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A weighted clustering algorithm for optimizing the energy consumption in MANET

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Abstract -**The mobile ad hoc network is a new generation communication technology. In this environment the network devices are fully Wi-Fi enabled devices. Additionally for controlling these nodes not centralized control authority available. Therefore the topology formation and their management is the key of the network configuration. In this network these processes are handled by the routing algorithm. In this network the resources are developed with the network devices. In order to support the mobility models. But the resources are limited in these devices therefore the resource preservation is one of the most important research area in network technology. In addition of that frequent development of topology and their changes are also affecting the performance of network. Therefore a new technique of routing is required to minimize the resource consumption and maximization of performance factors. In this presented work the energy preservation is the key aim. Therefore a weighted clustering approach based energy efficient routing technique is proposed for work. In this context the energy targeted quality of service parameters are selected for work. Thus the buffer length, remain energy and the signal strength of the nodes are utilized for weight computation. Here the buffer length helps to understand the router load, remain energy distinguishes the energy efficiency of the node and signal strength shows the transmission ability of network node. Finally using the computed nodes weight based cluster head is selected. The proposed clustering scheme is implemented with the help of NS2 network simulator and their evaluation with respect to traditional normal network is performed. For comparative performance study the end to end delay, energy consumption, packet delivery ratio, throughput and routing over head is the main parameters. According to the results the proposed methodology for cluster formation is adoptable for network.**

Keywords: MANET, NS2 simulation, weighted clustering algorithm, energy efficiency, and performance optimization

I. INTRODUCTION

Although establishing correct and efficient routes is an important design issue in mobile ad hoc networks (MANETs), a more challenging goal is to provide energy efficient routes because mobile nodes' operation time is the most critical limiting factor. Mobile ad hoc networks support the communication among the nodes when they are on the fly. Mobility of the nodes in and around the network causes frequent change in the network topology. Thus the change in network topology that is associated with the link failures and creations perturbs the routing stability. Along with that, the scarce in radio resources and bandwidth, limited battery power and computing capability pose challenges in MANET scalability and efficiency [1]. Energy consumption is the most challenging issue in routing protocol design for mobile ad-hoc networks (MANETs), since mobile nodes are battery powered. Furthermore, replacing or recharging batteries is often impossible in critical environments such as in military or rescue missions. In a MANET, the energy depletion of a node does not affect the node itself only, but the overall network lifetime. Two mobile nodes are in transmission range with each other then they can communicate with each other directly otherwise the intermediate nodes in between have to forward the packets for them. It means every intermediate mobile node has to function as a router to forward the packets for others. Ad hoc networking allows the devices to maintain connections to the network as well as easily adding and removing devices to and from the network. Due to nodal mobility, the network topology may change rapidly and unpredictably over time. The network is decentralized, where network organization and message delivery must be executed by the nodes themselves [2].

So, this research work is dedicated to establish a novel energy efficient based clustering approach to simulate the wireless network and provide maximum network energy utilization with support of node efficiency.

II. PROPOSED WORK

This chapter provides the detailed discussion about the proposed solution for optimizing the energy consumption of network nodes. Therefore a clustering based scheme is

proposed for design and implementation. This technique helps to regulate network performance in terms of energy consumption and others.

A. System overview

The mobile ad hoc network is a new generation communication technology. The network is a self-organizing in nature additionally all the network nodes are enabled to send, receive or forward the data form each other. In this network the radio range is limited thus the network follows the relay technique for sending and receiving the messages across the network. Thus the network topology is frequently changing and frequent path break issues are observed in the network. In this context the network suffers from various performance issues. In order to control the losses in the mobile ad hoc network the literature suggested that to implement the clustering based approaches for regulating the different performance factors. Basically the clustering is a technique by which the similar property nodes are grouped for perform efficient communication. In addition of that the clustering approaches are helps to enhance the scalability of network.

