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Optimal Fault Tolerance Using Intuitionistic Fuzzy and Selection of Cluster Head in MANET

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Abstract— In recent years exploration of wireless devices with small in size and platforms based on processing mobile have bring great attention towards the ad hoc networks. These Ad hoc networks are generally consists of temporary links connected among the nodes. MANET is such a dynamic network which compromises many good qualities to handle the wireless communication devices which are roaming randomly. MANET holds certain restriction on them because of the energy, battery consumption, load management, etc. Due to the nodes mobility nature and the characteristic of error prone nature the wireless medium pretense a lot of confronts, together with recurrent route change and packet losses, in the way of conferencing the necessities of QoS. Such disputes amplify packet delay, reduces throughput and lesser network failure.
The first phase adapts the behavior of ants to discover the route and the intuitionistic fuzzy estimation is used to find the direction for searching the optimal route and the fault occurred in the node or link is handled using the check point and fault manger. In nature MANET are logically realized as a set of clusters by grouping together nodes which are in close proximity with one another or through another wireless node. The nodes communicate to the base station directly for data transfer. But it is not efficient in mobile environment because of the energy restriction on each node. The second phase focuses on such issue by creating the cluster topology to group similar nodes by adapting intuitionistic fuzzy k means and electing the cluster heads using the evolutionary algorithms known as genetic algorithm. Then elected cluster head collects the data from other nodes within the cluster and aggregates the data packets for transferring it to the base station directly or by gateway or cluster heads of other clusters. The simulation model for each phase is deployed using MAT lab and the outcome of the result shows that in each phase the proposed techniques performs better than other existing techniques discussed in each phase due to their enhancement in the proposed techniques.

Keywords—Intuitionistic fuzzy, cluster head, optimal route

I. INTRODUCTION

A temporary network with collection of mobile nodes which moves adversial without any control on central authority and not having any standard devices like traditional network is termed as Ad hoc Network [1]. In this Ad hoc environment due to the limited capability of transmission power each node needs help of their nearby nodes for sending their packets to the destination. These neighbor nodes act as intermediate nodes for forwarding packets. Thus in this type of network each node plays the role of host and the router. This is greatly adapted in real time networks where a fixed network environment cannot be able to deploy. Some of the real time applications are during discussions, sensor based networks, emergency situations and military services. These areas require different specification of routing protocols.

In general Ad hoc network holds dynamic topology due to the mobility nature of the nodes and this will influence the effects on characteristics of the network. These mobile nodes hold restriction on CPU, bandwidth of the path and memory consumption because these nodes are functioning using battery power. This will necessitate network utility that is source effectual. Additionally, the wireless media will also influence the activities of the net due to irregular link bandwidths ensuing from comparatively high fault rates.

These exclusive enviable features cause numerous novel issues in the aim of wireless Ad hoc networking protocols. Functions of networks such as routing, allocation of address, verification and permission must be intended to handle with a dynamic and unstable network topology. In order to set up routes among nodes, which are beyond than a single hop, especially configured routing protocols are unavailable.

Section I contains the introduction of Ad hoc network and its characteristics, Section II contain the related work of the distribution of loads and its energy consumption, Section III

contain the methodology to develop efficient techniques on load balancing in MANET, Section IV describe the results and discussion of the algorithm, Section V concludes the research work with future directions.

II. RELATED WORK

The major issue that affects the performance of Mobile Ad hoc Network (MANET) is the distribution of loads among the sensor nodes in a balanced way. The nodes in MANET holds limited power consumption and resources so when the large volume of data packets are passed to a node beyond its capability and it doesn't have any means to share the load to other nodes means then data transfer is too complex. The irregularity in usage of power consumption leads to disproportion of nodes. There are circumstances where some of the nodes possibly idle and few will be overloaded. A node which has more processing power completes its individual work speedily and is expected to have a smaller amount or no load at the majority of the time. So, in the incidence of under-loaded nodes keeps idle, the necessity for over-loaded nodes is unpleasant.

