Load Balanced Reliable Routing in Cluster based MANETs to Reduce Energy Consumption

Jayashree Lakshmi
PG Scholar
Department of ECE,(DEC)
MVJ College of Engineering
Bangalore, India

Arshiya Sultana
Assistant Professor
Department of ECE
MVJ College of Engineering
Bangalore, India

***Abstract*— Mobile Ad-hoc network is a "self configuring" network of mobile routers. A node doesn't need an extensive knowledge of network parameters before joining the network. MANETs are free to move in any direction. They use wireless links to connect with other networks. MANETs are widely used in military field, disaster relief operations during tsunamis and earthquakes and Ad-hoc gaming in subways and cafes etc. As the technology improves, application of MANETs are also improving day by day, so maintaining the bandwidth efficiency plays a major role in improving the network performance. By minimizing the energy consumption, delay and properly distributing the workload during non uniform load distribution, we can improve the network performance. In this paper, Cooperative load balancing and dynamic channel allocation scheme has been used to overcome the issues of MANETs. In the Proposed system MATLAB is used as a tool to create optimal number of clusters based on Partitioning around Medoids (PAM) algorithm**

Keywords*— *Mobile Ad hoc networks (MANETs), Partitioning around Medoids (PAM), Dynamic Channel allocation, MH TRACE.

I. INTRODUCTION

In today's rapidly growing world of technologies, many business industries understand the advantages of computer networking usages. A computer network is a system that provides communication between computers. Wireless networks became popular in the computing industry. There are two variations in mobile wireless networks. The First type of mobile wireless network is infrastructure network i.e., network with fixed and wired gateways. Base stations [BS] serve as a bridge for these networks. A mobile unit communicates with the nearest BS that is within its communication range. As the mobile travels out of range then the hand off occurs from old BS to new and the communication continues throughout the networks. Applications of this type of networks are the wireless local area networks (WLANs). The second type of mobile wireless network is the infrastructure-less network, commonly known as Ad-hoc network. It has no fixed routers. A node doesn't need an extensive knowledge of network parameters before joining the network. Nodes function as routers which maintain path to other nodes in the network. Applications of ad-hoc networks are emergency search, rescue operations, group communication, and ad-hoc gaming in subways and cafes.

MANET is a "self configuring" device [1]. Each node in the network acts as a router to exchange the information from source node to destination node. Nodes are limited in power, memory and they are free to move anywhere within the network. As MANETs users increase, maintaining bandwidth efficiency also increases in terms of throughput, energy consumption, and delay. This plays a major role in the network to improve the lifetime of the network. It is pivotal for medium access control (MAC) protocol to not only "adapt to the dynamic environment" [1] but also to manage the bandwidth efficiency. Some of the key challenges faced within the MAC protocol are maximization of spatial reuse, providing support for non uniform load distribution and support to perform multicasting. Multicasting is essential to use the network resources in a proper way [1].

Spatial reuse means multiple devices has an ability to use the same channel resources for communication, this intern prevents the unnecessary usage of channels and speed will be high. Because of the dynamic behavior of the MANETs, load will be distributed in a random manner so it is very important for the MAC protocol to handle the non uniform load distribution.

Coordinated MANET MAC protocols require special designs to use the same channel resources for their communication and to balance the non uniform load distribution. This special design overcomes the fundamental issues of MANETS. In our research we used algorithms to form a cluster of several nodes, for encrypting the data and to dynamically access the channel with proper load balancing.

This paper is organized as follows. In section 2 we discuss literature survey; proposed work is described in the section 3 with the short description about CDCA TRACE protocol and PAM algorithm, section 4 consists of simulation results and section 5 is the conclusion.

II. LITERATURE SURVEY

Mobile Ad Hoc networks are commonly increasing and as the application evolves, the network loads considered for MANETs are also increasing. Coordinated channel access protocols have been developed that is suitable only when the network load is distributed uniformly [3]. Suppose if the load is distributed randomly then it fails to maintain the bandwidth efficiency.