In this presented work the WCA algorithm based energy efficient clustering is proposed for work. Using this technique the preservation of energy resource is the key aim of the proposed work. The WCA (weighted clustering algorithm) is basically usages the node quality parameters for selecting the optimal node as cluster head. Therefore in the entire clustering process the cluster head election is the main work using this cluster head the service of network is distributed to the cluster members. In addition of that between the two clusters the common nodes are termed as the gateway nodes which are help to enable communication among two clusters. The clustering approaches are also usages the mapping and addressing technique to reduce the network overheads. In addition of that due to the topology control methods helps to optimize the other performance parameters of the network. This section provide the overview of the clustering approach in the further section the core working of the proposed methodology is described.

B. Proposed technique

The proposed clustering algorithm includes the following three main phases for completing the clustering on the network.

1. **Parameter selection:** in this phase the node QoS parameters are selected for performing the weigh computation.
2. **Weight computation:** in this phase the weights of the all nodes are computed and their exchange is performed for selecting the best node among the available nodes.
3. **Cluster head election:** in this phase the cluster head is elected to server their cluster members.

Parameter selection

The key objective of the proposed clustering technique is to regulate the energy consumption in the network. Therefore the following key properties are selected for solution development purpose.

1. Remain energy: the remain energy of a node indicate their energy efficiency, additionally their life time to be live. Energy less than a predefined threshold can affect the normal functioning of network. Therefore in order to serve the network longer it is required the cluster head node has the sufficient energy level. According to the definition of energy consumption the difference of two time based energy level is used for computing the energy consumption rate which is used for cluster head selection. Thus suppose at time t_1 the node have the energy $E_1$and after a time difference Δt the new energy level becomesE_2. Then the rate in change on energy can be computed using the following formula;

$$\Delta E = E_1 - E_2$$

2. **Buffer length:** the buffer or queue length of a node demonstrates the amount of workload which is processed by any node. In this context the amount of buffer length is free to use indicate the node if free and can able to serve better the cluster members. This here for the length of buffer the letter B is used.
3. **Signal strength:** the signal strength of a node shows the transmission power ability thus for more optimal node selection the signal strength of the node is used. The signal strength of the node can be represented using the letter S for further discussion.

Weight computation

In order to select most optimal cluster head from the available cluster members the normalization process is required to compute the weights. Therefore the weight computation required some additional coefficients for computing weight factor. The weight computation is performed by all the nodes in network. To compute the weights the following formula is used:

$$W = \Delta E * w_1 + B * w_2 + S * w_3$$

Where the w_1, w_2, w_3 are the weight coefficient for normalizing the weights. The coefficients can be selected by the designer according to the following conditions:

$$w_1 + w_2 + w_3 = 1$$

Cluster head election

The higher weight of the node indicate efficient node, thus the higher weighted node among the all the neighbour nodes is selected as the cluster head.

Input: number of nodes N
Output : cluster head CH
Process: 1. A node in network broadcast the clustering request 2. Wait for response generated by network 3. $for(i = 0; i \leq N; i++)$ a. $compute\ \Delta E\ (change\ in\ energy), B\ (buffe$ b. Compute weight using $W = \Delta E * w_1 + B * w_2 + S * w_3$ 4. End for 5. Exchange computed W to one hop neighbour 6. Highest weigh node in one hop neighbour broad cast self as cluster head 7. Return CH