There are many approaches on load balancing based routing techniques in the MANET environment. Next to load balancing most existing designs of ad hoc networks are based on the hypothesis of non-adversarial environments, i.e., each node in the network is supportive and well performed. Nevertheless, in adversarial environment, disobedient nodes forever survive, and may appreciably disgrace the routing recital. In such cases designing and developing routing protocols poses additional confront when one needs to propose routing schemes in the existence of adversarial environments in MANET. The necessity for fault tolerant routing protocols was recognized to deal with routing in adversarial environments, purposely in the existence of faulty nodes, by exploring network redundancies. Hence this work takes these two factors as major issues load balancing and fault tolerance in designing routing protocols in MANET and developed an enhanced mechanism.

With the development in the computing environment, the applications and services of the MANETs have also increased. MANETs are susceptible due to an assortment of physical characteristics of environments and devices itself. This proposed work put forth the design and development of protocols focusing on load balancing with fault tolerance in MANET.

Lack of failure recovery mechanism in MANET

One of the benefits of multipath is that when a node fails to deliver a packet, the protocol could performance packet salvaging for fault tolerance. With packet salvaging, intermediate nodes maintain multiple routes to the destination and a RERR message propagates only until an intermediate node cannot forward the packet along an alternate path. This leads to overhead in designing an efficient fault tolerance mechanism to decrease the route discoveries in MANET.

Lack of energy consumption in MANET

Another important issue in efficient load balancing is energy consumption. The topology control plays an important technique to reduce consumption of energy and increase the network life time. In this work clustering is adopted for feasibility of selecting cluster head and devising shortest path with balanced load sharing among cluster heads in MANET

The objective of this work is to develop an efficient and intellectual routing protocol in MANET to overcome the imbalance of load along with failure recovery. This is achieved more precisely by the proposed work

1. Ant colony optimization based fault tolerance and load balancing using Intuitionistic Fuzzy Estimation is proposed to handle both fault tolerance and load balancing based on Intuitionistic Fuzzy Estimation and Ant Colony Optimization Algorithm. In this work the best part of the intuitionistic based starting strategy is utilized to choose the potential path in MANET along with failure recovery using check points.
2.
3. Deploying an Optimized Cluster head selection approach for Link Stability with Load Balancing in MANET using Reliable Shortest Route AOMDV. This proposed work finds the minimum load shortest path among the sender node and base station by framing the clusters and electing the cluster heads for data transfer in the aggregated form.

III. METHODOLOGY

This methodology encompasses of two different phases and their aim is to develop efficient techniques on load balancing in MANET. The first phase handles the problem of fault tolerance in path chosen for traversal of packets. During data transmission if any of the link failure occurs then using the check point manager and fault tolerance the data can be passed in alternative shortest path without loss of any packets. It is attained by proposing the bio-inspirational based IFEACO algorithm which performs load balancing with effective fault tolerance. The potential of traditional ACO is increased by introducing Intuitionistic Fuzzy Estimation as a starting strategy instead of scheduling packets randomly to the ants. The fault tolerance is overcome by checking point index manager. The second phase is related to energy consumption of nodes so that the load can be distributed evenly among the sensor nodes. This is deployed by clustering the nodes using Intuitionistic Fuzzy k-means and from the clustered nodes. A cluster head is selected for each cluster using genetic algorithm which elects the optimal node based on the characteristic of them like energy, density, centrality and the distance between nodes.

After the cluster head is selected each node within the cluster passes the packet to the cluster head where cluster head collects the data, aggregates them and then send to the base station by choosing the shortest path prevailed. Thus it saves the energy consumption of the nodes. The figure depicts the overall framework of the work.

