An Effectual Load Distribution Approach based on Transmission Power and Topology Controlled Clustered Environment in Mobile Ad Hoc Network

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ABSTRACT
Mobile ad-hoc networks (MANETs) are demanding considerable improvement in energy efficiency, as their applications are being developed continuously and consistently which also includes high level performance oriented application. In MANET the mobile nodes are dynamic in nature. It also suffers from other two constraints which are Limited Processing capability and Limited Power Supply. Energy Consumption in the nodes takes place mainly during the communication process between the nodes. One of the approaches to improve the efficiency in energy is by applying Transmission Power Control (TPC) technique to adjust the transmission power in communication between nodes. Another approach is, distributing the loads within the network and also maintaining clusters in this uncertain network. Therefore, we investigate different effects of TPC on two load distribution approaches like Localized Energy Aware Routing (LEAR) and Conditional Max-Min Battery Capacity Routing (CMMBCR) protocols for MANETs, in a restricted customized environment by forming clusters within the nodes. This improves the network scalability and also decreases the probability of the network failure. This topology control focuses on the clustering of the nodes in a particular formation and communicates with the nodes according to the status of them in the clusters. The experimental results show a noticeable effect of TPC implementation technique on MANETs in respect to transmission energy consumption and packet received ratio at low node mobility.

Keywords
MANET, Transmission Power Control, load distribution, Localized Energy Aware Routing (LEAR), Conditional Max-Min Battery Capacity Routing (CMMBCR), clustering.

1. INTRODUCTION
Many applications are being emerged with the use of mobile ad-hoc networks as a basic platform for their functions, for research and development of wireless network. Energy dissemination in an unwanted or unanticipated ways is to be reduced and required factors should be considered when working for improving energy efficiency in ad-hoc networks [1, 4]. Essential Considerations has to be taken over the limitations of the mobile ad-hoc networks. Application of MANETs vary from different sizes and sources which may be a small scale application or medium/large scale applications such as commercial sectors, military/defense forces, health and safety sectors and so on [15]. These applications, demands mandatory mobile ad-hoc networks with minimal energy wastage with maximum benefits for its users.

Energy Preservation in MANET is a challenging task because of the limitations of the mobile nodes. This, as a result, made the design and development of the routing protocols in mobile ad-hoc networks to consider several controllable and un-controllable factors, which made this as a difficult process [3]. To extend the lifetime of the network, several approaches and strategies are being defined. These approaches can be categorized as: (1) Transmission power control (2) Load distribution and (3) Topology control. The transmit power control approach, manages the transmission power required for a node to transfer the data to its destination/neighbor nodes. In the load distribution approach, the nodes with minimal energy levels are avoided in communication process in order to increase the network lifetime. Sleep/Wake approach or simply power down approach are also widely been used as a tool to conserve energy in the network [6].

Topology control in MANETs aligns the nodes into a group and manages the cluster of nodes. The intended goal of clustering is to form a structured arrangement/collection of nodes which is not possible in actual MANET formation. The nodes must not act in a selfish manner by avoiding the transmission/relaying the data packets in order to preserve energy. The forwarding of packets and the topology control are mutually proportional to each other in such a way that, both of the process must have a balanced and proper approach towards the cluster nodes, which, as a result, makes the topology more reliable. Moreover, due to the mobility nature of MANET, the nodes have least information about the connectivity and the information of the other neighbor nodes. In order to solve the issues which are discussed above, the balanced clustering algorithms have been focused. Multi-hop communications plays a pivotal role in this system where the entire nodes involved in the communication within the network act as a router and host simultaneously. HEED is one of the clustering mechanisms of the nodes in the network which uses multi-hop communication. Multi-hop communication works on the concept of Route Clustering. Route cluster node can receive data from any number of sensor nodes. When the presence of the same node in two different cluster groups is identified, it will not be elected as a cluster head [2].

The intention of node clustering process is to form a structured infrastructure of the mobile nodes which facilitates a reduced communication overhead, because the number of nodes are restricted into a group of clusters, where the communication between the groups are clear, in turn reduces the packet loss during communication.

