PSO-PAC: An Intelligent Clustering Mechanism in Ad Hoc Network

S. Thirumurugan and E. George Dharma Prakash Raj

Abstract The impact of wireless network has been growing day by day. The communication without any infrastructure has been the phenomenon for the present and future has been felt and realized. In line with that, ad hoc network with clustering mechanism proves an improved result. The existing algorithm considers either single parameter or multiple parameters to form clusters using IPv4 nodes. This work proposes PSO-PAC as an optimized clustering mechanism with the help of swarm intelligence to devise the clusters by considering the vital parameters. This study takes crucial parameters to form clusters dynamically using IPv6 configured nodes. This paper work has been supported by the implementation using OMNET++ as a simulator.

1 Introduction

The wireless network places an important role in present situation. This network with an improved performance has been indispensable since the scalability will limit the functionality. In order to put the efficiency value of the ad hoc network to the high value multiple parameters are being considered. It is obviously realized that the distance parameter alone couldn't decide the efficiency of clustering mechanism. Since the nodes which are in wireless network are facing energy drain as a problem with respect to time. Further, the cluster head needs maximum energy among the nodes in a cluster to act as a transceiver. The existing distance based algorithms are

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showing deficiency in giving an optimum solution. Thus, this work proposes multiple parameter based algorithm PSO-PAC (Particle Swarm Optimization of Partitioning Around Clusterhead). The swarm intelligence has been the base for the formulation of this efficient clustering mechanism. The behavior of the crow has been considered to devise the procedure of this technique.
This paper has been organized as follows. Section 1 deals with introduction. Section 2 says about the related works. Section 3 tells about the Ex-PAC mechanism. Section 4 gives out the proposed PSO-PAC procedure. Section 5 deals with the experimental results. Section 6 puts down the future works. Section 7 ends up with the concluding remarks.

2 Related Work

The purpose of clustering has been realized when the protocols like AODV [1] has been integrated with the clustering mechanism. Since this addition to the existing protocols produces an improved result.
The application of the clustering mechanism [2] with AODV as a routing protocol in the real world scenario has been unavoidable. This shows that clustering technique makes the network to be suitable for various real world applications. The clustering mechanism PAC [3] over the k-means approach tells the purpose of parameters in cluster formation. These parameters decide the efficiency level of clusters. This study also confirmed that k-means takes more time when the number of nodes are high in count. This work lacks in implementation and also the sample set of nodes are small in size.
The PAC procedure worked well for less number of nodes. But for more number of nodes this has left many nodes as non clustered nodes. The Ex-PAC [4] came out as an extension to PAC which takes entire nodes and produces the maximum possible clusters. The cluster formation process eventually improved in Ex-PAC procedure. This approach concludes that Ex-PAC has shown significant improvement over k-means in terms of computational speed.
The cluster formation algorithms devised so far lacks in obtaining an efficient cluster in terms of time, maintenance and selecting proper re-clustering phenomenon. The IPv4 address no longer will serve the world has been realized. The IPv6 address has got the focus in the present scenario. The configuration of address can be done in two ways. The configuration using DHCPv6 server and stateless autoconfiguration [5]. This configured address can be local link address or global address. This will be decided based on the application requirement. But there must be awareness on the limitations of using the address range has been vital.
The stateless autoconfiguration of IPv6 nodes should have duplicate address detection mechanism. Since when the nodes move across the clusters there is a chance of address duplication. To eliminate this passive duplicate address detection mechanism [6] has been introduced. This method shows better results than passive autoconfiguration for mobile ad hoc networks.

The purpose of autoconfigured address has been recognized while the ad hoc network has come to reality. The limitation of IPv4 and the need of IPv6 [7, 8] has been understood clearly. Having understood the difference between IPv4 and IPv6 the scenarios will demand the specific way of addressing the nodes. These works are dealing with the autoconfiguration or manual configuration of IPv4 and IPv6 nodes. The clustering as a mechanism comes for this IPv4 or IPv6 autoconfigured node to make the routing simple and also confirms the efficient utilization of bandwidth and resources.

