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Optimizing and Generating Dynamic intricate Cluster construction in MANETs using Integer Linear Programming with Rough set (ILPR) Model Technique.

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Abstract:MANETs are wireless, self-organizing networks consisting of nodes with limited resourceble residual energy levels. So one of the main Challenges in MANETs are saving the Outlay of energies with various features of nodes as much as possible. So one technique we proposed that Mobile ad-hoc networks uses clustering methods to allow fast connection ,better routing and topology management which meets the above challenging tasks with minimum time complexity. In that process one main problem here in mobile ad-hoc network is selecting the most suitable node as Master cluster head, cluster head, ensuring that all regular nodes are connected to it, such that the lifetime of the network is maximized through ILP with Rough Set Model. So Integer Linear Programming (ILP) model with Rough sets have been applied to solve real-life optimized dynamic clustering problems. To test and meet the optimized results can be done by Rough set tools like Rosetta, Rose2, and 4eMka2[17] for classification of nodes with Boolean rules in efficient manner, for optimizing cluster topology and identifying cluster heads with minimum time complexity by ampl solvers like CPLEX, BSOLO, MINOS, and SCIP.

Keyword – Mobile ad-hoc network (MANETs), clustering,Integer Linear Programming (ILP), Rough sets , Data Solvers.

1. INTRODUCTION

Mobile Ad hoc Network (MANET) is defined as a collection of wireless nodes that can dynamically form a network to exchange information without using any pre-existing fixed network infrastructure. Advantage of MANETs is flexibility, mobility, infrastructure-less, and self reconfiguration networks. To operate MANETs in an optimum state which means minimizing energy levels and to achieve maximum network sustenance time can be done through optimizing cluster formation routing and communication. Topologies in MANET were non-hierarchical networks where all nodes had identical roles, as the nodes in non-hierarchical network increases the throughput fall drastically.

In addition several factors such as unpredictable topology changes, frequent route breakage, and routing overhead make it difficult for a flat topology to be scalable.
Clustering concept was introduced to overcome the scalability limitations of a flat network. Clustering means

Share the network into clusters with certain nodes in each cluster being chosen to be cluster head. The responsibility of cluster head is managing communication and routing for their particular cluster. Clustering has the advantage of reducing computational complexity of the underlying network and mitigating the effects of mobility by making a mobile topology “appear” relatively static. The use of clustering technique has the advantage of reducing the information storage overhead for regular nodes as nodes need to be aware of “local” changes (changes in the same cluster) and not global changes(changes occurring in other cluster). Since the cluster head is mainly responsible for managing its cluster, routing, relaying messages from/to other clusters etc, residual energy depletes faster than the other nodes hence, choosing another cluster head to manage the cluster or sometimes re-clustering the whole network is a needed operation.re-clustering becomes an important factor in cluster optimization problem for the goal to achieving fault-tolerance. Re-clustering however is resource intensive and introduces disruptions in the network. Therefore in case where a high performance fault-tolerant configuration is required, It is preferable to include the election of backup cluster heads during the clustering process.