A distributed dynamic channel allocation algorithm has been proposed in [4]. The idea of the algorithm is to split the shared channel in to control segment and transmission segment. Control segment is used to avoid clashing between the nodes and to increase the usage of transmission segment. The flaw of the algorithm is that there is no optimal guarantee for a network that the particular control channel will be assigned with the priority.

In multi-hop wireless sensor network, CSMA (Carrier Sense Multiple Access) technology enables the usage of same radio receivers to increase the bandwidth efficiency but at the expense of possible collision. Collisions are due to the hidden terminal problems. In order to tackle these problems RTS/CTS (Request to Send/Clear to Send) packet exchange mechanism before the transmission of packets has been proposed. Though handshake signals reduce the hidden problems but it fails in case of heavy network loads, so several modifications has been done to the RTS/CTS exchange mechanism. This approach solves the channel assignment problems when there is a single destination for transmission of data however it fails to provide group communication [1].

III. PROPOSED WORK

Fig.1 shows the architecture of the proposed system. Network initialization is the initial step then formation of the cluster and balancing the loads between the nodes using PAM algorithm after distributing the workload, channel allocation is necessary to transmit the data using CDCA TRACE algorithm, later the encrypted data can be transferred to Base Station (BS) and finally decrypt the data. Encryption and decryption is performed using Caesar cipher algorithm.

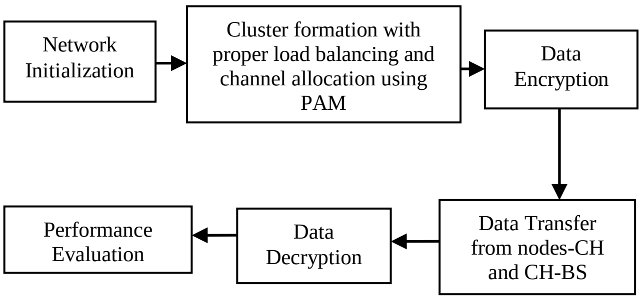

Fig. 1 Block diagram of the Proposed System.

Network initialization is the initial step of the proposed system. Each node in a network acts as a router to send the message from source node to sink node. Each sensor node has equal probability of being placed at any point in the given field. Sensing range will be the length of the unit cell. Within the sensing range the node can able to transmit and receive the information. Totally we are placing 20 nodes in the sensor field. The sensor field is 100 by 100m in dimension.

Following are the steps to initialize the network.

1. Initialize X and Y axis.
2. Initialize (3,n) distance matrix to zero, where n indicates the number of nodes.
3. Allocate the particular axis to the node; simultaneously update the distance matrix and other node parameters.
4. Above steps will be repeated till n number of nodes gets a particular axis.

Same procedure has been followed for the allocation of base station (BS).

Cluster Formation is nothing but clubbing number of nodes to minimize the dissimilarity between the nodes. Dissimilarity is in terms of distance between the nodes and the CH. Formation of the cluster can be done using Partitioning around Medoids (PAM) Algorithm [5].
Cluster Head (CH) or Centroid is the node which communicates with other neighboring nodes. Following are the steps for cluster formation using PAM algorithm.

1. Initialize the number of cluster to be formed.
2. Choose any k nodes as a CH, where k is the number of clusters.
3. Calculate the distance between each node to the closest CH by using the formula (1).

$$D_{ij}=\sqrt{\sum_{a=1}^{p}(X_{ia}-X_{ja})^2} \quad i=1,2\ldots n,\ j=1,\ldots,n \qquad (1)$$

Where D_{ij} represents the distance between i node to j CH, P is the number of nodes and X indicates the node and CH.

4. Associate each node to the closest CH based on their distance.

5. Calculate the total cost of each cluster by using the formula (2).

$$Cost(x,c)=\sum_{i=1}^{d}\left|X_i - C_i\right| \qquad (2)$$

Where X_i indicates the node; C_i is the centroid and d is the dimension of the object K.

6. If the cost increases, swap the CH and node, and re-compute the cost by using the step 5.

7. If the cost decreases, stop the process.

Load balancing is the method of distributing the workload from the heavily loaded area to less loaded areas.