Table 2.1 proposed algorithm

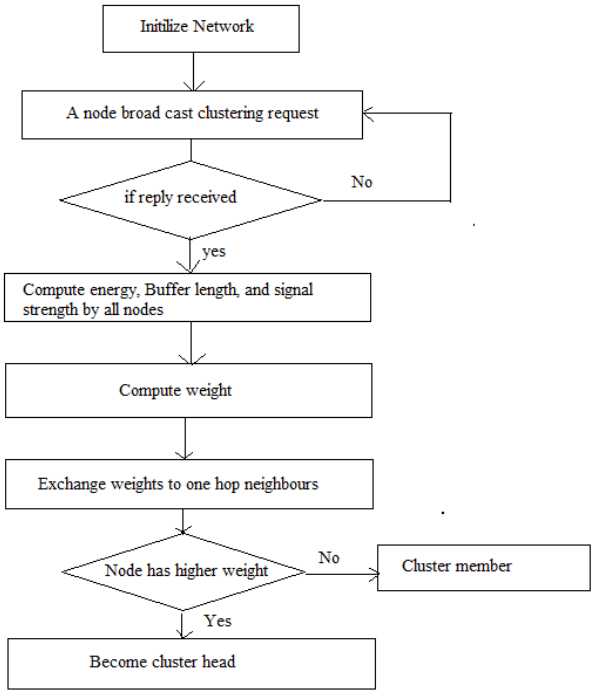

Figure 2.1 flow diagram

The entire process of the cluster head selection approach can be summarized as the algorithm the table 2.1 shows the process of the proposed algorithm.

C. Flow chart

In order to understand the entire process of the proposed algorithm the flow diagram of the algorithm is also developed. The figure 2.1 shows the algorithm description of the entire process.

III. Simulation Setup & Scenario

This section provides the network configuration and the experimental scenarios for simulation of proposed network.

A. Simulation setup

In this section the required network configuration of the proposed approach implementation is described. In addition of their parameters and the required values are also reported. The table 3.1 contains the network setup parameters and their description.

Simulation properties	**Values**
Antenna model	Omni Antenna
Simulation area	750 X 550 or 1000 X 1000
Radio-Propagation Model	Two Ray Ground
Channel Type	Wireless Channel
No of Mobile Nodes	20, 30, 50, 80, 100
Routing Protocol	AODV

Table 3.1 Network Simulation Setup

B. Simulation Scenario

In order to perform the experiments the following experimental scenarios are demonstrated in the proposed work.

1. **Simulation of AODV routing protocol based network:** in this phase the network is configured with the help of AODV routing protocol and with the different number of nodes the experiments are performed. During the experiments different performance parameters are computed and their comparative study is performed with proposed approach. The traditional network is demonstrated using figure 3.1.

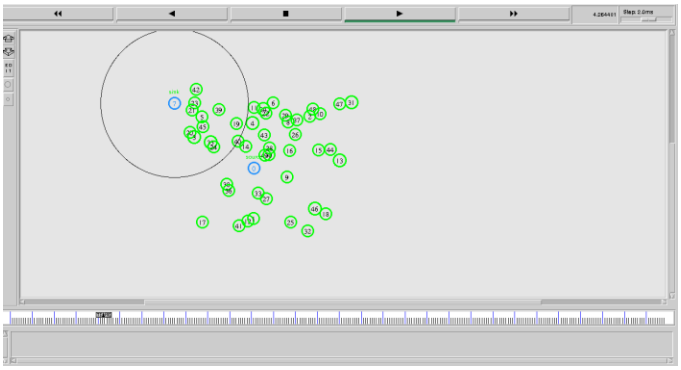

Figure 3.1 normal network

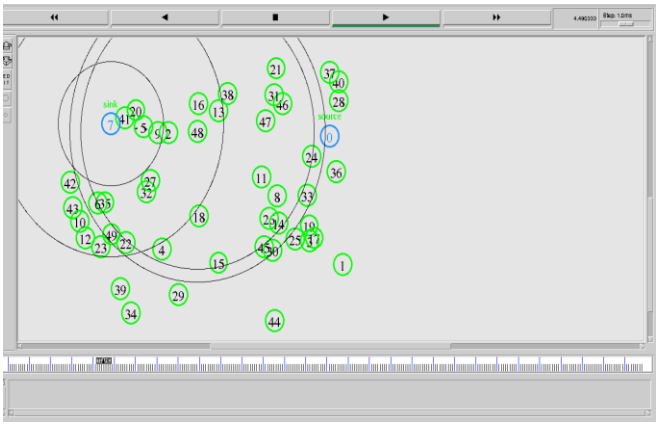

Figure 3.2 proposed network

Simulation of proposed clustering based network: in this phase the network is configured with the help of proposed cluster based routing technique and their performance is estimated for comparative performance study. The required network is demonstrated using figure 3.2.

