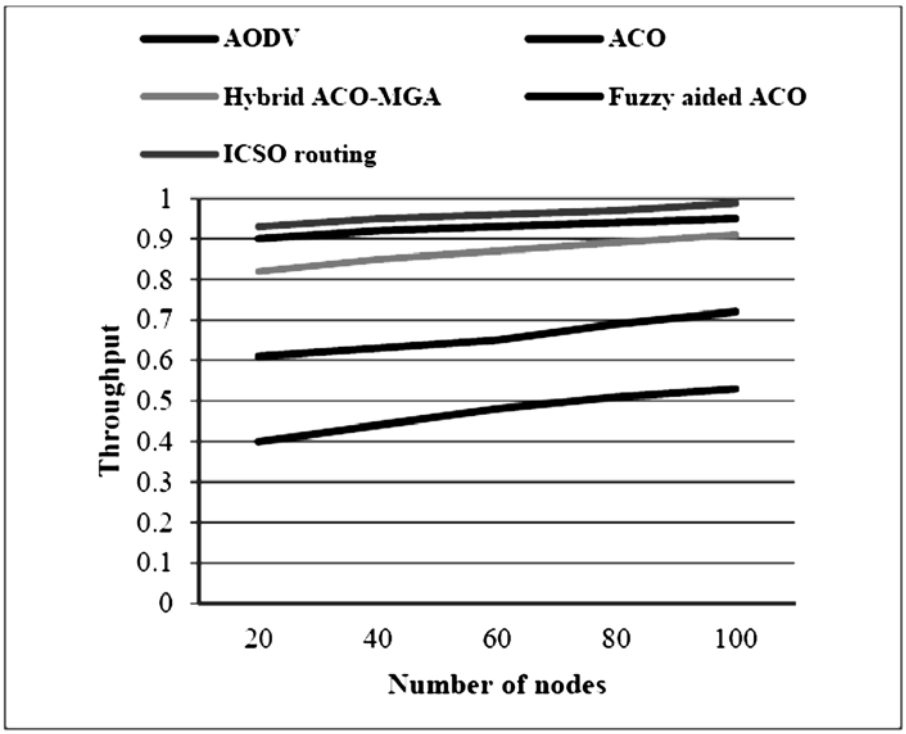

Figure 5: Throughput comparison

Figure 5 demonstrates the contrast of throughtput recital for AODV, ACO, Hybrid ACO-MGA, Fuzzy aided ACO and anticipated ICSO grounded routing. From the graph it is perfect that the ICSO grounded routing delivers advanced amount than other replicas owing to the practice of energy and delay aware routing idea.

Packet deliver ratio

The proportion of packets that are effectively distributed to a target associated to the amount of packets that have been directed.

Figure 6 displays the contrast of packet delivery ratio recital for AODV, ACO, Hybrid ACO-MGA, Fuzzy aided ACO and anticipated ICSO grounded routing. The nodes are changing from 20 to 100 and packet delivery ratio is strategized for certain nodes per seconds. From the graph it is vibrant that the ICSO grounded routing owing to the assortment of optimal path outdoes the other replicas with great packet delivery ratio.