II. EXISTED WORK

Different clustering techniques[6][7] and methodologies are tabulated as follows

Clustering Technique	Peculiarity/Properties	Selection Condition for Clusterhead(CH)	Objective Function
Lowest-ID	Based on the node ID,the cluster formation and maintenance is done in this technique.	Node with lowest ID is choosen as CH among one-hop	$W_v=w_1B_v-w_2M_{v,p}w_1+w_2=1$
DMAC	Formation of the cluster is message-driven.ID and weight value is assigned to each node.	Among one-hop neighbours,highest weight value node is choosen as CH.	$h=\underline{y_{max}-y_{min}}$ 2
Max-min d-cluster	Formation of Cluster is based on 2d rounds of flooding.By using the node id ,d-hop clusters are formed.	The registered entriesof each node after 2d rounds of flooding are followed based on three rules.	$\|S^t\|\leq k+\sum_{(u,v)\in\pi} Iu,v$
K-CONID	Merges Lowest ID and Highest degree forms K-hop cluster.	Node should possess highest degree and should have unique ID.	K-means equation
Highest Degree	The bunch is produced based on the highest degree.	Direct neighbors are connected by highest connectivity.	DR=
WCA	Based on No of nodes handled, mobility, diffusion influence and battery influence.	Neighbours are connected to nodes having minimum weight.	$W_v=w_1\Delta_v+w_2D_v+w_3M_v+w_4E_v$
PMW(Robust Clustering Algorithm)	Weight is calculated by using metrics Power,mobility and workload.	Selection of clusterhead is based on weight.Broadcating of CLUSTERHEAD,HELLO,WEIGHT,JOIN messages to the nodes.	$W_j=\underline{f_1}+f_2 * RP_j+\ \underline{f_3}\ e^{MP}{}_j\ e^{PDR}{}_j$
Mob Dhop	Based on received signal strength of each node d-hop clusters are formed.	Among neighbours there will be lowest value of local stability.	$P_r=P_t*G_t*G_r*\underline{\lambda^2}$ $(4*\pi*d)2$
WCA with mobility prediction	Occurrence of node to the neighbors is acknowledged by broadcasting note.	Based on the weight and nodes having lowest weight is chosen as CH.	$M_i=1\sum_{t=1}^{T}((Xt-Xt-1)2+$ $Yt-Yt-12\ \ 1/2$
Improved WCA	For each parameter node computed its own value.	Minimum weight of node is chosen as CH.	$D_v=\|N(v)\|=\sum_{v`\in V,v`\neq v}\{dist(v,v`)<txrange\}$
CBMB	Local optimal cluster heads are selected based on the parameters,distance of nodes,average mobility(M),connectivity(c),residual battery power(B).	Selection of CH,based on largest local weights.	
Multihop Clustering Protocol	Larger size multihop cluster are formed of limited number.	Path to CH is longer than 6 hops, a new CH is formed.	$D_{ch}+d_{us\text{-}mem}+d_{s\text{-}mem}+d_{nc}$

Table 1 : Analysis of various clustering Models

III. ILP MODEL ON CLUSTERING PROBLEM:

The core idea of ILP Model was to find the smallest set of cluster heads. The paper mainly focuses on selection of cluster head and obtaining minimum number of cluster heads.

We proposed three different ILP formulations, each with a different approach to the creation of a backbone.

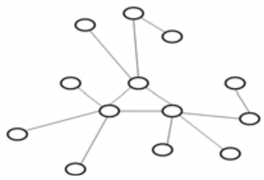

Fig. 1. Triangle with loop network topology.

The first formulation, Triangle with loop network topology, connects the selected cluster heads to backbone through a mesh topology which leads to produce too many redundant links in the back bone.

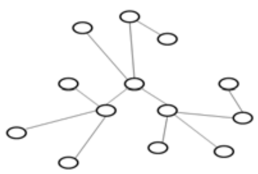

Fig. 2. Triangle without loop network topology

Table 2 : Sample Manet Nodes and parameter Values.

Node NO	Mobility	Battery Strength	Signal Strength	Load Balance	Trust Worthiness	HI	LI	WD
N1	4	3	2	2	1	1	2	1
N2	2	1	1	3	1	1	2	1
N3	1	1	1	3	1	2	2	1
N4	4	3	2	3	1	3	1	1
N5	3	3	1	4	2	3	1	1
N6	1	1	2	1	3	4	1	1
N7	4	3	2	2	3	2	3	2
N8	4	3	2	3	4	2	4	2
N9	4	3	2	3	2	1	4	2
N10	1	1	3	1	2	3	1	1
N11	3	3	1	1	1	3	1	1
N12	2	2	2	2	3	4	1	2
N13	4	3	2	3	4	4	2	2
N14	1	1	1	1	4	1	2	1
N15	3	3	3	1	1	1	2	1

The second Triangle without loop network topology carries so many redundant connections. By using Master Cluster head (MCH) concept which reduces the number of unnecessary links. But there is a collapse of entire network if MCH being a central point of failure.