IV. RESULT DISCUSSION

This chapter provides the detailed discussion about the experiments performed with the traditional AODV routing and the proposed cluster based routing technique. The comparative study among both the techniques is also reported in this chapter.

A. End to end delay

End to end day on network refers to the time taken, for a packet to be broadcast across a network from resource to purpose device, this delay is calculated using the beneath given formula.

$$E2E\ Delay = Receiving\ Time - Sending\ Time$$

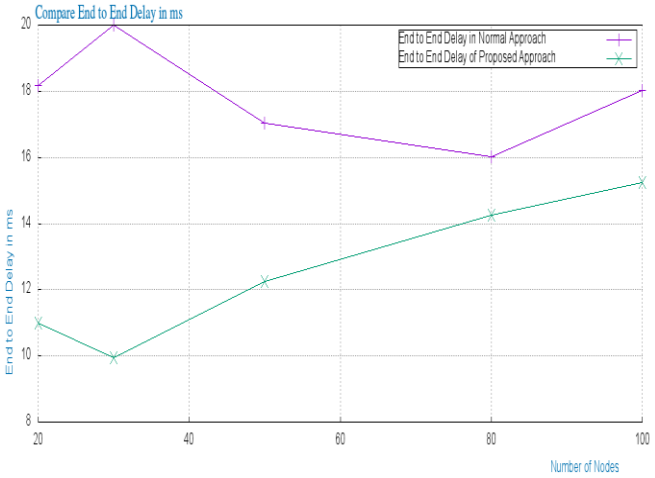

Figure 4.1 end to end delay

The end to end delay of the proposed technique and traditional AODV routing is reported in figure 4.1. In this diagram the X axis shows the number of network nodes in the experiments and the Y axis shows the amount of end to end delay in terms of milliseconds. The results show the end to end delay of the network in traditional AODV is higher as compared to the proposed cluster based routing. Therefore the proposed technique is much adoptable as compared to the traditional approach. Additionally the increasing amount of network nodes is impact on end to end delay. In other words the end to end delay increases with the increasing amount of network nodes.

B. Consumed energy

During the communication and network events the nodes consumes a part of energy from its initial amount of energy. The consumed energy of network nodes are recorded and reported here as the performance parameter of network.

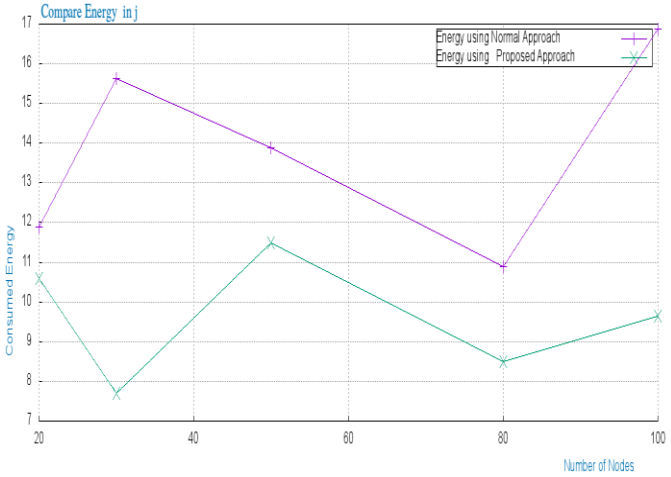

Figure 4.2 consumed energy

The figure 4.2 shows the amount of energy consumed in network nodes during the different experiments. The experiments are performed over 20, 30, 50, 80 and 100 numbers of nodes. In order to demonstrate the performance of networks the X axis contains the number of nodes in experimental network and the Y axis shows the amount of energy consumed after experiments. The measurement of energy is given here in terms of Jules. According to the experimental results the proposed technique of clustering consumes less amount of energy as compared to the traditional AODV routing protocol. Therefore the proposed approach of clustering is energy efficient as compared to normal network configurations.