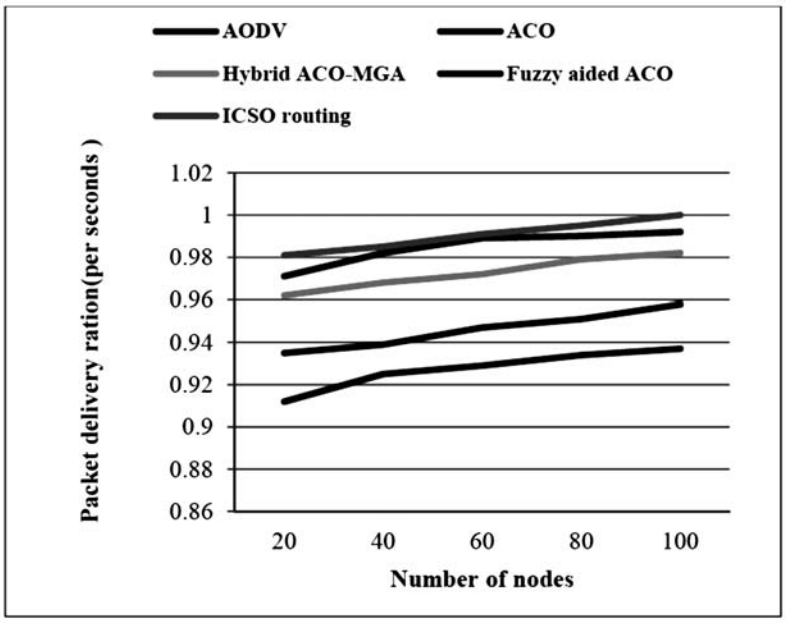

Figure 6: Packet delivery ratio comparison

Energy consumption

Energy consumption is the usual energy essential for sending, receiving or forward processes of a packet to a node in the system throughout the period of time.

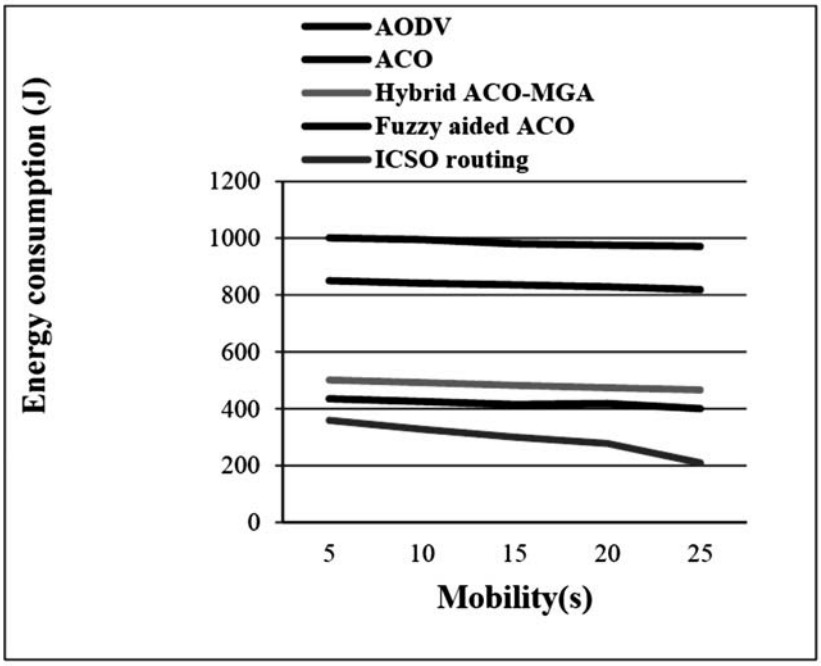

Figure 7: Energy consumption

Figure 7 illustrates the contrast of energy utilization for AODV, ACO, Hybrid ACO-MGA, Fuzzy aided ACO and anticipated ICSO grounded routing. The movement is changing from 5 to 25s and energy utilization is strategized for certain nodes in Joules (J). From the graph it is obvious that the ICSO grounded routing owing to concern of residual energy outstrips the other replicas with low energy utilization.

Network lifetime

Network life was experiential to be proportionate to the energy left in the nodes.

Figure 8 illustrates the evaluation of network epoch for AODV, ACO, Hybrid ACO-MGA, Fuzzy aided ACO and suggested ICSO based routing. The network size is 1100x1100m. From the graph it is distinct that the ICSO based routing owing to deliberation of residual energy outdoes the other replicas with great network lifetime.

