An Effective Loosely Coupled Clustering Approach for Energy Heterogeneous Mobile Ad-hoc Network

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Abstract : ***Today mobile ad-hoc network becomes network of heterogeneous devices in sense of power, range, mobility pattern and energy. Heterogeneity property of devices leads number of issues like network partition, routing overhead, low throughput and short network life. Though optimum utilization of the resources is major concern for researcher. The motive of work is to focus energy heterogeneous mobile ad-hoc network. In this paper, loosely coupled clustering approach have proposed that compatible with energy heterogeneous network. Proposed approach efforts to resolve or minimize above discussed issues. Proposed approach, experimented in NS-2 and evaluated certain result criteria like throughput, cluster head overhead, packet delivery ratio etc.***

IndexTerms - Mobile Ad-hoc Networks, Energy Heterogeneous Networks, Tightly Coupled Clustering, Loosely Coupled Clustering, Cluster Head Election Method.

I. INTRODUCTION

According to literature, mobile ad-hoc network comprises of portable devices [1]. Involvement and interconnection of portable devices increase demand of such network in numerous areas. Participating devices of network are responsible for self-configuration and routing [2]. Each device has finite number of resources such as transmission coverage, bandwidth and battery backup. During the association with the network, devices may have identical or different resource capability. More precisely devices may varies for specific resource like mobility or energy or transmission range etc. Though, device capabilities, mobile ad-hoc network classified as homogeneous and heterogeneous. Figure 1 depicts homogeneous and heterogeneous classification of network on the basis of device capabilities. The objective of the work is to resolve issues of heterogeneity property occurred during the communication.

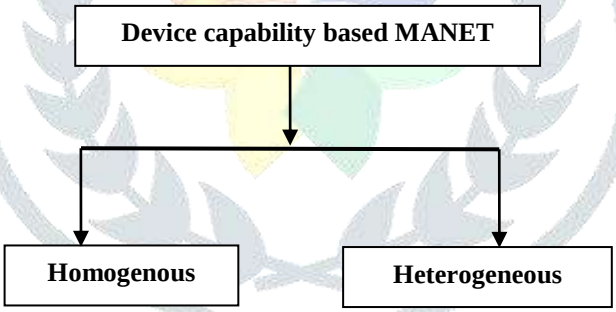

Figure 1 Device capability based MANET

Further, paper have organized in different sections. Section I described overview of MANET. Section II presented energy heterogeneous MANET. Section III list out issues of heterogeneity. To control routing overhead and efficient utilization of resources, clustering and its type have covered in section IV. Section V presented brief view on relevant work. Proposed methodology and algorithm is described in Section VI. Section VII given experimental setup and result analysis of proposed methodology. Section VIII concludes proposed work and gives further direction for the work.

II. ENERGY HETEROGENIOUS MANET

Preceding section discussed device heterogeneity in different sense. Here, energy heterogeneous mobile ad-hoc networks that means devices have different energy level have presented. Figure 2 shows the energy heterogeneous MANET. In the energy heterogeneous network, each device has different energy assign during the association or may be different energy model applied. In the figure 2, during the network initiation device 1 and 7 have full energy backup. Device 2, 3 5 and 6 have different energy, device 4 have less energy.

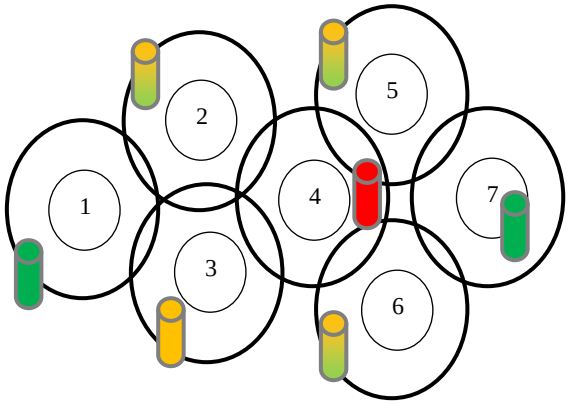

Figure 2 Energy Heterogeneous MANET

As shown in above figure, device 4 has less energy value and may be high traffic because of it is high devices coverage. When device 4 act as forwarder means forward messages that initiated by other device. Though device 4 drain out its energy immediately and die. Therefore its lead network partition or other problems. Apart from that, various number of issues arise due to device heterogeneity.

III. DEVICE HETEROGENEITY ISSUES

Heterogeneous devices leads number of problems related to network performance. Here, some issues are point. Traditional routing strategy does not concern about device heterogeneity that may leads route break or network partition problem [3]. Additionally, devices with different battery power contributes in network communication may reduce network lifetime and service unavailability issues. Therefore, device heterogeneity property may also reduce network performance and leads high overhead.