In this paper, the load distribution schemes like LEAR and CMMBCR schemes are used for TPC by using clustering communication schemes. The presented schemes performances are evaluated in terms of throughput, average delay and packet delivery ratio and the performance are compared with existing TPC scheme of Efficient Power Aware Routing (EPAR). The nodes in the network are clustered in the first place, and the loads on the nodes are distributed using different mechanisms mentioned above and it will be compared with each other. The transmission of packets in this whole process is controlled by the TPC approach. By simulating this comparison, it will facilitate us to identify the better approach in order to increase the energy efficiency.

2. RELATED WORK

Femila & Vijayarangan (2014) [16] presented Cooperative Communication (CC) where the main objective is to link the disconnected and separated networks into a group of individual network in order to maintain network connectivity and also to reduce the transmission power required for each and every nodes in the network for transmission from the source to intended receivers or destination. The main aim of the cooperative communication is to improve the quality of service in MANETs. Network coding is a concept introduced in this paper alongside with the cooperative communication where the bandwidth usage is also reduced. This uses the Energy aware power routing with network coding. Identifies the node battery capacity and it also predicts the expected battery level of the node in the forthcoming communication process. This process is compared with other similar protocols which showed some limitations in packet delivery ratio [4].

Harsha Tembekar et al., (2017) proposed a style approach, which is something different when compared to the usual network style which mainly focuses on the cross layer interaction. The cross layer style for power management is experimented which shows improvement in the results when compared to that of AODV protocol approach. The Transmission powers of the nodes have been managed in an efficient manner in this approach. Again the simulation has been done through NS-2 and comparison to other approaches is made. This approach has a constraint in terms of throughput which has to be addressed [18].

Muthuramalingam & Rajaram (2010) presented a novel algorithm for clustering of nodes by transmission range based clustering (TRBC). This approach believes that the transmission power of each and every node in the network can be reduced by reducing the transmission/communication range of the nodes in the network. As a result the energy consumed by each node is also decreased in such a way that it will facilitate the formation of topology of the nodes and make the process easier. Clustering involves in formation of cluster heads. Efficient selection of cluster heads improves the performance of the network to a considerable extent and prolongs the battery life. The node density, the area of coverage of individual nodes and the node’s processing capability are analyzed before the formation of the clusters [7].

Majumder & Sarma (2010) presented an energy and mobility aware clustering approach. The improvement in the performance of the network is anticipated in this approach where the clustering is applied in the load distribution DSR protocol and the performance metrics are identified and evaluated. Considerable gain in the performance is noted in this approach when combining the clustering approach to the load distribution approach. The throughput, delay and the performances are simulated using Ns-2. The results concluded that the proposed approach has an upper hand when compared to the CBRP approach [8].

Li et al., (2014) presented an algorithm which is based on Power assignment in combination to the cooperative communication (CC). The dynamic cooperative clustering is induced in this methodology. The clustering of nodes takes place and this approach facilitates the communication between the clusters through CC. A static number of redundant links are been identified between the clusters. The kruskal algorithm is used to remove those redundant connections. The Cluster head rotation schema is introduced in this approach in order to increase the life span of the network to a greater extent. Simulation results show that it can improve both the network capacity and lifetime by 80% and 20% [17].

3. METHODOLOGY

3.1 Load Distribution Approach

The load distribution in a wireless network balances the loads on the sensor nodes. Communication between the nodes takes places in a manner without affecting or depleting the energy levels of the node in such a way that the nodes in the state of depleting energy levels, i.e. nodes which have been used extensively in the communication process continuously will be avoided during the routing process [5]. Hence this approach enhances and makes considerations both on routing efficiency and energy efficiency of the sensor nodes, which on the whole increases the network lifetime.

Load distribution approach is one of the key factors contributing in the power management of the nodes by even usage of all the nodes involved in a particular communication. The fact is that, the shortest path to the destination is always preferred during any transmission.