C. Packet delivery ratio

The Packet delivery ratio is also termed as the PDR ratio. The packet delivery ratio provides information about the performance of any routing protocols using the successfully delivered packets to the destination. The PDR can be computed using the following formula:

$$Packet\ Delivery\ Ratio = \frac{Total\ Delivered\ Packets}{Total\ Sent\ Packets}$$

The comparative packet delivery ratio of traditional AODV routing and cluster based technique is described using figure 4.3. In this diagram the different number of nodes are given in X axis and the Y axis includes the percentage amount of packets successfully delivered. According to the obtained results the proposed technique able to deliver more packets effectively as compared to the traditional AODV routing protocol. Additionally that shows 89-96% percentage amount of successfully delivered packets. Therefore the proposed technique is more effective as compared to the traditional AODV routing protocol. On the other hand the traditional approach shows the 79-81% of successfully delivered packets. Thus the proposed approach is more efficient than the traditional routing technique.

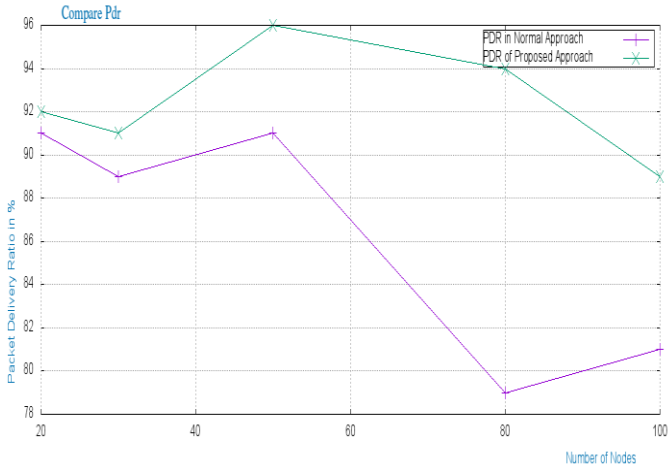

Figure 4.3 packet delivery ratio

D. Routing overhead

The routing overhead is the amount of additional control messages exchanged in network. The routing overhead is responsible to the network de-efficiency. The amount of routing overhead for both the network routing techniques is given using figure 4.4. In this diagram the amount of nodes in network is given using X axis and the Y axis contains the routing overhead of the network. According to the experimental results the proposed cluster based routing technique produces less routing overhead as compared to the traditional AODV routing protocol thus proposed technique much suitable for improving other network performance parameters. The main reason behind less routing overhead is the clustering approach by which the addressing and mapping of the location needs less amount of control message exchange in the proposed routing technique.

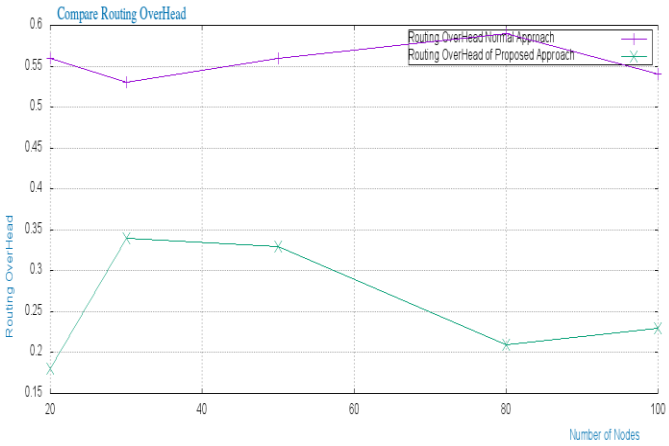

Figure 4.4 routing overhead

E. Throughput

Network throughput is the regular rate of successful message delivery above a communication channel. This data might be delivered above a physical or logical link, or pass during a certain network node. The throughput is regularly considered in bits per second (bit/s or bps), and sometimes in data packets per second or data packets per time slot. The comparative performance of the traditional AODV routing and proposed energy efficient routing technique is demonstrated using figure 4.5. In this diagram the amount of experimental nodes are given in X axis and the Y axis contains the amount of throughput achieved in the network. The computed throughput of network is reported here in terms of KBPS (kilobyte per seconds). According to the obtained performance results the proposed technique enable higher throughput as compared to the traditional routing technique thus proposed technique of clustering more efficient than the traditional AODV routing technique.

