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Predicted Fitness Based Clustering Algorithm for Manets

C.Kalaiselvi, S.Palaniammal

Abstract*: Secure data delivery, mobility, link lifetime, energy consumption and delay are the most important parameters to be highly concentrated in the self-organised network named manets. Where in Manets the nodes move unpredictably in any direction with restricted battery life, resulting in frequent change in topology and due to mobility the trust in packet delivery will suffer inside the network. These constraints are studied broadly to ensure the secured data delivery and the lifetime of such networks. In this paper we propose a PFCA(Predicted fitness based clustering) algorithm using fitness value. The cluster heads are selected based on the fitness value of the nodes. Whereas the fitness value is calculated using the trust value, link lifetime for different type of node mobility and energy consumed and the clusters are formed using the PFCA clustering algorithm. The proposed PFC algorithm is experimented in the NS-2 network simulator and the results are compared with the existing PSO-clustering algorithm. The results show the effectiveness of our proposed algorithm in terms of network overhead, average number of clusters formed, average number of re-clustering required, delay and packet delivery ratio.

Index Terms: Clustering, Fitness, Link reliability, Mobile adhoc networks(MANETS), Trust.

I. INTRODUCTION

MANETs [1] comprises of mobile node which are dynamically distributed in random manner without and pre-ordering or centralized control. One of the special characteristics of the network is, it is a multi-hop network. Data transformation is done in this network by hop-by-hop method. For instant communication it sets up a temporary network and due to node mobility there is a frequent changes in routes. It has a wide applications in the scenarios which includes disaster rescue emergency assistance, online payments, military services and so on [2],[3]. In case of emergencies and for many real time applications the high QOS is very much needed in the mobile ad-hoc networks.

The nature of ad-hoc networks is the network topology and the link between the nodes changes frequently. In the network any node will quit the network at any time mean while any new node will join the network. Due to ever changing network topology routing is a very big problem and finding an optimized route is a significant process in Manets. Proper routing algorithm enables efficient routes, less end-to-end delay and increased network throughput. In any network the route should be an optimized one to reduce the time and energy consumption. Many routing protocols have been proposed to find the optimal route. There are two types of routing protocols which are topology based routing protocols and the other one is position based routing protocol. Topology based protocols totally rely on the networks and their links where the position based protocols depends on the position of the nodes. Further the topology based protocol have two subcategories, they are proactive approach and reactive approach. In proactive approach when a route is decided from the source to destination each and every node in the network will be aware of the current route. It frequently monitors all possible routes in network and update the status of the current route to every node in the network. The only disadvantage of the approach is it will monitor all the possible paths in the network even though which are currently not in use. Reactive protocol is also named as on demand protocol because it will monitor the route when there is a need for a route from the source to destination. The dynamic source routing(DSR) is an example of on-demand reactive routing protocol. The Rest of the paper is organized as follows: In section.2 literature reviews are discussed. In section 3 the Mathematical Model is explained and the parameters are discussed one by one. In section 4 the proposed PFCA is presented. In section 5 the results of the proposed method is discussed. Finally the conclusion of the paper is presented in section.6.

II. REVIEW OF LITERATURE

This section describes the recent researches done to find optimal routing protocols for MANETs.

Due to the decentralized structure of the network trust of any node in the network is a difficult task to analyse. Many researchers have studied trust based routing algorithms for MANETs[4],[5]. The authors in [6], have discussed a trust based routing protocol for MANETs in which the trust values are calculated directly and indirectly. The trust value is found by matching the sequence ID from the log reports of the neighbour nodes that avoids the malicious nodes. They compared the results with many existing protocols and proved that their proposed work yields good results in average end-to-end delay, throughput, false positives and packet delivery ratio. In the research work [7] the authors have designed a new hybrid protocol by combining LA(Lion Algorithm)[8] with WOA(Whale Optimization Algorithm)[9] for MANETs.