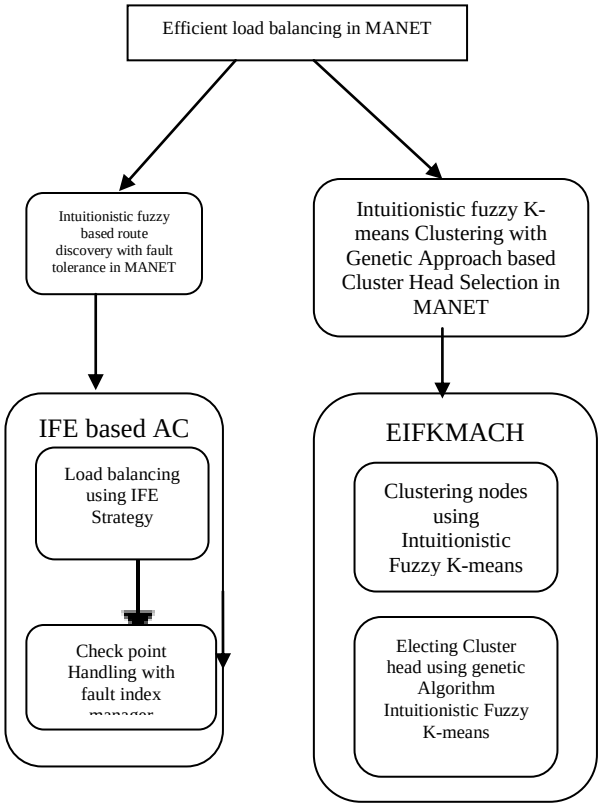

Figure 1:Overall Framework of this Work

Phase 1:An optimized Intuitionistic fuzzy based route discovery with fault tolerance in Mobile Adhoc Networks

The proposed algorithm has introduced the novel approach on existing ant colony optimization in MANET resource allocation problem. The known ACO algorithms generate a solutions starting from a random node. But for some problems, especially subset problems, it is important from which node the search process starts. For example, if an ant starts from node that does not belong to the optimal solution, probability to construct it is zero. In this paper intuitionistic fuzzy based estimation strategy is adapted in which the start node of each ant depends on the goodness of the respective region. This work also considers the fault tolerance by introducing checking points on particular criteria to manage a reliable load balancing. The general Ant Colony Optimization approach for load balancing have been modified by using start point IFE based strategy along with the checkpoint and fault index of resources to meet the fault tolerance issue in order to improve the throughput and make the effective utilization of available resources in a computational MANET environment.

Initializing from the ACO with IFE based start node strategy selection where ants will move continuously through the nodes in the MANET in search of food laying down the pheromones and updating the pheromones tables. ACO Algorithm will initially declare the threshold levels of each node in the MANET and will check the timer of ants and the load on the node, if the load on the node is below the threshold value [17], the control will flow to the Checkpoint algorithm which includes the following components:

A) Checkpoint Manager:

It receives the scheduled packet from the scheduler implemented by the ACO, sets the checkpoint based on the failure rate of the resource on which it is scheduled and submits the packet with checkpoints to the resource. Then the checkpoint manager receives packet delivery failure message from the MANET resource and responds to that accordingly. Checkpoint manager implements checkpoint setter algorithm to set packet checkpoints.

B) Checkpoint Server:

For each checkpoint the status of packet is returned to the checkpoint server. Checkpoint server save the packet status and return the packet status and last checkpoint whenever required i.e. during packet/resource failure.

C) Fault Index Manager:

Fault index manager updates the fault index of a MANET resource using fault index update algorithm depending upon the failure rate of the resource. The fault index of a MANET resource is incremented every time the resource does not complete the assigned packet within the deadline and also on resource failure. The fault index of a resource is decremented whenever the resource completes the assigned packet within the deadline.

Once the packet is completed update the pheromones on both the previous as well as on the current node. Again check if the node is under load, if yes then reassign the resources and reschedule the packet and if no then traverse to the node with maximum trailing pheromones ,update the pheromones on both nodes and repeat traversing until the node is overload, otherwise reassign the resources again.

Phase 2:An Evolutionary Intuitionistic fuzzy K-means Clustering Approach based Cluster Head Selection in MANET

This proposed work implements two stages in the Clustering phase the sensor nodes are clustered using the Intuitionistic Fuzzy K-means clustering using the membership and non-membership value of each factors taken into the account. Once clustering phase is over then the cluster head is selected

based on the highest fitness function obtained using the genetic algorithm here the node with highest energy consumption and lower distance from base station and neighboring nodes are considered as optimal cluster head. The data packets are aggregated and transferred using the cluster head to the base station. During each round the cluster in reframed using Intuitionistic Fuzzy k-means.

The main motive of this work is to reduce the energy consumption and to prolong the network lifetime in MANET in case of uncertainty in cluster head selection.