Following are the steps to perform Load Balancing

1. Initialize node parameters-Number of nodes present in the network, CH, initial energy of each node

2. Calculate the distance covered from each node to CH by Euclidean distance formula (1).

3. Calculate the Residual energy of the nodes by using the formula (3),

Residual Energy=Initial Energy-(0.1*distance Covered) (3)

4. Route establishment is from node to CH that is based on the calculated distance and energy. The node having more residual energy will get the chance to handle the load, in this manner load will be distributed equally.

MH TRACE (Multi Hop Time Reservation using Adaptive Control for Energy Efficiency) [1] incorporates spatial reuse concept, but it does not provide channel borrowing and work load distribution mechanisms. It also fails to support non uniform loads, therefore CDCA TRACE Protocol has been proposed which is a combination of DCA-TRACE and Cooperative load balancing. It has high bandwidth efficiency among the TRACE family. In MH TRACE time is sub divided into equal length super frames and further divided in to 6 frames, each frame is subdivided into control sub-frame and data sub-frame. Control sub-frame is for signaling between nodes and CH, Data sub-frames are for transmission of data payload.

In DCA TRACE, CH operates in more than one frame in a super frame, if these frames are overloaded. Based on the load level, CH decides the required number of frames and chooses those many frames from the least noisy frames. Interference level of the beacon and slot used for the estimation of interference for CH operating in the same frame, are updated with the measured values in the frame using the formula (4)

$$I_{n,t}=\begin{cases} P_{n,t} & \text{if } I_{n,t-1}<P_{n,t} \\ (1-\alpha)I_{n,t-1}+\alpha P_{n,t} & \text{o.w.,} \end{cases} \quad (4)$$

Where In,t and In,t-1 are the interference level of the nth slot in the present and previous super frame. Pn,t is the measured interference level in the slot is the smoothing factor(0.2).CH keeps track of the interference level of the information slot of each frame in the super frame. CH marks the frame as unavailable if the same frame is used by another cluster and abide closer to certain threshold. DCA TRACE makes use of channel borrowing mechanisms. Instead of reallocating the borrowed data slot from another CH, it must allocate another data slot which is having a lower interference level. CH assigns the data slots to the nodes which have sent the request for accessing the channel. DCA TRACE [7] is capable of adapting to shrinking network dimensions and non uniform load distribution.

In CDCA TRACE [1], nodes continuously monitor the data slots at the CH by sending the beacon messages. If all the available data slots are allocated with the probability p then the active nodes present in the corresponding cluster trigger the cooperative load balancing algorithm. The node which is using the data slots from the heavily loaded CH is maintained by the data slots of another nearby CH while storing its reserved data slots until it procured a new data slot from another CH. CDCA TRACE includes the additional frame selection algorithm with some delay to overcome the flaws of cooperative load balancing. A fully loaded CH resets the counter, $U_{DCA}=0$ and starts incrementing at the starting of each super frame. CH puts an effort to access an additional frame when $U_{DCA}>=$Response time. This provides the time for the active nodes to transfer their loads to nearby CH.

Data Encryption should be done to secure the data from the hackers. A Caesar Cipher algorithm [6] is used to encrypt the data. Encryption can be described using the formula (5)

$$E_i=(O_i+K) \bmod l \quad (5)$$

Where E_i indicates the i^{th} character of the closed text, O_i indicates the i^{th} character of the open text, K indicates the shift and l indicates the length of the alphabet, l=26. Encrypted data is transferred to CH based on the above discussed algorithm then after all the collected data is transferred to the BS for communication. Decryption [6] should be done to obtain the original data this can be performed by using the formula (6)

$$D_i=(O_i-K) \bmod l \quad (6)$$

IV. SIMULATION RESULTS AND DISCUSSION

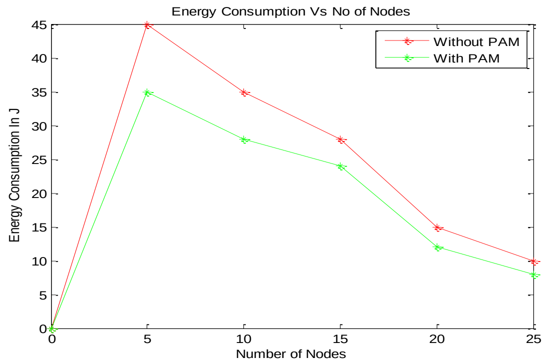

Fig. 2 Energy comparison of varying nodes with using PAM algorithm and without using PAM algorithm.