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* Correspondence Author
C.Kalaiselvi*, Department of Mathematics, Sri Krishna College of Technology, Coimbatore, Tamilnadu, India.
Dr.S.Palaniammal, Principal, Sri Krishna Adithya College of arts and Science. Coimbatore, Tamilnadu, India.

In this hybrid M-LionWhale algorithm the authors have considered five parameters such as trust energy, delay, distance and link lifetime. Using such parameters the fitness of the nodes are computed in a way to find the optimal routes.

In the paper [10] the authors utilised the link availability metric to design a reliable routing technique for aeronautical adhoc network. In this method they first propose a Semi Markov Smooth Mobility model to depict the airlines behaviour in the sky. By using the mobility model the probability density function for the relative speed of node is calculated and in addition they find the expectation of the link lifetime. The authors distinguish their proposed work by comparing their work with the existing traditional routing techniques.

In the article [11] the authors developed a FWCA (Forecast Weighted Clustering Algorithm) in the basis of WCA(Weighted Clustering Algorithm) for MANETs. In this system the cluster heads are chosen by considering the weight of the nodes. And the proper cluster heads are chosen by the method of considering the FWCA value of the previous node instead of the current FWCA value. Due to the usage of FWCA the wrong selection of cluster head is avoided. They have compared the simulations results of FWCA with WCA and reported proposed one is better.

The authors in [12] have established an energy efficient clustering algorithm for MANET using the bio-inspired PSO(Particle Swarm Optimization) approach. In this algorithm two things are majorly concentrated like mobility awareness and energy efficiency in the network. The cluster head selection using PSO will take care of the mobility and energy of the nodes and also the longer duration of a node being a cluster head. The cluster heads are chosen by considering the velocity, position and distance of the nodes where the strength of the cluster heads are optimized using a fitness function. The authors conclude that the proposed method works good than the existing protocols.

In the research paper [13] the authors have used a hybrid protocol named ACRRCC(Ant Colony based Rate Regulating Congestion Control) to design an efficient load balancing and congestion control routing for MANETs. In this algorithm the efficient path is selected using ACO(Ant Colony Optimation) method and the congestion is controlled by a predator –prey method. They compared the proposed hybrid method with the simple ACO and conclude that this hybrid algorithm is a best routing method.

In the paper [14] the authors have proposed a QoS based hybrid routing technique for MANETs. In this works the two QoS parameters such as delay and mobility rate. Initially the possible path sets from source to destination are found using ACO. After fifty iteration the work of GA(Genentic algorithm) starts. From the set of possible paths the optimal paths are found using GA by considering QoS parameters such as bandwidth, residual energy and buffer overflow. After a simulation study of the proposed work the author accomplishes that the proposed algorithm yields good results.

In the research paper [15] the authors have introduced the artificial neural network for WSN(Wireless Sensor Networks) for data transferring process. In the paper [16] the author have analysed an energy consumed and the delay in data delivery fir a WSN using opportunistic protocol instead of MAC(Medium Access Control). In [17] the authors have designed a hybrid protocol for WSN by combining ACO with AODV. The significance of this method is, if pheromone value is not available in the roué reply. The destination node uses the throughput , remaining energy cost and count to rely a route to the source node.

III. PROPOSED MATHEMATICAL MODEL

The main idea of the proposed PFCA algorithm is to design efficient routing protocol using clustering technique. This clustering algorithm is designed by calculating the fitness of the nodes participated in the data transmission procedure. Initially the clusters are formed and using the fitness value the cluster heads are selected which are responsible for the data transmission from source to destination and to find a optimal route by reducing the delay and energy consumption. The fitness value is obtained by considering three important factors such as trust, energy, mobility prediction, link lifetime which are summarized one by one in the following sections