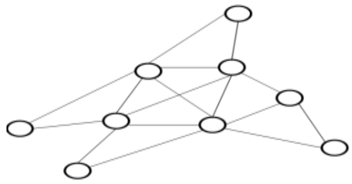

Fig 3 Triangular Mesh Topology

The third formulation network using mesh topology, In this model each cluster head has backup cluster head, for each
Selected cluster head. When dealing with large number of cluster heads. Even the original Cluster head fails; there will be another backup cluster head.

IV. Proposed ILPRS Technique For Clustering Problem:

Integer Linear programming (ILP) with Rough sets [2][3][4][8] model generates clusters with third mesh topology model. So the factors which decides Master Cluster head, cluster heads and regular cluster heads derived by applying rough set classification model. In which each node attribute and its sample values shown in the table 1.We have taken into consideration of 76 samples from that the final classified nodes are described with following scenario.

The Attribute Values are calculated from existed Models.Where from table 1 the Weighted Average Degree Decision Attribute Value 2 means above 70% & 1 means below 70%.For other Attributes: 1 means for >70%, 2means for > 50 to 70%, 3 means for 30 to 50 % and 4 means for below 30%.

Decision Attribute is WD. Where wd is

WD= ∑(W1*M+W2*SS+W3*L+W4*T+W5*BP).

S.NO	Attribute	Weighted Value
W1	Mobility	2
W2	Battery Power	5
W3	Signal Strength	5
W4	Load Balance	3
W5	Trust Worthiness	4

Table 3 : Weighted Attribute values Table:

We have taken more than 50 sample note values in which few of the values shown in Table 1.From the total all samples final decisions rules derived which are sown in following model

From The Decisions Rules:

1. Node 30 will be Master Cluster head. Based on the rule { SS > =2 } & { L > = 2 } & { T>=2}
2. Nodes 2,3,11,12,14,16,26,27,31,36,38,41 will be Intermediate cluster heads. Based on the rule { SS > = 2 } & { T <=1 }.
3. Nodes 3,10,16,24,25,41,56,58,64,67 will become cluster heads. Based on the rule { SS > =2 } & { BP <=1 }
4. Remaining all Nodes will become regular Nodes. Based on the rule {SS < = 1 } , { L <= 1 }, {BP <= 1 },{L<=1},{M<=2} & { T <=1 }.

Once the Master Cluster heads, cluster heads and regular nodes are classified through rough set model in order to form the cluster in mesh topology model the following mechanism is followed.

The variables used to define ILP[1] objective function are maintained as follows:

-N : Number of nodes in the network
-C : Number of clusters heads
-$g_{i\,j}$: Euclidean distance between nodes i and j
-L: Max number of nodes that can be connected to CH
-a_{ij}: outlay of connecting a regular node i to CH j (Proportional to g^2_{ij})
-b_{jk}: Outlay of connecting CH j to CH k(proportional to d^3_{jk})
-Pij: 1 when node i is connected to CH j or if node j is connected to CH i;0 otherwise
-Q_{ij}: 1when CH i is connected to CH j; 0 otherwise
-r_j: 1 when node j is chosen to be a CH;0 otherwise
-K_j: 1 when node j is a Master CH;0 otherwise
-s_{ij}: 1 when xij=1 and y_j =1;0 otherwise
-w_j: Weight associated with CH j.
-Ri : Residual Energy of particular node.
- Bi : Battery Power.

The Mesh Topology model improves on weakness present in the TWC (Triangle with cycle) Model and TWNC (Triangle with no cycle) Model.