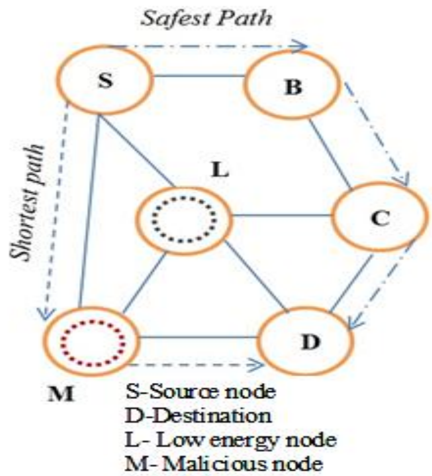

Figure 1: Load Distribution Based Routing from Source to Destination

But in this case rather than preferring a shortest path, the routes which consist of underutilized nodes is chosen here. Although this may result in longer turnaround time for the nodes involved in this communication, they are energy-rich nodes where they avoid the continuous overloading of other intermediate nodes. As a result this approach ensures a longer network lifetime.

3.2 Significance of routing and energy efficiency

Localized Energy Aware Routing (LEAR) is a load distribution protocol which is advancement to the DSR approach, where the route request message in DSR directly directs the message to the destination after examining the header of the request message. In contrast, in the LEAR protocol the node takes down the ultimate authority of deciding whether to forward the route request message to the destination node or not [9]. The node analyses the threshold value of the energy levels. The node forwards the request message only if the energy values are higher than the threshold value. If the Energy (Er) is higher than that of the threshold (Tr) value, the node has a further participation in the communication. Otherwise it drops the message and ignores to participate in the further transactions.

Conditional Max-Min Battery Capacity Routing (CMMBCR) is a load distribution approach where, it also follows the same principle of threshold similar to LEAR. In this an expiration sequence is maintained which is related to the battery capacity. This expiration sequence gives information about how fairly the energy is expended. In this schema the minimum power route is selected if the nodes in between the source and the destination have energy levels higher than the threshold value [10]. In contrast the max-min route is selected when the intermediate nodes has energy level minimum when compared with the threshold.

3.3 Topology Control

The topology control approach is used in mobile ad hoc networks in order to minimize the depletion rate of the nodes energy levels. Unlike in the wired networks which have a fixed infrastructure, each node in the network have the capability of making unanticipated changes in the topology of the network. Therefore the main aim of the topology control approach is to protract the network lifetime and throughput by providing a control mechanism which improves the network connectivity and provide performance optimization. Topology in MANET is affected by controllable factors such as transmission power and un-controllable factors such as interference, node mobility and so on [11]. Topology control involves in clustering of the nodes in a particular formation and communicates with the nodes according to the status of them in the clusters. Clustering sensor nodes improves network scalability and also decreases the probability of network failure due to communication overheads and so on [12].

HEED (Hybrid, Energy-efficient, Distributed) Clustering approach

The major objectives of the HEED approach is

i) Prolonging network lifetime through the dissemination of energy consumption.
ii) Clustering terminates within threshold iteration.
iii) Providing well distributed cluster heads with minimized control overhead.

The cluster head selection in this process is primarily based on the remaining amount of energy available in each node [13]. This residual availability of energy can be estimated and no measurement for the same is needed. To be more precise in this process the secondary clustering parameters such as “communication costs” are also considered in selecting the cluster heads.

The basic idea behind sensor nodes clustering is to select a cluster head among the available nodes in the network. The nodes with increased energy levels are usually considered for selecting as a cluster head, and these heads are responsible for clustering other nodes in the network. Co-ordination within the nodes is an important task of the cluster head and each head fetches the exact status of the nodes under its cluster. [14]. As the cluster heads acts as a representative for number of other nodes, the lifetime of network is increased as number of nodes rivalry for channel access is reduced. It forms relatively a smaller network diameter which reduces the communication overheads. Based on the above procedures, the energy consumption for routing has been reduced. The performance analysis is evaluated in given below section

4. RESULTS AND DISCUSSION

In this section, the presented LEAR and CMMBCR schemes performances are evaluated and compared with existing EPAR scheme. The factors such as throughput, delay, the delivery ratio of the packets, and the consumption of the energy during this entire process are considered for evaluating the performance. This simulation is done by using network simulator-2. For this simulation the sensor nodes are selected randomly and tested in an environment, where the placement of the nodes with the same transmission radius takes place in a 500 m x 500 m.