A. Trust Value:

In manet system every node have many nodes as neighbours in its transmission range. In the data transmission process the source node will be in a search for the proper neighbour node to transmit data and to define a path from source to destination. From the set of neighbour nodes the exact neighbour is selected to transmit data is found by calculating the trust value of the nodes. The trust values are calculated for the nodes whose distance from the source node is less than the transmission range. The distance is calculated using RSSI (Received Signal Strength Indicator) value using the following formula

$$Dist_{s,i} = RSSI(N, G_i) \quad (1)$$

where N is the input node, $Dist_{s,i}$ is the signal strength between the source node S and the current node 'i' and G_i is the ith node in the graph. After calculating the distance the trust values of the nodes are obtained. Let $Trust_{xy}(i)$ is the trust degree of node x on node y which is obtained based on the packet forwarding and receiving capability of the node and the trust value is computed by two factors called direct trust and indirect trust values of the nodes.

$$Trust_{xy}(i) = \omega Trust_{xy}^{DT}(i) + \gamma Trust_{xy}^{IDT}(i) \quad \text{….} \quad (2)$$

Where $Trust_{xy}^{DT}(i)$ is the direct trust value of node 'x' on its neighbour 'y' at time 'i'. $Trust_{xy}^{IDT}(i)$ is the indirect trust value of the node 'x' on its neighbour 'y' at time 'i'which is the trust degree of neighbour nodes of 'x' have on 'y', since the neighbours of 'x' are also the neighbours of y. The trust value ranges from 0 and 1 where, 0 represent the mistrust and 1 represent full trust value of the neighbour nodes. ω and γ are the fitness factors ranges from 0 and 1. The direct trust value is calculated based on the packets received by the node 'x' and the packets forwarded by the node 'y'.

$$Trust_{xy}^{DT} = \frac{P_{xy}^{RX}(i)}{P_{xy}^{SY}(i)} \quad (3)$$

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Indirect trust degree is the mean of the trust degrees of the neighbour nodes of x which are also the neighbours of y.

$$Trust_{xy}^{IDT}(i) = \left(\frac{1}{N_d}\right) * \sum_{d=1}^{N_d} Trust_{xy}^{IDT}(i) \quad (4)$$

where N_d is the number of neighbouring nodes at time 'i' . this factor improves the trust value of the nodes by identifying nodes the malicious and choosing the nodes with full trust values for packet forwarding process. This trust factor is restructured in the iteration process using a moving average model as follows:

$$Trust_{xy}^{*}(i+1) = \tau * Trust_{xy}(i) + (1-\tau) Trust_{xy}(i+1) \quad (5)$$

where τ is the fitness factor used to maintain the stability in the present and previous iteration which lies in a range $0 < \tau < 1$, and $Trust_{xy}(i+1)$ is the trust value at time i+1. The trust values of all the neighbouring nodes which are involved in the data forwarding process are always maintained in a table.

B. Energy Consumed:

In the communication networks the energy is consumed by data transferring, receiving, and routing processes. The energy consumed in the proposed method is designed by considering different attributes like initial energy, energy consumed when receiving one packet, energy consumed when transmitting one packet, energy consumed in sleep state and the energy consumed in the idle state. The energy consumed by a node Ni at time interval Δt is given by

$$Energy_{consumed}(N_i, \Delta t) = Energy_{res}(N_i, t_0) - Energy_{res}(N_i, t_1) \quad (6)$$

Where $Energy_{res}(N_i, t_0)$ and $Energy_{res}(N_i, t_1)$ denote the residual energy of the node Ni at time t_0 and t_1 respectively.

C. Mobolity Prediction:

Node mobility is a major problem in manet because of the unpredictable topology changes. And due to node mobility there will be link breakage which leads to loss in data packets and energy in the network. In this proposed system to avoid link breakage as given in [18] we calculate the link life time of two nodes which will help in propoer data transfer to appropriate node in its transmission range. We consider speed of the nodes as four types such as high speed, idle speed, low speed and pause state which are represented as $X = \{H_\alpha, I_\beta, L_\sigma, P_\varphi\}$.

i) High Speed state(H_α) :