IV. TIGHTLY AND LOOSELY COUPLED CLUSTERING

Device participation with the finite resources in the network is restricts to scale out. Because of device has constant memory that overflow due to increasing of routing table size. To overcome network scalability issues, clustering method have introduced. Clustering method is conceptual splitting of network topography in regions of device refers cluster that satisfy certain criteria [4]. Here a logical central coordinator named cluster head is responsible to manage designated cluster. Clustering method accomplish in two phase cluster formation and cluster maintenance. Cluster formation is form logical group of devices on the basis of neighbor hop criteria. Cluster formation may be 1-hop or k-hop. Cluster maintenance is later phase where cluster head elections and keep update of cluster information is required. Clustering method classify in two ways: tightly coupled and loosely coupled clustering [5].

A. *Tightly Coupled Clustering-* In this method, every device plays role of any one from cluster head, cluster gateway and cluster member. Here, device should strict to participate only any one of them. Figure 3 depicts tightly coupled clustering. Cluster head elections is precious process for clustering method. Cluster head is sole responsible for manage cluster members that should be much capable.

B.

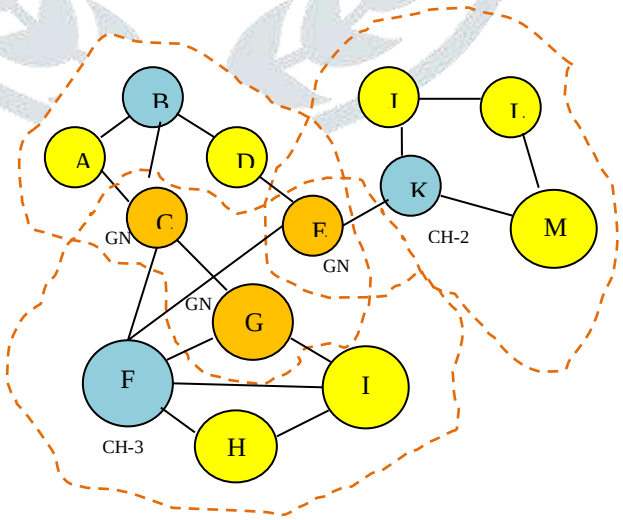

Figure 3 Tightly Coupled Clustering

C. *Loosely Coupled Clustering-* In loosely coupled clustering, device does not to strict to play role of any one like tight coupled clustering. Here, every device is free to play one or more role at any time period. This property reduce cluster maintenance overhead. Figure 4 depicts loosely coupled clustering in which device G play roles of cluster head as well as gateway.

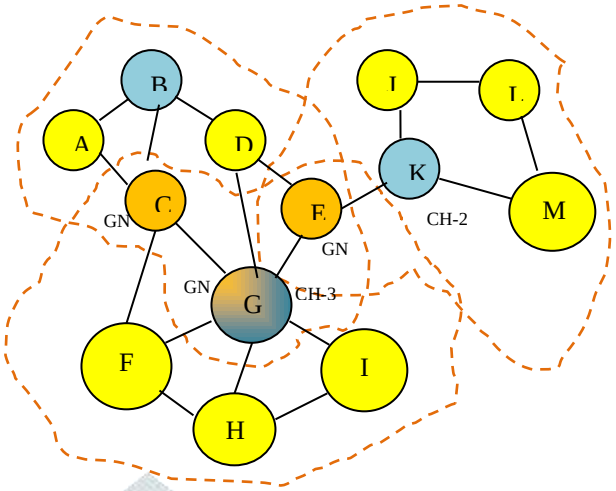

Figure 4 Loosely Coupled Clustering

V. RELEVANT WORK

In recent years, number of efforts have putted to advise efficient clustering method for both homogenous and heterogeneous network. Some contributions discusses here.

Traditional and initial clustering method was LID [6] that used lowest ID of devices for cluster head elections. Next method was advised named Highest-Degree clustering. Highest degree clustering, elected cluster head device those have maximum neighbors [7]. Further WCA [8] was proposed which elects cluster head based on weight calculation of device.

Another one MCFA [9] suggested, that work on mobility of devices and unidentified distribution of random variables.

Further, an approach was proposed named as AMQR [10] which amplify parameters like addictiveness, competence, scalability and more over decrease end-to- end postponement.

Recently mobility aware loosely coupled [11] clustering have been proposed. Here authors considered transmission power heterogeneous network to accomplish mobility aware clustering.

As literature study, most of clustering method considered network with homogenous devices may not results desired performance for heterogeneous environment. Though, still it require some clustering method for different heterogeneous network. Further section presents an effort towards effective loosely coupled clustering method for energy heterogeneous network.