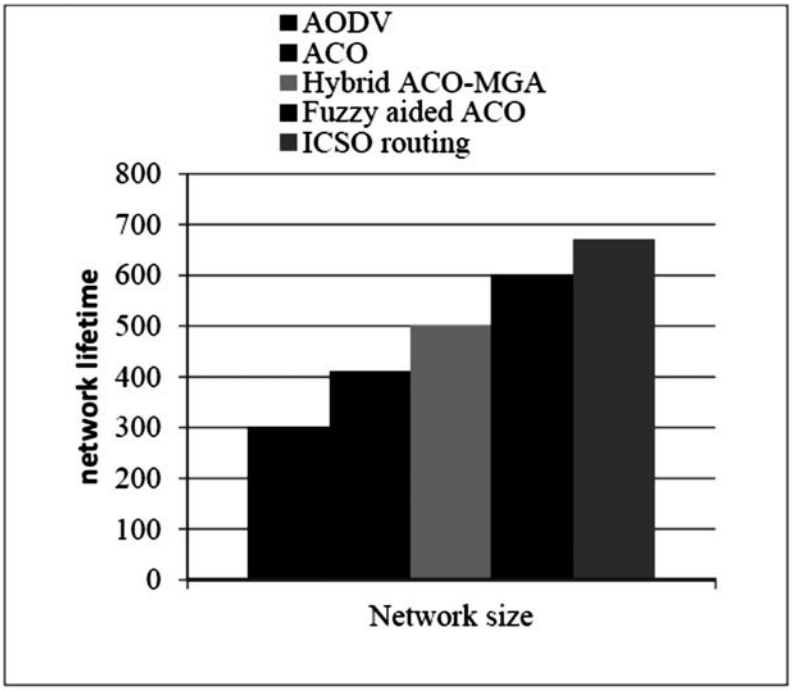

Figure 8: Network Lifetime

Reliability

Reliability is the safety factor measured in a system which describes the dependability of packet transmission along a designated path.

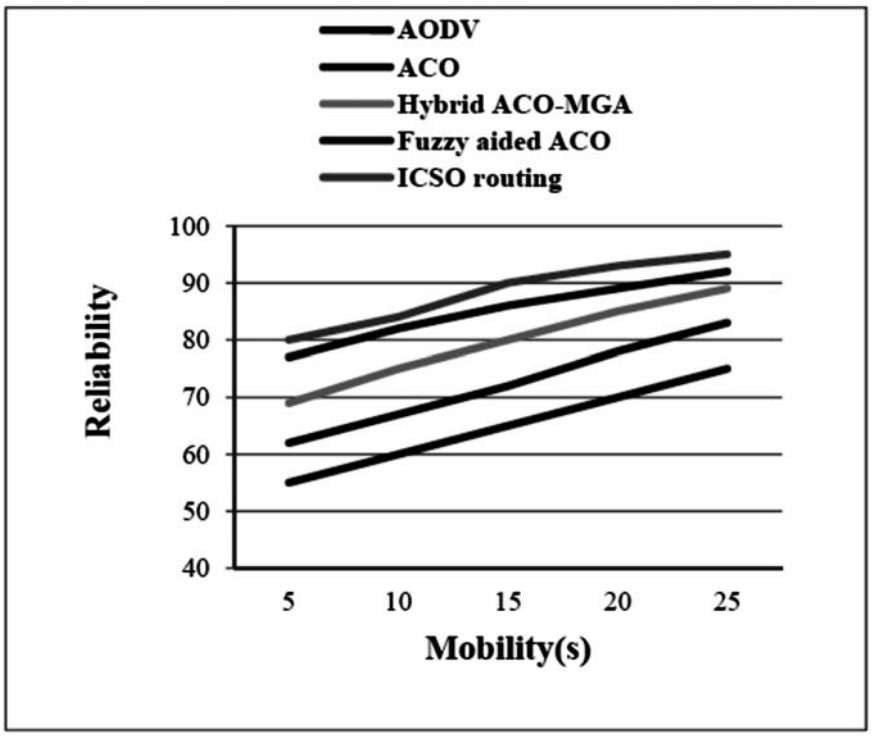

Figure 9: Reliability

Figure 9 demonstrates the contrast of dependability for AODV, ACO, Hybrid ACO-MGA, Fuzzy aided ACO and recommended ICSO based routing. The movement is changing from 5 to 25s and the consistency is strategized along y axis. From the graph it is distinct that the ICSO based routing owing to deliberation of residual energy outperforms the added models with high consistency. From these outcomes it is shown that the anticipated ICSO based routing scheme offers optimal energy and delay aware routing in MANET for rescue operations in crisis situations.