In this state H_α the node speed Ns will uniformly accelerate from 0 to a target value Ns_α . Suppose T_0, D_α, a_α and λ_α represents the initial time, direction of moving, rate of acceleration and duration in this high speed state. $Ns_\alpha, \lambda_\alpha$ and D_α are distributed uniformly as $\lambda_\alpha \sim U(\lambda_{\alpha\,min}, \lambda_{\alpha\,max})$, $Ns_\alpha \sim U(Ns_{min}, Ns_{max})$ and $D_\alpha \sim U(0, 2\pi)$. The time elapsed in this phase is $T_\alpha = T_0 + \lambda_\alpha$ and the rate of acceleration is $a_\alpha = \frac{Ns_\alpha}{\lambda_\alpha}$. As in [18] the probability density function of the node speed Ns_α in high speed phase isdefined as

$$r_V^{\alpha}(Ns) = \begin{cases} \frac{2}{Ns_{min} + Ns_{max}}, & 0 \le Ns \le Ns_{min} \\ \frac{2}{Ns_{min} + Ns_{max}} * \frac{Ns_{max} - Ns}{Ns_{max} - Ns_{min}}, & Ns_{min} \le Ns \le Ns_{max} \end{cases} \quad (7)$$

ii)Idle Speed state (I_β):

In the idle speed phase the nodes moves in a straight line direction DE_β with a speed Ns_β . There will be a change in nodes movement direction from DE_β at any time. To realize the smooth change from H_α to I_β the difference between DE_β and D_α should be within D_d^β which should be greater than zero and the memory degree $\delta\ [\delta \in (0,1)]$ should lie between Ns_α and c. Also this model assigns a Gaussian random variable Y0 in the formulation of Ns_β as in [18] and $Y_0 \in N(0,1)$

Let $T_\beta = T_\alpha + \lambda_\beta$ where $\lambda_\beta \sim U(\lambda_{\beta\,min}, \lambda_{\beta\,min})$, $DE_\beta \sim U(D_\alpha + D_d^\beta, D_\alpha - D_d^\beta)$ and the initial node speed this phase $I_\beta(Ns_0^\beta)$ is same as Ns_α . Now Ns_β is calculated as follows:

$$Ns_\beta = \delta\ Ns_0^\beta + (1-\delta) Ns_\alpha + \sqrt{1-\delta^2}\, Y_0$$
$$= Ns_\alpha + \sqrt{1-\delta^2}\, Y_0 \quad (8)$$

The probability density function of the node speed Ns_β is defined as

$$r_V^{\beta}(Ns) = \left\{ \frac{G\left(\frac{Ns - Ns_{min}}{\sqrt{1-\delta^2}}\right) - G\left(\frac{Ns - Ns_{max}}{\sqrt{1-\delta^2}}\right)}{Ns_{max} - Ns_{min}}, \quad 0 \le Ns \le Ns_{min} \right. \quad (9)$$

where $G(x)=\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{x}\exp\left(\frac{y^2}{2}\right)dy$.

From the above derivation in this phase Ns_β is extended to a multi-state Gauss Markov process.

iii)Slow Speed state (L_σ):

In the idle speed phase the speed of the node Ns uniformly decreases from Ns_0^β to 0. Now $T_\sigma = T_\beta + \lambda_\beta$ and $a_\alpha = \frac{Ns_0^\sigma}{\lambda_\alpha}$. Change in the nodes moving direction is represented by D_d^σ and it should lie within the range D_α and DE_β where $D_\sigma \sim U\left(DE^\beta + D_d^\sigma, DE^\beta - D_d^\sigma\right)$.