3 Ex-PAC

The PAC creates the clusters based on Manhattan distance. The Manhattan distance saves time in computing the distance between pair of nodes. The results achieved are not adequate to find out the appropriate cluster in the ad hoc scenario network. This has been further enhanced through Ex-PAC algorithm which has been laid on top of PAC. The experimental results show that Ex-PAC has given better results than K-means [9] algorithm in forming clusters. The formula (1) puts down the calculation of Manhattan distance.

$$\text{Manhattan Distance} = \sum_{i=1}^{n} |xi - yi| \tag{1}$$

Ex-PAC algorithm

(1) Assume Ni = temporary Cluster head.
(2) Compute Manhattan distance between pair of nodes.
(3) if (MD < range)
    Begin
      Add (Ni, Ci)
      Count = Count + 1
    End
(4) Repeat the steps 1 through 3 till all the nodes in the cluster are examined.
(5) Select the First Cluster which has maximum count value.
(6) Select the non cluster nodes.
(7) Choose the cluster which includes non cluster nodes.
(8) Select cluster returned in step 7 as Second Cluster.
(9) Repeat the steps 6, 7 and 8 until there is no change in Cluster formation.

The Ex-PAC procedure has produced remarkable improvement over the PAC procedure. But still lacks in ensuring the perfectness of the clusters. Thus, the validation parameters are needed to be considered to check the integrity of the clusters.

4 PSO-PAC

The crow behaves distinctly when it finds eatables. It alerts others after seeing the eatables through the acoustic signal. Thus, a group of crows will devise the cluster. This formation is based on more than one parameter. Those parameters are distance and energy of the crows in communication process. This multi parameter specifies that the cluster formation with the help of swarm intelligence makes the clustering process in a highly efficient way. This behaviour of the crow can be put in making dynamic clusters.

The Fig. 1 shows the network model consist of two clusters where each cluster has separate crow head node. The gateway acts as mediator between two clusters. This ensures inter-cluster communication to happen. In this model the destination is far away from the source. This network setup will be retained till the communication between the source and destination gets over. After the data transfer gets over then network has to be reformed with new energy source and destination. In this way the cluster formation happens completely dynamic in nature which suits very well with the behaviour of the crow.

4.1 Cluster Formation by Crow Behavior

(1) Input the clusters formed in Ex-PAC procedure.
(2) j = j + 1
(3) Cluster = Cj
(4) i = i + 1
(5) E = Get_energy (Ni, Cluster)
(6) If (E < EnergyThreshold)
    Newcluster (Kj, Ni)
(7) Repeat the steps 4, 5 & 6 until all the nodes belong to the cluster Cj gets examined.
(8) Repeat the steps 2 through 7 until all the clusters of network are examined.

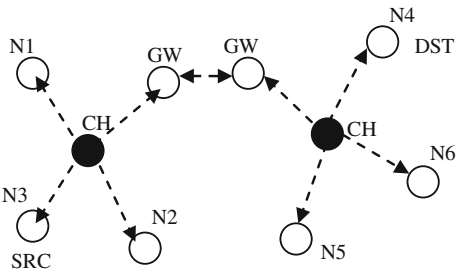

Fig. 1 Network model:two clusters

4.2 IPV6 Configuration of Clusters

The cluster formation takes the output of Ex-PAC procedure and recreates the cluster dynamically based on the energy level of nodes. The Fig. 2 shows the IPv6 nodes to form the clusters dynamically in a stateful way.

IPv6 Configuration Procedure

(1) Input the clusters from crow behaviour procedure.
(2) Install the DHCPv6 server process in Cluster head node.
(3) Cluster head sends hello message to all the members.
(4) For each Cluster Ci

```
Begin
  For each member node Nj
    Begin
      Node Nj sends reply to the Cluster head.
      Cluster head sends an IPv6 address to Nj.
    End
End
```

(5) Repeat the step 4 for j = 0 ... Number of Nodes in cluster Ci and for i = 0 to Number of clusters.

The IPv6 configuration procedure configures the nodes belong to the clusters under stateful way using DHCPv6 server. In this method the cluster head sends hello message to all the members at the initial stage. The member nodes send the reply to the cluster head. This reply informs the member belong to the cluster where the cluster head exists. The cluster head now sends IPv6 address to the member node as a part of configuration.

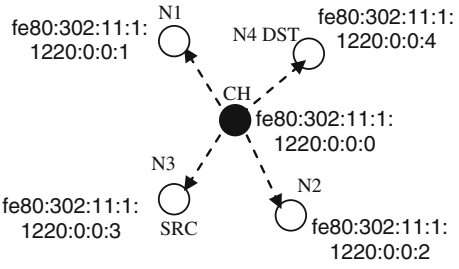

Fig. 2 IPv6 configured network model

Table 1 Simulation parameters

Parameter	Values
N (number of nodes)	25, 50
Space (area)	100 × 100
Tr (transmission range)	20 m
Ideal nodes percentage	90 %
Simulation time	5 s
Threshold(energy)	500

5 Experimental Results

This PSO-PAC algorithm has been implemented in OMNET++ and the results are tabulated. This work has been carried out with the system configuration of 64 bit AMD processor, 2 GB RAM and windows XP as an operation system. This simulation has been done for 25 nodes and 50 nodes.