VI. PROPOSED METHODOLGY

Energy heterogeneous mobile ad-hoc network may arise low throughput, routing overhead issues when inefficient utilization of finite resources. To address these issues, here a loosely coupled clustering approach is proposed. Proposed clustering approach use initial energy of device during the association with network, less transmission power and more pause time of device to elect cluster head. Proposed approach results fairness scheme for device participation in cluster head procedure when they join network with less energy. Proposed approach works in two phase. First phase deals with cluster formation via exchange of beacon signal. In this phase, energy value of mobility pattern and transmission power embeds in beacon signal field. Later phase uses value of these parameters in cluster head election and maintenance process. Exchange of beacon signal is periodic process if any changes happen in network topology.

Therefore an algorithm is designed to define the entire process of proposed approach given below.

A. Algorithm- Designed algorithm described below that stated phenome of proposed work.

Algorithm: An algorithm to states proposed loose clustering approach

Phase1: Cluster formation through beacon signal exchange.

```
LCA(Node[], N );
    Input: Energy,TP, PT, i , n, NV[], NB[], CH[]
    Output: Cluster Head for each cluster
For  i=1 to N do
     SendHello(Node[i],Node[i+1])
     Node[i+1].look(Node[i]->Info);
     NV[i]=Node[i].Energy;
     NV[i]=Node[i].TP;
     NV[i]=Node[i].PT;
    NB[i]=Node[i];
 End for
```

Phase2: Cluster Head Election and Maintenance

```
For i=1 to n do
   If (NV[i].Energy>NV[i+1].Energy && NV[i].TP<
NV[i+1].TP && NV[i].PT>NV[i+1].PT) then
 CH[i]=NB[i];
Else
   If(NV[i].Energy>NV[i+1].Energy && NV[i].TP>
NV[i+1].TP && NV[i].PT>NV[i+1].PT) then
 CH[i]=NB[i];
Else
  CH[i]=NB[i+1];
end for
```

VII. SIMULATION AND RESULT ANALYSIS

Proposed clustering method experimented using Network Simulator-2 (NS-2) [12] software by considering different simulation criteria's which define table 1.

Table 1. Network Parameters and Values

Parameters Name	Value
Number of Devices	50,100,150,200
Topography Area	1200×1000
Simulation time (seconds)	200
Transmission area (meters)	200, 300, 400
Propagation Model	Two Ray Ground
Traffic type	CBR
Packet size (bytes)	512
Routing Protocol	AODV
Connection Type	TCP

Figure 5 shows network scenario with 100 devices that simulated in network simulation software's.

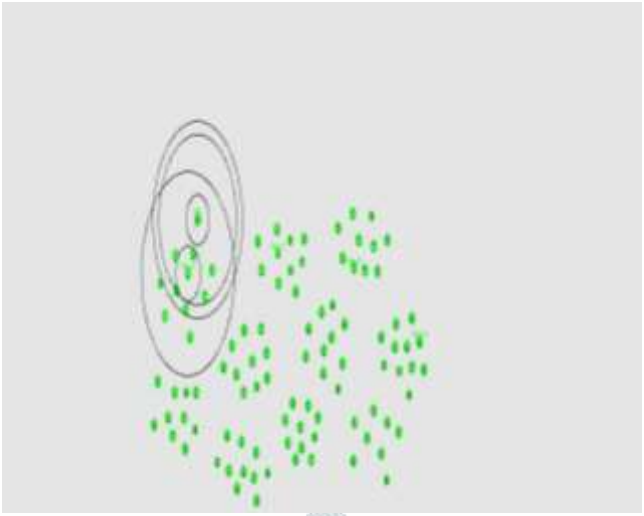

Figure 5 Simulation scenario

A. *RESULT ANALYSIS*- The performance of proposed clustering method were evaluated on the basis of different criteria's which illustrated below.

- Throughput- Data units received in form of bits, bytes or packets per unit time are known as throughput.

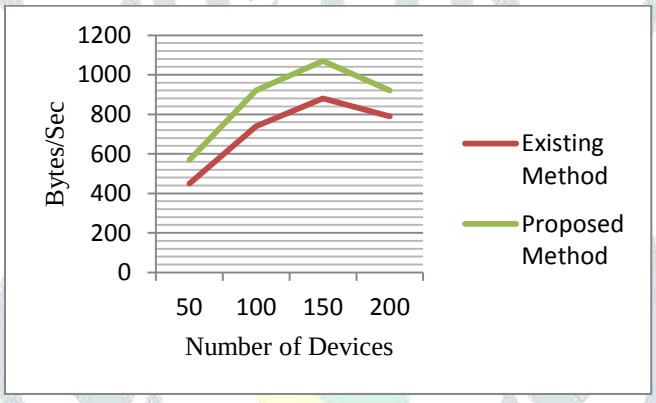

Figure 6 Throughput Comparison

- Cluster head overhead- Cluster head overhead define by number of beacon message transmitted during cluster head elections and maintenance.