Let $\tilde{Y}_0 = \sqrt{1-\delta^2}\,Y_0$ then $\tilde{Y}_0 \sim N(0,1-\delta^2)$. As given in [18] we assume Ns_0^σ is uniformly distributed as Ns_α and according to 3-sigma principle $\tilde{Y}_0 \in \left[-3\sqrt{1-\delta^2}\ ,3\sqrt{1-\delta^2}\right]$ Applying the above two assumptions in equation (7) we get

$$P\left(Ns_0^\sigma > Ns\right)=\frac{Ns_{\max} + 3\sqrt{1-\delta^2} - Ns}{Ns_{\max} - Ns_{\min} + 6\sqrt{1-\delta^2}}$$

(10)

As given in [18] L_σ have symmetric properties with H_α hence we get

$$r_V^\sigma(Ns)=\begin{cases}\frac{2}{Ns_{\min}+Ns_{\max}}, & 0 \le Ns \le Ns_{\min}^{low} \\ \frac{2}{Ns_{\min}+Ns_{\max}}.P\left(Ns_0^\sigma > Ns\right) & Ns_{\min}^{low} \le Ns \le Ns_{\max}^{up}\end{cases}$$

(11)

where

$Ns_{\min}^{low} = Ns_{\min} - 3\sqrt{1-\delta^2}$, $Ns_{\max}^{up} = Ns_{\max} + 3\sqrt{1-\delta^2}$. These assumptions made in this phase does not affect the formulation of $r_V^\beta(Ns)$.

iv) Pause state (P_ϕ):

In the pause state the nodes will not move for a random interval $\left[T_\sigma, T_\phi\right]$ where $t_\sigma \sim U\left(T_{\sigma\, min}, T_{\sigma\ max}\right)$ and $T_\phi = T_\beta + \lambda_\sigma$

Based on the above defined parameters we can estimate the link lifetime in the following section as given in [18].

E. Link Lifetime $\left(LL_{ij}\right)$:

The link lifetime between any two nodes is estimated using the RLL_{ij} (Residual link life time) of the nodes i and j. Let us denote $\vec{V}_i$ and $\vec{V}_j$ as the speed of the nodes Ni and Nj and the relative speed as $\vec{V}$. $\theta(\theta \sim U(-\pi,\pi))$, μ ,η and R represents the angle between $\vec{V}_i$ and $\vec{V}_j$, angle between $\vec{V}$ and $\vec{V}_j$, Ni's original direction to Nj and the transmission range of the nodes respectively. The cumulative distribution function (CDF) of RLL_{ij} is calculated as in [18] is given below

$$F_{RLL_{ij}}\left(t_{ij}\right)=P\left(\frac{R_{ij}\cos(\mu+\eta)+\sqrt{R^2 - R_{ij}^2\sin^2(\mu+\eta)}}{Ns}\right) \le T_{ij}$$

(12)

$$F_{RLL_{ij}}\left(t_{ij}\right)=\int_{-\pi}^{\pi}\int_{\varpi}^{N_{\sup}} r_{Ns,\mu}\ d(Ns)\,d\mu.$$

(13)

Where

$$\varpi = \frac{R_{ij}\cos(\mu+\eta)+\sqrt{R^2 - R_{ij}^2\sin^2(\mu+\eta)}}{T_{ij}}$$

and Ns_{up} is the V's upper limit of Vi and Vj in all specific phases $X=\left\{H_\alpha, I_\beta, L_\sigma, P_\varphi\right\}$. As explained in [19] the final result is given as follows

$$r_{V,\mu}(Ns,\mu)=\int_{Ns_j}\frac{Ns\, r_{v_i}^p\left(Ns_i^*\right) r_{v_j}^q\left(Ns_j\right)}{2\pi\sqrt{Ns^2 + Ns_j^2 + 2Ns\,Ns_j\cos\mu}}\,dNs_j$$

(14)

Where $Ns_i^* = \sqrt{Ns^2 + Ns_j^2 + 2Ns\,Ns_j\cos\mu}$,

$r_{v_i}^p$, $r_{v_j}^q$ are defined in previous sections and $p,q \in \{\alpha,\beta,\sigma,\phi\}$. The link lifetime is defined as the probability of the existing link's RLL value greater than the threshold(thr).

$$LL_{ij} = P\left(RLL_{ij} \ge thr\right)=1-F_{RLL_{ij}}(thr)$$

(14)

LL_{ij} value lies between 0 and 1 and LL_{ij} is calculated by using (14) in equation (13).