Novel Genetic algorithm based Intuitionistic fuzzification techniques in selection of cluster heads from clusters

After Clustering of nodes, the best node is selected based on the optimal value of energy, density, centrality and the distance between nodes one should be selected from each cluster. In this paper genetic algorithm technique is proposed in order to consider Intuitionistic fuzzy memberships of attributes of nodes in clusters during selection. At first each feature is consider to belong to a cluster which has highest membership degree. Members of r^{th} cluster are represented by member r. Rank of each feature in its cluster is calculated and the one with the highest ranks are selected as the candidate. For calculating the rank of each feature in Intuitionistic fuzzy approach technique assigns a positive weight to the inter-dependency of features which are belonged to membership to cluster r. It also assigns a negative weight as a penalty to the interdependency of features as non-membership to cluster r. The assigned weight is equal to the membership degree of the feature in its cluster.

Set-up Phase:

First phase is the set-up phase and it is performed only one time.

- In the set-up phase, pre-defined numbers of sensor nodes are chosen as cluster heads.
- The number of CHs also indicates the number of clusters in the network.
- Intuitionistic fuzzy K-means based Cluster formation
- Once the Initial Clusters heads are selected and framed clusters then each Non-CH nodes are assigned to the clusters based on Intuitionistic fuzzy K-Means clustering
- The non-CH nodes with similar range of membership and non-membership values are assigned to different clusters based on the features of residual energy, density, centricity and distance.
- Once Cluster formation is completed then the optimal cluster head is selected Steady State Phase based on Genetic Algorithm based Cluster head Selection
- In this phase the potential cluster head is selected using genetic algorithm.
- In the method, GA is used to maximize the lifetime of the network by means of rounds. Binary representation of the network is used and each sensor node corresponds a bit. CHs are represented as "1" and non-CH nodes are represented as "0".
- The representation of a network is called a Chromosome or Genome, a collection of bits. Initially the GA starts with a population, a pre-defined number of chromosomes, consists of randomly generated individuals.
- Then GA evaluates each chromosome by calculating its fitness. Fitness of a chromosome depends on some fitness parameters described as follows

$$F=\sum_i (f_i X w_i) \forall f_i \in (R_{FND}, R_{LND}, -C)$$

  - Where, w value is an application-dependent weight of a fitness parameter that indicates which parameter is more effective for the function.
  - RFND: The round which first nodes dies
  - RLND: The round which last node dies
  - C: The cluster distance is the sum of the distances from the member nodes to the CH and the distance from the CH to the BS.
- After evaluating the fitness of each chromosome in the population, GA selects the best fit chromosomes by using a specific selection method based on their fitness values and then applies two operators, Crossover and Mutation, respectively. These operations are carried out to produce a new population better than the previous one for the next generation.
- The Cluster Head for each round is selected the node with highest fitness value ie the residual energy and distance from its neighbor nodes are considered.
- The elected CH node once it receives messages from all member nodes, it fuses the data packets into one packet and sends it to the base station (BS).
- When all CHs send their data to BS, a round is completed.
- At the end of each round the BS checks the fitness function (energies) of CHs and the member nodes. If the energy of a CH is under the average energy of the member nodes of its cluster then the reclustering is performed using Intuitionistic Fuzzy K means.
- This round is completed, and the next round begins with a set-up phase and a steady-state phase; this process is repeated

IV. RESULTS AND DISCUSSION

This section discusses about the simulation result conducted on the each of the two proposed phase of this work in detail

Experimental Results of Intuitionistic fuzzy based ant colony route discovery with fault tolerance in Mobile Adhoc Networks

The comparison of the proposed IFEACO method with ACO algorithm and three traditional packet scheduling algorithms: First-Come-First-Served (FCFS), Largest Job First (LJF) and Shortest-Job-First (SJF).