So to minimize the above defects the final defined objective function

$$\textbf{Min :(} \sum_{i=0}^{N}\sum_{j=1}^{N} ai,jP_{i,j} + \sum_{j=1}^{N} wjrj + \sum_{j=1}^{N} wjKj + \sum_{j=1}^{N}\sum_{k=1}^{N} bj,k\ Qj,k + \sum_{i=0}^{N} Ri + \sum_{i=0}^{N} Bi)$$

links between nodes and cluster heads is represented by first term in the objective function. Selection of cluster heads is represented in the second term. The MCH is not a regular cluster head and therefore needs to have its own term in the objective function so that its Outlay is taken into account when designing the network. It is represented in the last term of the objective function. The objective function aims to minimize the Outlay of sending/receiving data along these connections

Condition 2 is that there should be only one MCH

$$\sum_{j=1}^{N} Kj = 1$$

Condition 3 is The total number of CHs is C – 1.That is total C cluster heads and there will be 1 MCH and C-1 regular cluster heads

$$\sum_{j=1}^{N} rj = C - 1$$

Condition 4 is the superior limit on the total number of associates a node has. If it a normal node it must be joined to at least one other node. If it is a cluster head, it will be connected to at most L other regular nodes.

$$\sum_{i=1}^{N} Pi,j \leq 1 + (L-1)rj \quad \forall\ j$$

Condition 5 is the inferior limit on the total number of links a node has. If a node is a cluster head it must hold at least one node. If a node is a MCH I is not limited to "1 connection to a regular node". Else it can have(in this case it should have) no connections to regular nodes

$$\sum_{i=1}^{N} Pi,j \geq 1 - Kj \quad \forall j$$

Condition 6 enforces on maximum number of backbone connections. There should not be more than 3 backbone for the CH(one will be the MCH forming star connection and other two regular cluster heads establishes the ring links).A node to be MCH, then there will be (C-1) regular cluster heads connected to it.

$$\sum_{\substack{j=1 \\ j\neq k}}^{N} Qj,k \leq (C-1)Kk + 3rk \quad \forall k$$

Condition 7 enforces on lower limit for number of backbone connections. The regular cluster head will have two connections, one with at least two other nodes and another with MCH. There will be (C-1) regular cluster head connections for the node to be MCH.

$$\sum_{\substack{j=1 \\ j\neq k}}^{N} Qj,k \geq (C-1)Kk + 2yk \quad \forall k$$

Condition 8 The backbone connections should be only between MCH and regular cluster heads or among regular cluster heads.

$$Q_{j,k} \leq \frac{K_j + r_j + K_k + r_k}{2} \quad \forall j \forall j \neq k$$

Condition 9 A node selected to be a regular cluster head, it cannot be MCH and vice versa, it may not be both

$$(r_j + K_j) \leq 1 \quad \forall j$$

Condition 10 is used to guarantee that nodes are not associated to themselves.

Condition 11 does the same for the z matrix which represents the interconnections between cluster heads

$$\sum_{i=1}^{N} Pi = 0$$

$$p_{i,j} = p_{j,i} \quad \forall i \forall j$$

$$Q_{i,j} = Q_{j,i} \quad \forall i \forall j$$

Condition 12 restricts the total number of connections between regular nodes and cluster heads to the same number as the number of regular nodes. Each regular node must be connected to at least one other cluster head

$$\sum_{i=1}^{N} \sum_{j=i+1}^{N} Pi,j = (N-C)$$

Condition 13: Total number of spine connections to 2(P-1)-1.

$$\sum_{i=1}^{N} \sum_{j=1+1}^{N} Qi,j = 2(C-1)-1$$

Condition 15 The ∑Ri and ∑Bi should be MAX.