5. CONCLUSION

This investigation suggests ICSO grounded energy-delay aware routing procedure for well-organized routing in MANETs for the rescue and crisis application. This method optimally groups the nodes with the cluster head assortment procedure is completed using an Improved LEACH (I-LEACH) protocol. The energy efficient and delay aware shortest paths are resolute by the ICSO Algorithm. Thus the routing paths are designated with energy efficiency and minimal delay with abridged security intimidations from diverse attacks. This method offers low energy and small delay with improved packet delivery and load circumstances than most prevailing cluster grounded routing organizations. The outcomes accomplish that the suggested routing algorithm offers well-organized routing for rescue operations in relationship to enhanced performance.

6. REFERENCES

1. S. Basagni, M.Cont, S.Giordano, I.Stojmenovic, “Mobile ad hoc networking”, JISR, 2004, pp. 201-207.
2. Y. Jiazi, A. Asmaa, D. Sylvain, P. Benoît, “Multipath optimized link state routing for mobile ad hoc networks”, Ad Hoc Networks 9, 2011, pp. 28-47.
3. M. Abolhasan, T. Wysocki, E. Dutkiewicz, “A review of routing protocols for mobile ad hoc networks”, Ad Hoc Networks 2, 2004, pp. 1–22.
4. M. Tarique, K. Tepe, S. Adibi, Sh. Erfani, “Survey of multipath routing protocols for mobile ad hoc networks”, Journal of Network and Computer Applications 32, 2009, pp. 1125–1143.
5. Boukerche, A., Turgut, B., Aydin, N., Ahmad, M. Z., Bölöni, L., & Turgut, D. (2011). Routing protocols in ad hoc networks: A survey. *Computer networks*, *55*(13), 3032-3080..
6. Mohseni, S., Hassan, R., Patel, A., & Razali, R. (2010, April). Comparative review study of reactive and proactive routing protocols in MANETs. In *4th IEEE International Conference on Digital Ecosystems and Technologies* (pp. 304-309). IEEE.
7. S.Y. Wang, , J.Y Liu, C.C. Huang, M.Y. Kao, Y.H. Li, “Signal strength-based routing protocol for mobile ad hoc networks”, In: Proceedings of 19th International Conference on Advanced Information Networking and Applications, 2005, pp. 17–20.
8. Wang, J. W., Chen, H. C., & Lin, Y. P. (2010). A secure destination-sequenced distance-vector routing protocol for Ad hoc networks. *Journal of Networks*, *5*(8), 942-948.
9. C.E. Perkins, E.M. Royer, S.R. Das, “Ad hoc on demand distance vector (AODV) routing” , IETF Mobile Ad Hoc Networks Working Group, 2003, pp. 205-212.
10. D.B. Johnson, Y-C Hu, D.A. Maltz, “The Dynamic Source Routing Protocol (DSR) for Mobile Ad Hoc Networks for IPv4”, RFC 4728, 2007, pp. 87-96.
11. Pirzada, A. A., & McDonald, C. (2004, May). Trusted route discovery with TORA protocol. In *Communication Networks and Services Research, 2004. Proceedings. Second Annual Conference on* (pp. 121-130). IEEE.
12. Zaki, S. M., Ngadi, M. A., & Razak, S. A. (2009). A review of delay aware routing protocols in MANET. *Computer Science Letters*, *1*(1), 48-60.
13. S. Misraa, S.K. Dhurandherb, M.S. Obaidatc, P.Guptab, K. Vermab, P. Narulab, “An ant swarm-inspired energy-aware routing protocol for wireless ad-hoc networks”, The Journal of Systems and Software 83, 2010, pp. 2188–2199.
14. [Zh. Guo, S. Malakooti, S. Sheikh, C. Al-Najjar, M. Lehman, B. Malakooti, “Energy aware proactive optimized link state routing in mobile ad-hoc networks”, Applied Mathematical Modelling 35, 2011, pp. 4715–4729.
15. J. Vazifehdan , R. Venkatesha Prasad, E. Onur, I.Niemegeers, “Energy-aware routing algorithms for wireless ad hoc networks with heterogeneous power supplies”, Computer Networks 55, 2011, pp. 3256–3274.