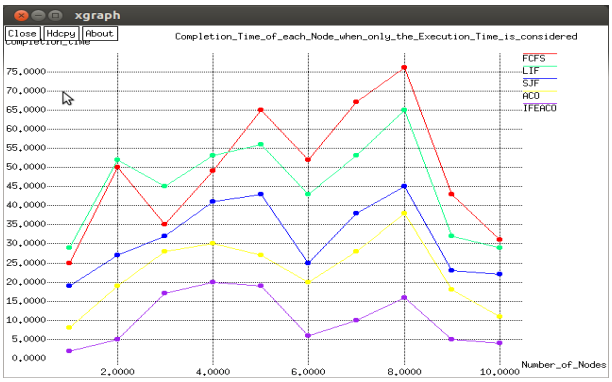

Figure 2

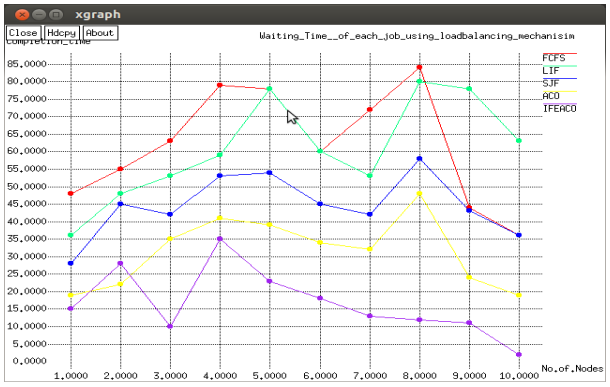

Figure 3

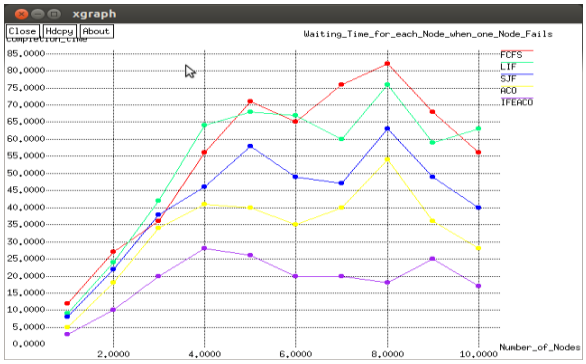

Figure 4

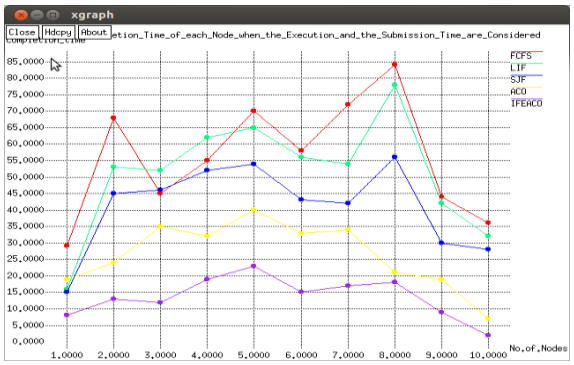

Figure 5

Figure: 2 to Figure 5- Performance comparison of proposed work with other algorithms based on five different factors

The comparison result of the proposed work with other existing algorithms is shown in the figures. The Figure 2 to Figure 5 shows the Completion Time of each Node when only the Execution Time is considered. In Figure it can be viewed that all the nodes have minimum completion time when using the IFEACO algorithm as compared to others. This completion time includes the execution time and the waiting time of all packets at their nodes.

The figure 2 compares the Completion time of each Node when the Execution and the Submission Time for proposed method with others. Total waiting time of each packet contains the execution time of all previous packets plus the time from its submission to the time when it gets a processor. The results are shown in Figure and hence it can be concluded that the proposed IFEACO algorithms have similar completion times as compared to other algorithms when the submission time is considered.

The figure 3 depicts the Waiting Time of each packet by using Load Balancing Mechanism and it is revealed that proposed algorithm continuously monitors each node, and, if any node becomes overloaded, the packets are migrated from one node to another

The figure 4 shows the comparison result of Waiting Time for each Node- when one Node Fails In order to support fault tolerance, packets on node 4 are distributed between different nodes taking care of the completion time as well as the load balancing using checkpoint-restart during runtime. The results are shown in Figure 5. It is depicted that that the proposed IFEACO algorithm outperforms all other algorithms despite the failure of nodes.