Fitness Calculation:

Based on the parameters discussed in the previous sections such as trust, energy, mobility and link lifetime the fitness of a node is calculated as folloes:

$$Fitness_k = \frac{1}{3}\left[\sum_{n=1}^{N} Trust_{xy}(i) + \sum_{n=1}^{N} Energy_{consumed}\left(N_i, \Delta t\right) + \sum_{j=1}^{N-1}\sum_{i=j+1} \frac{LL_{ij}}{\rho}\right]$$

(15)

Where ρ is the parameter that normalizes LL_{ij}.

D. Predicted Fitness Based Clustering Algorithm.

In this proposed PFCA algorithm the source nodes calculates the fitness of all noes in its transmission range initially to form clusters. Cluster formation algorithm is given in table1. Once the clusters are formed the cluster heads are selected. The source will node will have the fitness information of all its neighbour nodes and due to some data traffic many eligible nodes cannot send its fitness value to the source node on that time wrong cluster head selection may occur. To overcome this problem we propose a predicted fitness based algorithm is used. In PFCA algorithm the considers the current fitness value as well as the previous fitness value of a node whereas in normal fitness calculation current fitness alone is used. This leads to a proper cluster head selection which is given in table 2. The nodes in the clusters broadcast their fitness values and the predicted fitness is calculated as follows:

$$PF = k\, Fitness_{current} + (1-k) Fitness_{previous} \quad (16)$$

$$PF_{i(t+1)} = k \sum_{l=0}^{t-1} (1-k)^l Fitness_{i(t-k)} + (1-k)^l Fitness_i \quad (17)$$

$PF_{i(t+1)}$ is the predicted fitness value of period (t+1) at time t, $Fitness_{i(t-k)}$ is the fitness value in the period (t-1) at time t and $Fitness_i$ is the fitness value at time t.

Table:1 Cluster Formation Algorithm

Input: number of nodes
Output: forms the number of clusters
Initialize Cluster=1
Redo
Choose the node Ni randomly and collect its one-hop neighbours satisfying the distance value Dists,I
Do
N=ni , d<Dists,i
Now a cluster is formed with Ni as center and d as radius.
Compute new radius $dist_1 = d + \lvert n_i - n_j \rvert$
While $n_i \neq n_j$
Cluster-1 is formed with cooperating nodes lying within the circle;
End

Now the number of cluster are formed in the network next the cluster head is selected which is given in the next section.

A. Cluster head and member selection

In the cluster head selection procedure one of three different situations occurs for non-member nodes of a domain set

(1) Non-members nodes of a domain set receive introducing messages from a cluster head. In this case, the node joins the origin cluster;

(2) Non-member nodes of a domain set introduce reply messages to a cluster head. In this case, the free nodes join a cluster head with highest value and introduce themselves to the cluster head as the gateway;

(3) Non-member nodes of a domain set receive no message. In this case, a node with the highest fitness value is chosen as the cluster head and others are the members

B. Clusters' Maintenance Phase:

This phase starts immediately after creation of the first cluster. This phase is activated when one of the following problems occurs. PFCA algorithm has a solution for each problem.

Case 1 : A node leaves its cluster range

In this case, the node needs to join a new cluster. The node that left the cluster sends a message to cluster heads in its transmission range. When a cluster head is ready to accept the node, it sends back a message and declares its value. By comparing received values from multiple clusters (if any), the node joins a cluster with the highest value.

Table:2 Cluster Head Selection Algorithm

$Fitness_{current} \leftarrow 0$
$Fitness_{previous} \leftarrow 0$
$time_{previous} \leftarrow 0$
$current\ time(\ ) \leftarrow 0$
$Time - time\ out\ loop \leftarrow 3 * counter$
$Fitness\ value\ is\ evaluated\ using\ equation(15)$
$If\ time_{previous} \leq current\ time(\ )\ or$
$Fitness_{current} - Fitness_{previous} \leq 1 = true$
$Then$
$MAX(PF_{i(t+1)})\ remains\ as\ cluster\ head$
$else$
$Select\ new\ cluster\ head.$
$End\ if.$

Case2 : Cluster head fails as a result of discharged battery:

In this case, two actions are possible:

(a) Nodes join the other cluster heads through the process Cluster head and member selection.