16. L. Lin, N.B. Shroff, R. Srikant, "Asymptotically optimal energy-aware routing for multihop wireless networks with renewable energy sources", IEEE/ACM Trans. Network. 15, 2007, pp. 1021–1034.
17. Jagadev, A. K., Pattanayak, B. K., Mishra, M. K., & Nayak, M. (2010). Power and Delay Aware On-Demand Routing For Ad Hoc Networks. *arXiv preprint arXiv:1012.0887*.
18. Kim, D., Garcia-Luna-Aceves, J.J., Obraczka, K., Cano, J.-C., Manzoni, P.: Routing mechanisms for mobile ad hoc networks based on the energy drain rate. IEEE Trans. Mobile Comput. 2(2), 161–173 (2003)
19. Lim, S., Yu, C., Das, C.: RCast; a randomization communication scheme for improving energy efficiency in mobile ad hoc networks. In: Proceedings of 25th IEEE International Conference Distributed Computing Systems (ICDCS'05), pp. 425–432, (2001)
20. Lim, S., Yu, C., Das, C.R.: RandomCast: an energy efficient communication scheme for mobile ad hoc networks. IEEE Trans. Mob. Comput. 8(8), 1039–1051 (2009)
21. Zhu, J., Wang, X.: Model and protocol for energy-efficient routing over mobile ad hoc network. IEEE Trans. Mobile Comput. 10(11), 1546–1557 (2011)
22. Liu, W., Zhang, C., Yao, G., Fang, Y.: DELAR: A device energy load aware relaying framework for heterogeneous mobile ad hoc networks. IEEE J. Sel. Areas Commun. 29(8), 1572–1584 (2011)
23. De Rango, F., Guerriero, F., Fazio, P.: Link stability and energy aware routing protocol in distributed wireless networks. IEEE Trans. Parallel Distrib. Syst. 23(4), 713–726 (2012)
24. De Rango, F., Guerriero, F., Marano, S., Bruno, E.: A multiobjective approach for energy consumption and link stability issues in ad hoc networks. IEEE Commun. Lett. 10(1), 28–30 (2006)
25. Ramrekha, T.A., Talooki, V.N., Rodriguez, J., Politis, C.: Energy efficient and scalable routing protocol for extreme emergency ad hoc communications. Mobile Network Appl. 17(2), 312–324 (2012)
26. Tan, W.C.W., Bose, S.K., Cheng, T.H.: Power and mobility aware routing in wireless ad hoc networks. IET Commun. 6(11), 1425–1437 (2012)
27. Tavli, B. and Heinzelman, W.B. (2011) 'Energy-efficient real-time multicast routing in mobile ad hoc networks', *IEEE Transactions on Computers*, Vol. 60, No. 5, pp.707–722.
28. Morteza Maleki, Karthik Dantu, and Massoud Pedram, "Power-aware Source Routing Protocol for Mobile Ad Hoc Networks", IEEE proceedings on Low power electronics and design, Monterey, California USA, August 12-14 2002, pp: 72-75.
29. Mallapur Veerayya, Vishal Sharma, Abhay Karandikar, "SQ-AODV: A Novel Energy-Aware Stability-Based Routing Protocol for Enhanced Qos In Wireless Ad-Hoc Networks", IEEE Military Conferences, San Diego, USA, November 16-19, 2008, pp:1-7.
30. An Efficient Utilization of Spectrum in Wireless Mobility by Retransmission Mechanism" in Central government NISCAIR, Journal of Scientific & Industrial Research (JSIR), New Delhi, india in September 2015 issue
31. Arumugam, Gopi Saminathan, and Thirumurugan Ponnuchamy. "EELEACH: development of energy-efficient LEACH Protocol for data gathering in WSN."EURASIP Journal on Wireless Communications and Networking 2015, no. 1 (2015): 1-9.
32. Public Control Algorithm for a Multi Access Scenario comparsing GPRS and UMTS ",at Department of Computer Science and Engineering, National Conference on "Intelligent computing With IoT on April 16 2016 in Dhirajlal Gandhi College of Technology.
33. "Cluster based Key Management Authentication in Wireless Bio Sensor Network ", ,International Journal of pharma and bio sciences, Impact Factor = 5.121(Scopus Indexed).