V. Tests And Results

Testing was carried out in 2 phases. In which first phase is that in order to classify the based on rough set classified rules done with the help of 4eMka2, Rosetta and Rose2 tools. The second phase consists of to form cluster based on ILP technique done with the help of various solvers like CPLEX, MINOS, and MINISAT. And results are compared with various other ILP solvers like SCIP, BSOLO[17], and PEUBLO LPSOLVE and so on. The results of how the Master Cluster heads, Cluster heads, Intermediate Nodes and regular nodes are identified already shown in Vth chapter of proposed ILPR technique. For the sample 76 node approximation attribute values the nodes are classified and their support, relative strength results are

S.NO	Decision	Support	Relative Strength (%)
1.	WD at least 2 with rule1	1	100
2	WD at most 1 with rule 4	37	100
3	WD is 1 or 2 with rule 4	30	78.95
4	WD is 1 or 2 with rule 2	10	26.32
5	WD is 1 or 2 with rule 4	14	36.84

Table4: All Rules with Support and Accuracy Relative Strength

Solver Name	_ampl_time	_ampl_elapsed_time	NI	NN	NCH	NMH
CPLEX	0.257	700.448	39	5	2	1
LPSOLVE	0.008	500.568	32	12	5	2
SCIP	0.014	377.87	33	15	5	2
MINOS	0.160	405.782	20	22	14	4
BSOLO	0.0030	600.24	29	25	8	5
MINISAT	0.038	245.77	43	35	7	3

Table 5: ILPRS performance in terms of execution times

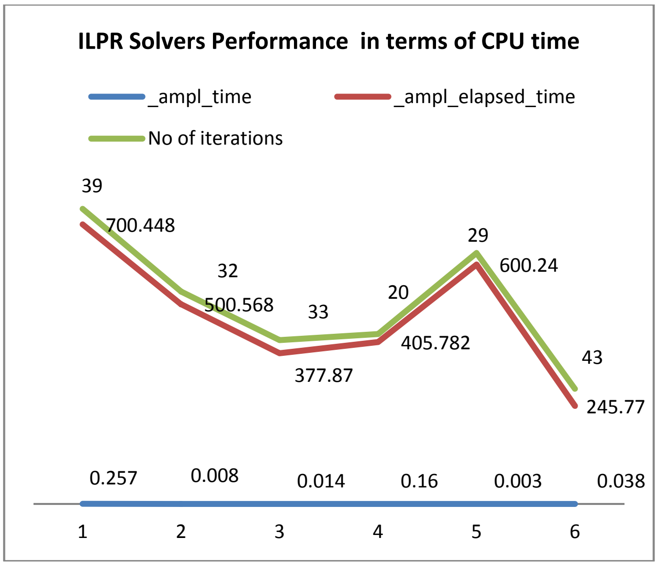

Figure 4: Performance of Various solvers under various iterations

S.NO	No of nodes	No of Cluster Heads generated	No of Master Cluster heads generated
1	10	4	2
2	20	7	3
3	30	3	1
4	35	14	5
5	40	23	8
6	45	22	13
7	50	33	12
8	55	44	24
9	60	56	44
10	65	33	17
11	70	56	14
12	75	22	12
13	80	33	12
14	85	21	13
15	90	49	24
16	95	33	13
17	100	22	7

Table 6 : No of nodes, Cluster Heads vs Master cluster heads

The objective function analysis between static clusters and dynamic cluster shown in below figure at various instance of time periods. In the below figure the TcostSN represents Total cost for static network and TcostDN represents the Total cost for Dynamic network.

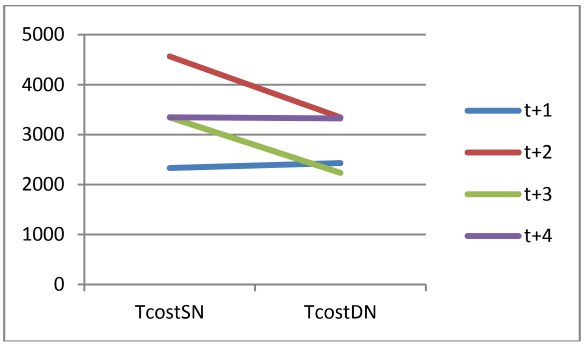

Figure 5 Cost analysis among static vs dynamic clusters.