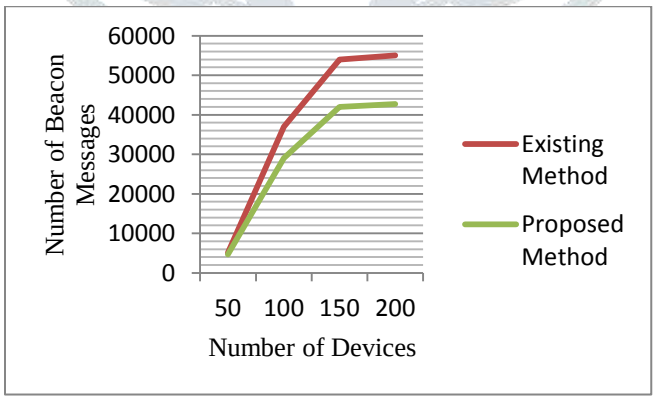

Figure 7 Cluster Head Overhead Comparisons

- Cluster head lifetime- Cluster head lifetime defined as time period spend by cluster head to server a particular cluster. Figure 8 show lifetime of cluster head with 100m coverage.

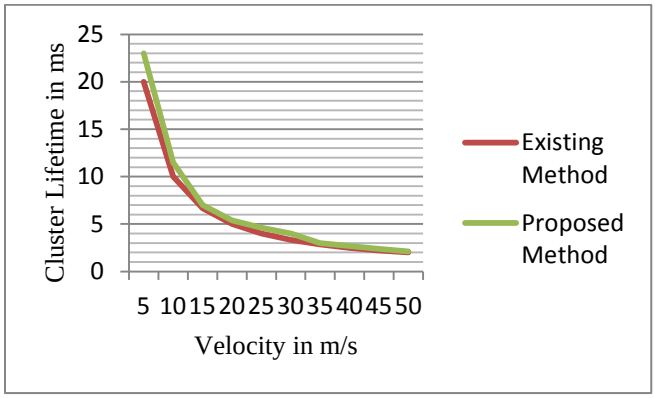

Figure 8 Cluster Head Life Time with 100m coverage

Figure 9 show lifetime of cluster head with 200m coverage.

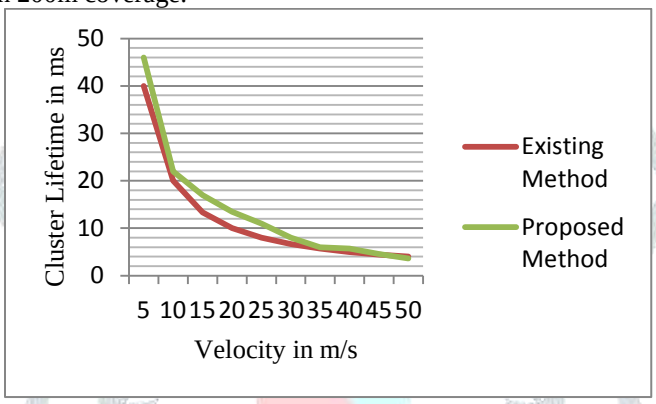

Figure 9 Cluster Head Life Time with 200m coverage

Figure 10 show lifetime of cluster head with 300m coverage.

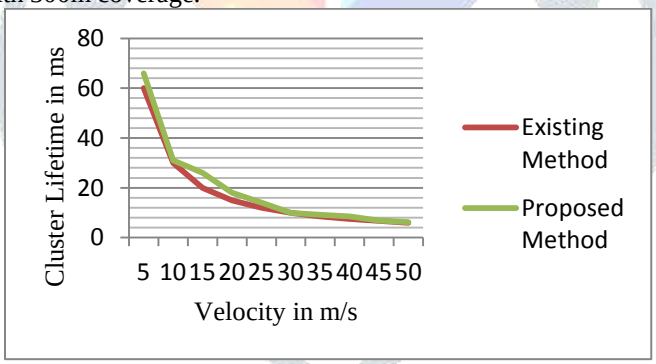

Figure 10 Cluster Head Life Time with 300m coverage

VIII. CONCLUSION AND FUTURE DIRECTION

Energy heterogeneous mobile ad-hoc network leads certain issues related to network performance like network partitioned and route failure due energy depletion. Most of optimum routing strategy mainly clustering concern about homogeneous environment. Proposed loosely coupled clustering approach compatible with heterogeneous network. Proposed method concerned energy heterogeneous device that enable fairness scheme in cluster head election process. Further approach will extends up to different heterogeneous characteristics with the use of additional parameters.

IX. REFERENCES

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