The Table 1 shows the simulation parameters considered while simulating the study. The cluster heads could be fixed and need to be changed in accordance with the time T. The energy level graph Fig. 3 at a specific time T1 identifies the node8 has been an eligible node to be considered as cluster head. After time period T1 some other node will be chosen as cluster head at time period T2. This graph clearly reveals the cluster heads selection in the order. The Fig. 4 shows the nodes and their respective energy level belongs to cluster C2. This ushers that the node21 will be chosen as cluster head since it has high energy level at time T1.

The Fig. 5 ushers the energy based results for the sample size of 50 nodes. This shows that node8 takes the role of cluster head.

The Fig. 6 ushers the energy based results for the cluster2 where the sample size has been 50 nodes. This identifies node39 as the cluster head.

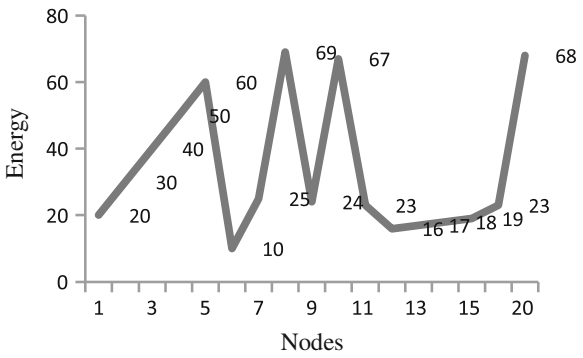

Fig. 3 Energy graph for 25 nodes: cluster C1

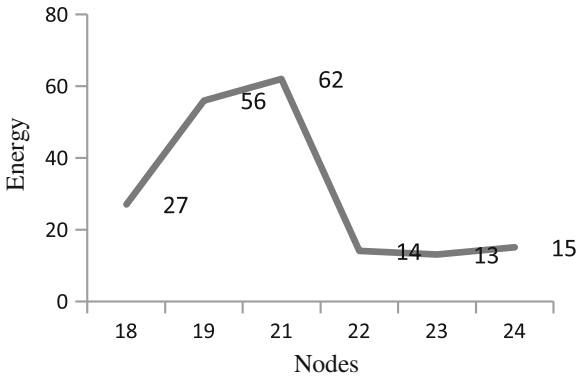

Fig. 4 Energy graph for 25 nodes: cluster C2

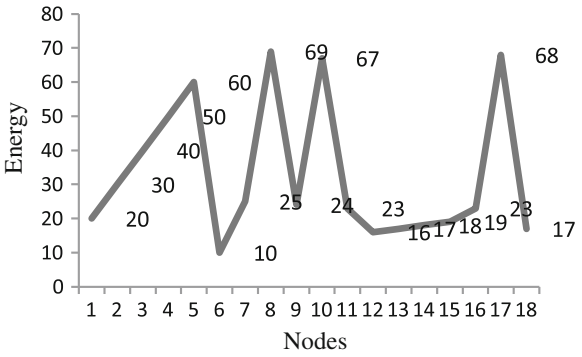

Fig. 5 Energy results for 50 nodes: cluster C1

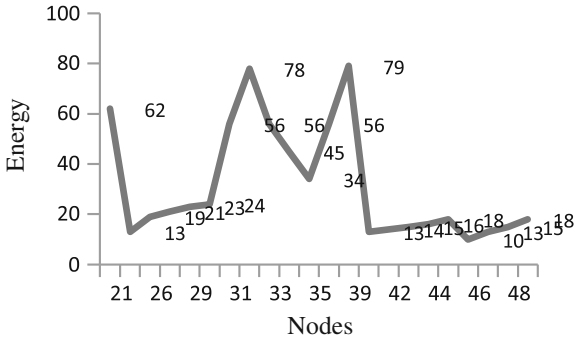

Fig. 6 Energy results for 50 nodes: cluster C2

6 Future Directions

This work considers the stateful configuration of IPv6 nodes. The future work should also consider the stateless auto configuration of IPv6 nodes to form the dynamic clusters in ad hoc networks. The implementation of mobility of nodes or cluster head should also be considered.

7 Conclusion

This study considers the dynamic cluster formation. The intelligence of crow has been simulated on formation of the dynamic cluster. These clusters tentatively exist till the data transfer gets over which has been similar to crow finds eatable, devising cluster of crows and eats off the food. This study gives an understanding of the crow's behavior to be applied on formation of clusters in ad hoc network. This work has been simulated using OMNET++ to substantiate the results.

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