Table 1. Simulation Parameters

Parameters	Values
Area	500 * 500 m
Number of Nodes	100+1 BS
Initial Energy	100 Joules
Cluster Radius	60 m
Duration	200 Sec
Packet Interval	0.1 to 0.7 Sec
Max. No. of Nodes for comparison	100

The network topology is randomly generated with different number nodes which are linked together where the number of nodes can vary from 50-100. When the density of the network changes the performance results vary accordingly. The simulation parameters are illustrated in table 1. The parameters and the values mentioned in the above table are adhered in the simulation, where the outcome and results using these parameter values may vary if they were increased or decreased. We simulate the scenario and compare the results with existing mechanisms.

4.1 Throughput

Figure 2 shows the throughput performance comparison among proposed LEAR, CMMBCR and existing routing scheme EPAR. It is noted that the proposed LEAR within the cluster scenario attained high throughput when compared with the existing protocols. Due to the effectual TPC and cluster head selection, the proposed scheme attained high throughput.

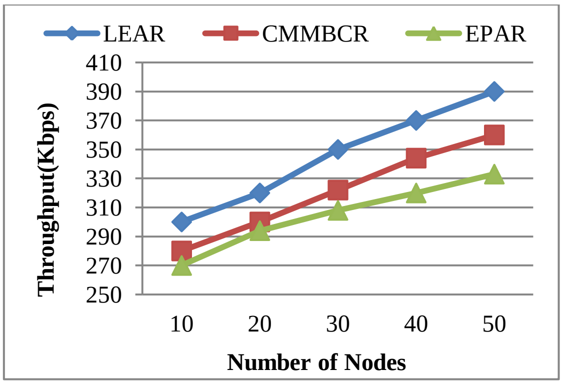

Figure 2: Throughput comparison Vs. Number of nodes

From this comparison it is proved that the proposed research method LEAR shows better throughput where it is 7.168% and 11.85% better, when in comparison to CMMBCR and EPAR.

4.2 Packet Delivery Ratio (PDR)

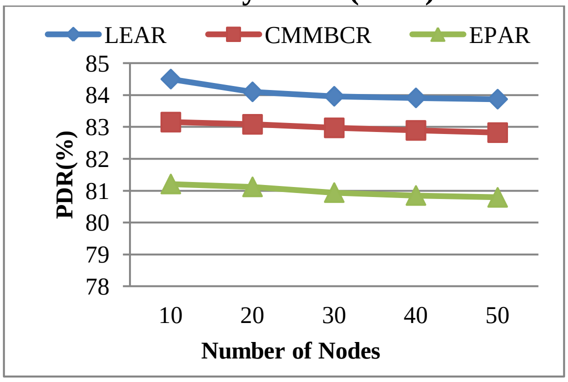

Figure 3: PDR comparison Vs. Number of nodes

Figure 3 presents the packet delivery ratio for proposed LEAR, CMMBCR and existing routing scheme EPAR. PDR plays a significant role in identifying the performance improvement where it finds the number of packets sent from the source successfully received by the intended destination. The graph above depicts clearly that LEAR has considerably higher packet delivery rate when compared to others. This, as a result, improves the lifetime of the cluster heads. From this comparison it is proved that the proposed research method LEAR shows better packet delivery ratio where it is 1.292% and 3.671% higher than CMMBCR and EPAR.

4.3 End-To-End Delay

Figure 4 depicts that the delay is being increasing in accordance to the number of nodes. It can be observed from the figure that the proposed LEAR protocol has a lower delay rate as compared to CMMBCR and EPAR.