(b) Choosing a new cluster head among survived nodes and inviting other nodes to the new cluster.

Case3 : Member nodes fail as a result of discharged batteries: In this case, the cluster head removes dead nodes from its members list. Then, it sends messages to member nodes and checks for their effectiveness and other changed features. If no message is received back from a node, the node is either dead or out of cluster's range. Therefore, the node is removed from the cluster's members list.

Case4 : Cluster heads interfere:

In this case fitness values of two interfered cluster heads are compared and the one with higher value is chosen as the cluster head. Then, the nodes of the lower valued cluster head join the new cluster. Among nodes which are not members of the new cluster head will be chosen based on their values and others will join it.

VI. RESULTS AND DISCUSSION

The proposed PFCA algorithm is tested using a network simulation tool NS-2 and the results are discussed.

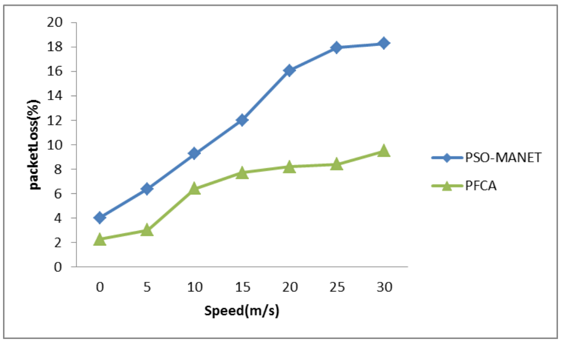

Fig: 1 Speed vs Packet Loss Percentage

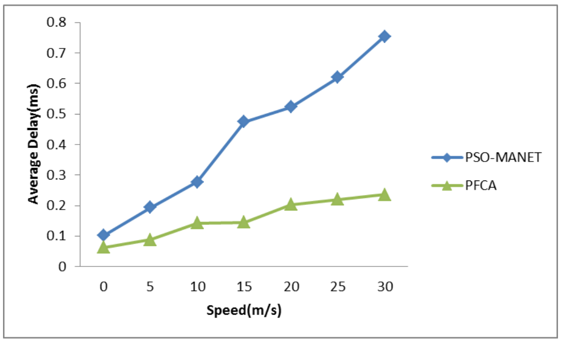

Fig: 2 Speed vs Average delay

A.Packet Loss Ratio:

In the networks there will be packet loss when there a buffer overflow or improper routing . Figure.1 shows in our proposed PFCA model the packet loss have been decreased when compared with the normal PSO-Clustering algorithm

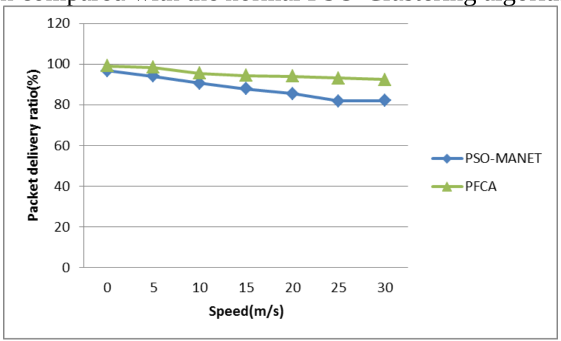

Fig: 3 Speed vs Packet Delivery Ratio

B. Average delay:

Delay is the very important constraint to be concentrated in all optimization problems. In our proposed model the delay have been decreased highly in comparison with PSO-MANET which is made clear in the figure.2

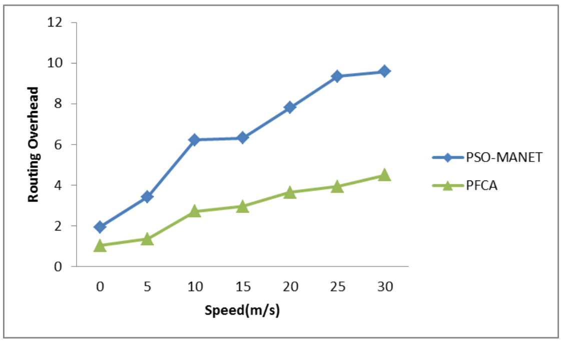

Fig: 4 Speed vs Routing Overhead.