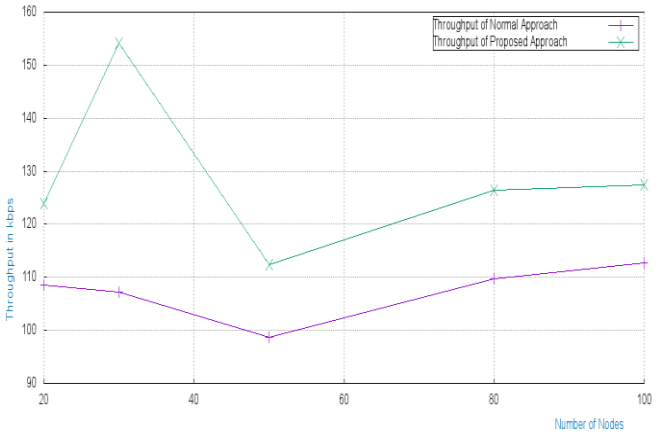

Figure 4.5 throughput

V. CONCLUSION

The main aim of the proposed work is to enhance the existing routing protocol for optimizing the energy consumption. Therefore a weighted clustering technique is implemented and their simulation and comparative performance study with the traditional AODV routing protocol is performed. This chapter includes the summary of entire work as conclusion of work and the future extension of the work is also reported with chapter.

A. Conclusion

The mobile ad hoc network is one of the recent and growing network technologies. A number of different applications are usages this concept. The main reason behind this is that it is rapidly configurable and deployable network. On the other hand the devices in this network are developed with their own resources therefore the network resources are limited and recovery of these resources is not feasible immediately. In addition of that the mobility is the also a major issue in network by which the network is suffers from the topology change issues and frequently packet drop conditions. Therefore a number of researches are performed for making it more and more resourceful. Among different network resources the energy is the key parameter of the network. That decides the suitability of the network node during their services. Therefore need to minimize the energy consumption for long life of the nodes.

The main aim of the proposed work is to enhance the energy consumption in mobile ad hoc network. Therefore a detailed literature review on different energy saving techniques is performed. According to obtained conclusion the clustering based techniques are much supporting for optimizing the energy consumption in ad hoc networks. Thus the proposed work is concentrated on the development of energy efficient clustering approach. The proposed clustering technique usages the energy change rate, buffer length and the signal strength for supporting the parameters for energy preservation. Using these parameters the weights for the entire node is computed and the higher weighted node is elected as the cluster head. The clustering is recalled after a small time delay for reducing the complexity and enhancing the QoS of the network because if the clustering is not recalled for long time can reduce the efficiency of the network.

The implementation of the proposed approach is provided with the help of NS2 network simulator. Additionally for implementing the proposed concept the AODV routing protocol is modified. After implementation of the technique the different performance parameters are computed and their summary is described using the table 5.1.

S. No.	Parameters	AODV	Proposed clustering
1	End to end delay	High	Low
2	Packet delivery ratio	Low	High
3	Throughput	Low	High
4	Energy consumption	High	Low
5	Routing overhead	High	Low

Table 5.1 performance summary

According to the obtained performance as listed in table 5.1 the proposed energy efficient weighted clustering algorithm is efficient as compared to the traditional routing technique. Therefore the proposed technique is adaptable for a network to preserve their energy consumption and optimization of other performance factors of the network.

B. Future work

The main objective of the proposed work is achieved successfully and the experimental results show the efficient performance over the traditional routing techniques. In order to work in future the technology can be extended for the following manners:

1. Includes the selection of optimal weight coefficient for optimizing more the performance
2. Considering the different security issues to achieve security and performance both
3. Consider more parameters for improving other application based aspects

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