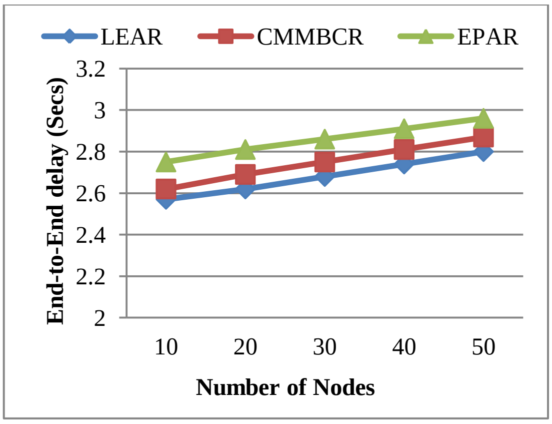

Figure 4: End-to-End Delay comparison Vs. Number of nodes

The cluster head optimization is focused in our approach and their stability deviation has been taken care. Thus, based on the strength of Cluster Heads, a node gets associated uniformly with the one having maximum strength in its transmission range. As a result, the CHs loads are been balanced, in turn the packet dropping ratio has also reduced which is directly proportional in decreasing the end to end delay. This comparison proves that the proposed research method LEAR has a decreased amount of end-to-end delay where it is 0.066s and 0.176s better than CMMBCR and EPAR.

4.4 Energy Consumption

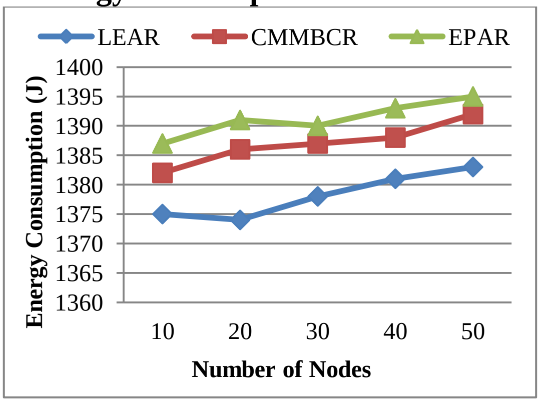

Figure 5: Energy consumption comparison Vs. Number of nodes

Figure 5 show that the graphical representation of energy consumption for proposed CMMBCR and EPAR. It can be observed from the figure that the proposed LEAR scheme has lower energy consumption when compared with the other protocols. Due to the effectual topology control through clustering, the proposed scheme used less energy for transmission. From this comparison it is proved that the proposed research method SRC shows less energy consumption where it is 8.8J and 13J less, than the energy consumption of CMMBCR and EPAR. The overall performance and the numerical average values are illustrated in table 2. It shows the performance of all parameters which shows the proposed LEAR resulted in better performance compared to the other defined approaches. Due to the effectual TPC with load distribution and topology control, the LEAR attained better results.

Table 2: All performance measures numerical evaluation

Performance measures	Routing protocols		
	LEAR	CMMBCR	EPAR
Throughput	346	321.2	305
Packet delivery ratio	84.068	82.982	80.982
End-to-end delay	2.682	2.748	2.858
Energy consumption	2.682	2.748	2.858

5. CONCLUSION

In this paper, an energy efficient load distribution scheme is presented with efficient transmission power control and using topology control clustering. In this process, the loads of the nodes are balanced through LEAR and CMMBCR protocols. Then, the topology of nodes is controlled through clustering communication for improving the network scalability. The load balanced nodes using different methods mentioned above are compared simultaneously in a clustered topological environment. Here the transmission power of the nodes is also maintained accordingly during the communication in this customized environment. Multi-hop communication is focused for reducing the probability of network failure. Finally, the simulation results show that the performance of LEAR protocol attained better results compared to CMMBCR and EPAR in terms of throughput, packet delivery ratio, delay, and energy consumption. In future, some swarm intelligence based schemes are focused for effectual cluster head selection to improve the packet delivery ratio.

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