VI Conclusion & Future Work

This paper describes an improved mechanism to solve the clustering problem in MANET's. The proposed Model presented the utility of Mesh topology which minimizes the limitations of various clustering topology models and generates new cluster in efficient and optimized manner. The concept we applied rough set model with ILP technique makes the network dynamic with almost similar objective cost values. So the final network is dynamic with minimum cost model. In future the work can be extended to optimize the network intensely with various heuristic and AHP[16][17] (Analytical Hierarchical Process) techniques. And this work also can be extended with Boolean satisfiability models and mixed integer linear programming models. And the cost of generating dynamic cluster can be reduced with various existed intelligent models.

References

[1] SZH Zahidi, FAloul and WEI-Hajj, " Optimizing Complex Cluster Formation in Manet's Using SAT/ILP techniques",IEEE sensor Journal,VOL 13,No 6,June,2013.

[2]. J.Grant, "Churn modeling by rough set approach", manuscript, 2001.

[3]. L. Polkowski and A. Skowron, Eds., *Rough Sets and Current Trends in Computing*. Lecture Notes in Artificial Intelligence 1424, Springer,1998.

[4]. Z.Pawlak; Rough sets: Theoretical aspects of reasoning about **data,** Kluwer Academic, Boston, MA, **1991.**

[5].H. Yan, J. Li, G. Sun, and H. Chen, "An optimistic power control MAC protocol for mobile ad hoc networks," in Proc. IEEE ICC,2006, pp. 3615–3620.

[6].M. Anupama and Dr. Bachala Sathyanarayana, "Survey of Cluster Based Routing Protocols in Mobile Ad hoc Networks" , *International Journal of Computer Theory and Engineering, Vol. 3, No. 6, December 2.*

[7].S. Chinara and S. Rath, "Energy efficient mobility adaptive distributed clustering algorithm for mobile ad hoc network," in *Proc. Int. Conf. Adv. Comput. Commun.*, 2008, pp. 265–272.

[8]. A. Schrijver, *Theory of Linear and Integer Programming*.New York, NY, USA: Wiley, 1999.

[9]. F. Aloul, A. Ramani, I. Markov, and K. Sakallah, "Generic ILP versus specialized 0-1 ILP: An update," in *Proc. Int. Conf. Comput.-Aided Design*, 2002, pp. 450–457.

[10].D. Chai and A. Kuehlmann, "A fast pseudo-Boolean constraint solver," *IEEE Trans. Comput.-Aided Design Integr. Circuits Syst.*, vol. 24, no. 3, pp. 305–317, Mar. 2005

.[11].A. Sagahyroon, F. Aloul, and A. Sudnitson, "Using SAT-based techniques n low power state assignment," *J. Circuits, Syst., Comput.*,vol. 20, no. 8, pp. 1605–1618, 2011

[12].A. Ling, D. Singh, and S. Brown, "FPGA programmable logic block evaluation using quantified Boolean satisfiability," *IEEE Comput. Digital Tech.*, vol. 153, no. 3, pp. 165–172, May 2006.

[13] S. Kim and J. Lee, "A system architecture for high-speed deep packet inspection in signature-based network intrusion prevention," *J. Syst. Archit., EUROMICRO J.*, vol. 53, nos. 5–6, pp. 310–320, May 2007.

[14]. G. Hughes and T. Bultan, "Automated verification of access control policies using a SAT solver," *Int. J. Softw. Tools Technol. Transf.*, vol. 10, no. 6, pp. 503–520, Oct. 2008.

[15]Mironov and L. Zhang, "Applications of SAT solver to cryptanalysis of hash functions," in *Proc. Int. Conf. Theory Appl. Satisfiab. Test.*, 2006, pp. 102–115.

[16] S.Greco,B.matarazzo,R.Slowinski,"The use of rough sets and fuzzy sets in MCDM,In:T.Gal,T.Hanne,T.Stewart,eds.Advances in Multiple Condition Decision Making,Kluwer Acadamic Publishers,Dordrechi,Boston(1999),1.4.1-1.4.59.

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