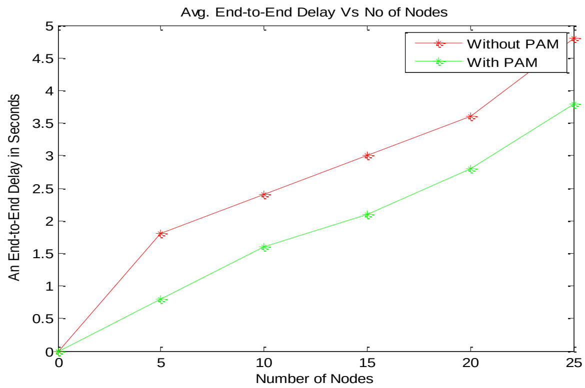

Fig. 3 End to end delay comparison for varying nodes with using PAM algorithm and without using PAM algorithm.

Unnecessary usage of the channels and improper distribution of work load among the nodes leads to more energy consumption, since we are using the PAM algorithm based on the distance between all the nodes and residual energy. Load balancing has been done and also data slots are properly utilized using CDCA TRACE. Fig.2 shows the comparison of the work done using PAM algorithm and without using PAM algorithm. After the utilization of PAM algorithm consumption of energy has been reduced. Similarly delay between the nodes has been reduced due to the proper utilization of the channel and less energy consumption.Fig.3 shows the comparison of end to end delay between the nodes. Red solid line indicates delay variation without PAM and Green solid line indicates the delay variation with using PAM algorithm.

As the number of nodes increases, energy consumption and delay is decreased by properly clubbing the nodes by calculating the distance between the nodes and properly accessing the channel for data transfer, due to this network lifetime is also improved when compared to the work done without using the PAM algorithm.

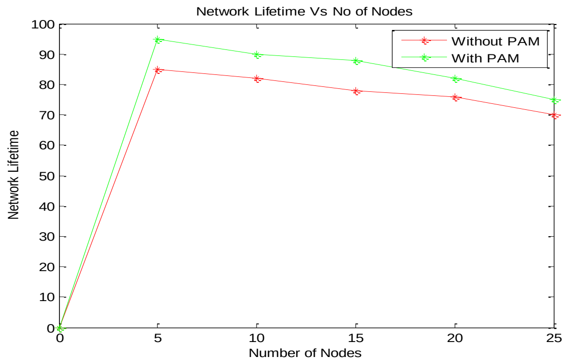

Fig. 4 Network Lifetime for varying nodes with using PAM algorithm and without using PAM algorithm.

In the simulation we have considered following parameters, simulation area-100X100m, energy of each node-100j,Number of clusters-3,number of nodes-20,MAC-802.11,simulation tool-MATLAB.

To sum up, under heavy and non uniform load distribution PAM and CDCA TRACE not only increases the nodes that can access the channel and load balancing techniques, it also reduces the energy consumption and absolute IPDV(Inter Packet Delay Variation) leads to a higher number of receptions. This intern maintains the bandwidth efficiency.

V. CONCLUSION

In this paper, we overcome the several fundamental issues of MANETs, by forming optimal number of clusters using PAM algorithm. The algorithms used in this paper minimize the energy consumption, end to end delay which intern improves the lifetime of the network. This plays a very important role in rescue operations and in military field to communicate with the other group of members in a faster way. But there is a lack of security in communication in the proposed work. This can be overcome in the future by considering other security related algorithms.

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