C.Packet Delivery Ratio:

Packet delivery ratio in a network may decrease due to link failure and congestion in the network. The link failure problem is addressed in our proposed PFCA method in the form of calculating the link lifetime. The packet delivery ratio for our model has been increased which is shown in figure.3

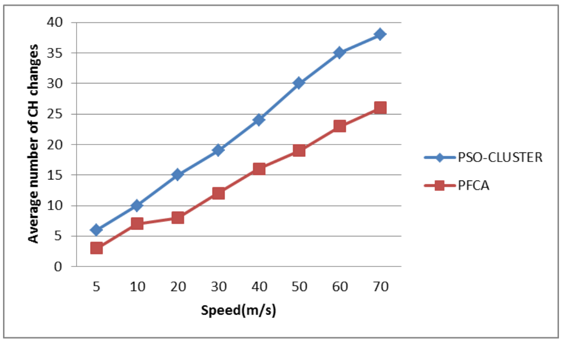

Fig: 5 Speed vs Average CH changes

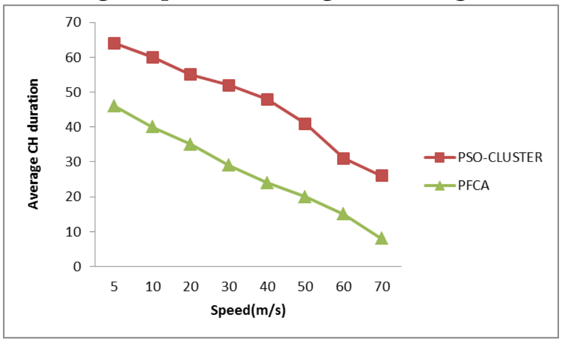

Fig: 2 Speed vs Average CH duration

D.Routing Overhead:

The routing overhead increases when the distribution of the control packets are large. The routing overhead in our proposed one less when compared to the PSO-MANET and it is shown in figure.4

E. Average Number of Cluster head Changes:

In the proposed PFCA method the average number of cluster heads changed is low which is shown in figure.5

F. Average cluster head duration:

Figure.6 shows that the time duration of a node being a cluster head is more when compared to the PSO-MANET.

VI. CONCLUSION:

PFCA algorithm has been proposed for clustering in MANETs. The fitness for every node is calculated based on trust, energy, mobility and link lifetime of the nodes. By determining these parameters and calculating each node's fitness value, a node's fitness is acquired according to the features of the neighbour nodes. Finally we compute predicted fitness value based on previous and current fitness value which we used to decide stable cluster head . Considering computer simulation and analysis on obtained graphs, we can conclude that the PFCA algorithm improves the network's stability, lifetime of the clusters, and decreases the average delay and routing overhead.

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AUTHORS PROFILE

C.Kalaiselvi is working as an Assistant Professor in the Department of Mathematic at Sri Krishna College of Technology. She has published Two research papers in refereed international journals and Pursuing Ph.D from Bharathiyar University. Her research area is Queueing Theory and Networks

Dr.S.Palaniammal is working as a Principal at Sri Krishna Adithya College of Arts and Science. She has more than 25 years of experience in teaching and 10 years of research experience. She has published more than 100 articles in national and international journals and she has authored 5 books for the under graduate engineering students. She has guided 10 Ph.D scholors and 7 are pursuing Ph.D under her guidance. His research area is Applied Mathematics.