Simulation Result of Evolving Intuitionistic Fuzzy K means based cluster head selection approach

The performance of using Evolving Intuitionistic Fuzzy K means based cluster head selection approach can be clearly seen in Figure 6, 7 and 8. The proposed method outperforms LEACH and SEP Schemes

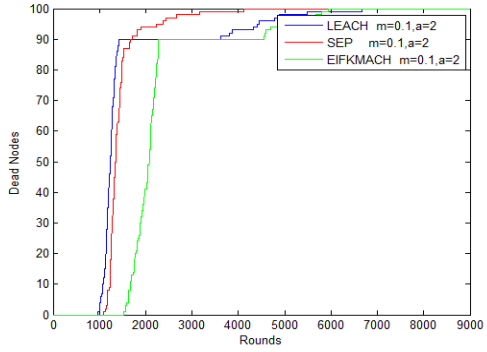

Fig 6 Peformance comparision based on Rounds vs dead nodes

The figure 8 shows the performance of LEACH, SEP and EIFKMACH schemes based on number of rounds vs dead nodes. The number of rounds varies from 1000 to 9000. Each rounds the dead nodes are determined for each scheme and the result shows the lower number of cluster head nodes found dead in proposed Scheme comparing to other existing scheme used in this work. This due to the selection of cluster head with highest residual energy with the help of intuitionistic fuzzy K-means based clustering and selection of highest fitness value based nodes as cluster heads in MANET.

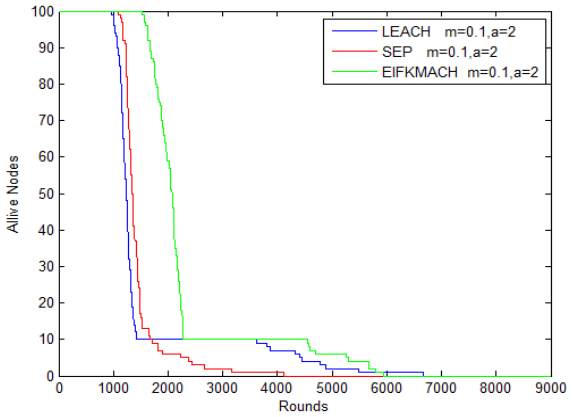

Fig 7 Performance comparison based on Rounds vs Alive nodes

The figure 7 shows the performance of LEACH, SEP and EIFKMACH schemes based on no of rounds versus number of alive nodes. The number of rounds varies from 1000 to 9000. In each round alive nodes are determined for each scheme and the result shows the increase number of cluster head nodes prolonged life time in proposed Scheme comparing to other existing scheme used in this work. This due to the selection of cluster head with lowest member ship value of distance from the base station to cluster head and the non cluster head density with the help of intuitionistic fuzzy K-means based clustering and selection of highest fitness value based nodes as cluster heads in MANET.

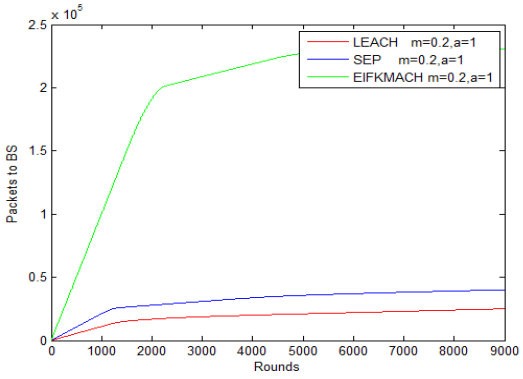

Figure 8 Performance Comparison based on Rounds vs Packets to Base station

The figure 8 shows the performance of LEACH, SEP and EIFKMACH schemes based on number of packet delivered to base station from the cluster head. The number of rounds varies from 1000 to 9000. The packet delivery ration of the each scheme is determined and the result shows that the proposed work deliveries more number of packets to the based station due to the optimal selection of cluster head. This due to the selection of cluster head with lowest member ship value of distance from the base station to cluster head and the non cluster head density with the help of intuitionistic fuzzy K-means based clustering and generation of promising nodes as population in each round, election of cluster head with highest fitness value with the distance as the factor.

V. CONCLUSION AND FUTURE SCOPE

This work focuses on effective load balancing with shortest route discovery in mobile Ad hoc networks. The work executes in two different aspects to overcome the problem of load imbalance. First if the failure occurred in the path or nodes its previous state or data information is recovered using the check point manager and the fault index manager using the intuitionistic fuzzy ant colony optimization with well defined starting strategy for search the optimal route. Finally the energy consumption is well performed by performing clustering of the sensor nodes using the intuitionistic fuzzy K-means and electing the cluster head among the sensor nodes of each cluster to collect, aggregate and transfer data packets to the base station in an efficient way. Thus the work achieves its objective by development and design of these two phases.

REFERENCES

[1] Jayakumar, Geetha Gopinath G, *Ad hoc mobile wireless networks routing protocols--a review*. ,Journal of Computer Science, Source Volume: **3** Source Issue: **8, 2007**.

[2] Narasimhan, B. and S.S. Baboo, 2009. *A hop-by-hop congestion-aware routing protocol for heterogeneous mobile ad-hoc networks*. Int. J. Comp. Sci. Inform. Security.

[3] Venkata subramanian, S. and N.P. Gopalan, 2009. *A QoS-based robust multipath routing protocol for mobile adhoc networks*. IACSIT Int. J. Eng. Technol., 1: **391-396**.

[4] Fard, M.A.K., S. Karamizadeh and M. Aflaki, 2011. *Enhancing congestion control to address link failure loss over mobile ad-hoc network.* Int. J. Comput. Netw. Commun.

[5] Yi, J., A. Adnane, S. David and B. Parrein, 2011. *Multipath optimized link state routing for mobile ad hoc networks*. J. Ad Hoc Netw., 9: 28-47. DOI:10.1016/j.adhoc.2010.04.007.

[6] Liu, S. and J. Liu, 2010. *Delay-aware multipath source routing protocol to providing QoS support for wireless ad hoc networks.* Proceedings of the 12th IEEE International Conference on Communication Technology (ICCT), Nov. 11-14, IEEE Xplore Press, **Nanjing**, pp: **1340-1343**, DOI:10.1109/ICCT.2010.5689050.

[7] C. Liu, C. Lee, L.ChunWang, "*Distributed clustering algorithms for data gathering in wireless mobile sensor networks*", Elsevier

Sci. J. Parallel Distributed Computing., Vol.**67**, 2007, pp.**l187 - 1200**

[8] W. Heinzelman, A. Chandrakasan and H. Balakrishnan., "*An Application -Specific Protocol Architecture for Wireless Microsensor Networks*", IEEE Trans. Wireless Communications, Vol. **1**, No.**4**, October 2002, pp.**660-670**.

[9] W. Heinzelman, Application - *Specific Protocol Architectures for Wireless Networks*, Ph.D Thesis, Massachusetts Institute of Technology, June **2000**.

[10] G. Smaragdakis, I. Matta, A. Bestavros, SEP: *A Stable Election Protocol for clustered heterogeneous wireless sensor networks*, In Second International Workshop on Sensor and Actor Network Protocols and Applications (SANPA), **2004**

[11] D. J. Baker and A. Ephremides. *A Distributed Algorithm for Organizing Mobile Radio Telecommunication Network*. In proceedings of the 2nd International Conference on Distributed Computer Systems, page **476 - 483**, April **1981**.

[12] D. J. Baker and A. Ephremides. *The Architectural Organization of a Mobile Radio Network via a Distributed Algorithm*. IEEE Transactions on Communication, COM - 29 11:1694, 1701. November **1981**.

[13] Ratish Agrawal, Dr. Mahesh Motwani, "*Survey of Clustering Algorithm for Mobile Ad hoc Network*", IJCSE, Vol. **1** Issue 2, pp. **98-104**, **2009**

[14] M. Gerla and J. T. Tsai, "*Multicluster, Mobile, Multimedia Radio Network. Wireless Network*," **1995**

[15] R.S. Walse, G.D. Kurundkar, P. U. Bhalchandra, "*A Review: Design and development of Novel Techniques for clustering and classification of data" ,*International Journal of Scientific Research in Computer Sciences and Engineering, Vol **06,** Special Issue **01,** pp **19-22, Jan 2018**

[16] G. Abare, E. J. Garba, "*A Proposed Model for Enhanced Security against Key Reinstallation Attach on Wireless networks,* International Journal of Scientific Research in Network Security and Communication- Vol **7**, Issue 3, PP **21-27**, June **2019**

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