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A Study of Load Balancing with Energy Conservation: A New Approach to Load Balancing With Energy Conservation Using Bayesian Optimization Algorithm in MANET

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Abstract: ***In Mobile Ad hoc Network, solving the load imbalance in routing with respect to energy conservation is an important issue which is likely to be addressed. Nowadays there are many load balancing techniques such as Energy-aware load balancing multipath routing protocol for MANET'S, Modified Energy Aware Load Balancing Multipath, and Energy efficiency and load balanced geographic routing has been used to solve this problem. In line with, this paper introduces a new technique which uses Bayesian Optimization Algorithm along with link aware on demand multipath load balancing and MAC based state transition for preserving node lifespan to optimize the load imbalance which results in minimum energy consumption in the network. This research work includes a various study on load balancing and identified the different issues like congestion control, end-to-end delay, energy consumption etc. Energy conservation is considered to be the most important factor because heavy loaded nodes can exhaust battery energy leads to degradation of a network. Initially, this proposed algorithm will be implemented and tested on a small set of nodes in a MANET using NS simulator and analyzes its performance.***

Keywords: Manet, Load Balancing, Bayesian Optimization Algorithm, Energy Consumption

1. INTRODUCTION

In Mobile Ad hoc Network load imbalance is one of the major issues which are needed to be addressed. There are techniques which solve this problem but still, the issue is not solved. The load will be distributed across the network then the processing and communication will be carried out across a computer network do that no single node is overwhelmed. Load balancing is one of emerging key tool to enhance the routing in MANET; with the help of load balancing there will be a better use of MANET resources and improves performance. It can help to minimize traffic congestion and load imbalance, as a result, end-to-end delay can be minimized and mobile nodes lifetime can be maximized. Load balancing is one the emerging area for research in various different types of network.

In order to overcome the issues, there are many load balancing techniques in MANET, but the solution for this problem is having been addressed partially. In this paper, the various load balancing techniques are been studied and a new technique has been presented here. In this technique, an algorithm which is been proposed uses a Bayesian Optimization algorithm to provide with feasible solution for load balancing in a network with the metric load and energy. In case of load balancing link aware on-demand dynamic multipath load balancing algorithm is used and for energy conservation MAC based state transition for preserve and the algorithm is implemented in it. The remainder of the node life span is been used. A random network is been designed. This paper is organized as follows. In section 2, Literature survey is been discussed. Section 3 gives a brief overview of load balancing techniques in various networks. Section 4, discusses the proposed system. Section 5 gives the conclusion.

2.LITERATURE SURVEY

This section deals with the literature survey of various algorithms' and its pros and cons. SnehaR.Deshmukh and Vijay T.Raisighani proposed a [1]EALBM algorithm which is an on-demand routing protocol implemented especially for the applications which are very large in size and difficult to attain energy efficiency and load balancing. It has three phases of working: neighbor discovery, multipath discovery and data transmission. The source initiates a multipath discovery process to determine all existing disjoint multipath from source to destination. Each disjoint path is assigned a weight based on the energy level of nodes along that path. The path with maximum energy has least weight i.e. most preferred. The problem is that in Manet the nodes will always be in mobility and there will be a frequent change in topology so, it is difficult to find the node with maximum energy. In order to overcome these drawbacks, this new concept is proposed.

The authors Arvind Kushwaha and Prof.Nitika Vats Doohan propose a multi-path load-balancing mechanism named as [2] M-EALBM for diverting the load from low energy node to high energy node. The solution is given here is not only for load balancing but for also the energy conservation. The workflow is all possible route is been discovered and energy state of intermediate nodes are collected then route energy state is compared and a data

packet is distributed and it is been monitored and maintained. The major advantage here in this proposal is an end-to-end delay is reduced and the load is been normalized. This algorithm is considered as the enhancement of EALBM because it is the modified EALBM. Here calculating the energy of the node will be helpful but there arises a hidden exposed terminal problem which is an issue in Ad hoc networks.

The authors Wang Gudong et al. have presented an algorithm called [3] ELGR .This algorithm is used in order to increase the network lifetime with the high delivery ratio. It is mainly designed for geographical applications. Geographic routing is of great importance for large-scale Mobile Ad hoc Networks. However, it is not easy to design an effective geographic routing algorithm for a MANET because of its particularity. Here the workflow is First; a link estimation scheme for the PRR is presented that increases the network energy efficiency level. Second, a learning method is proposed to adaptively sense local network loads, allowing enhanced whole network load balance. The advantage is to increase the network lifetime about 20% with the high delivery ratio. This algorithm is presented for lossy MANET's. In a geographical environment, the major problem for this algorithm is that the cost of implementing is higher for network design.

Floriano De Rango and Mauro Tropea proposed a new multipath routing algorithm named [4]LBE-ARAMA in order to discover minimum MDR paths preserving the energy and to balance the data traffic through the round trip time delay evaluation on the path from source to destination. This algorithm is based on Swarm Intelligence approach, in particular, ant colony behavior. The algorithm is able to satisfy multiple metrics for a multi-objective optimization like end-to-end delay, load balancing, and energy saving. The time to converge is uncertain in ant colony optimization then route discovery time will be higher which will lead to the time delay in data transmission, so time convergence is one of the issues which are to be addressed in this paper.

P.Francis Antony Selvi and M.S.K.Manikandan proposed multipath routing for the [5] latency reduction and energy consumption. Here the backbone nodes collect the information of residual energy, delay, MAC connection and load balancing from which the best routing paths are selected using the backbone residual energy. The advantage is that it is easy to determine the route which is good for transmission with the help of the backbone network. The problem here in this study is the cost that is due to the frequent change in topology to maintain the backbone network.

Souihli et al. proposed [6] load-balancing mechanisms which push the traffic away from the center of the network. Novel routing metrics were provided to reduce average route centrality considering nodes degree of centrality, for both proactive and reactive protocols, were proposed. However, the proposal is slightly costly in terms of routing overhead.

The authors Yin and Lin propose a multi-path load-balancing mechanism named as MALB. [7] MALB iteratively regulates the traffic rate on each discovered route. Regulating traffic rate is used to minimize the average end-to-end delay of the network.

Lin and Shao proposed a new [8] multipath routing algorithm relying on improved ant colony optimization (ACO) with coordination of ant colony optimization characteristics and the idea of traffic engineering. On choosing ant's next hop, selection criterion was added with the utilization ratio of router's buffer queue; utilization ratio of the link was introduced to update the global pheromone; multiple paths were chosen to transfer data. However, in practical application, each path delay is different and varied immediately thereby the packet reaching the destination was out of order.

3. LOAD BALANCING TECHNIQUE IN VARIOUS NETWORK

Load balancing is one of the major issues which are to be considered in many fields in computer networks. Here in this paper, we have discussed some of the fields which deal with load balancing

3.1. Load balancing in Distributed systems:

The workload has to be evenly[9] distributed among all processors based on their processing speed so that time to execute all tasks gets minimized and idle time of each processor can be reduced. This is why we need load balancing. Load imbalance is also the main problem in data parallel applications and here also it mainly occurs due to the uneven distribution of data among the various processors in the system. Without good load distribution strategies and techniques, we cannot aim to reach good speedup and good efficiency. There are many issues related to load balancing in a distributed system like task dividing, task migration, workload distribution, processor capacity etc., in order to overcome these issues there are many load balancing approaches like Round robin, Randomized, Central manager, Threshold algorithm, etc. exist. Though there are many algorithms exist, still it needs to be improvised.

3.2. Load balancing in wireless sensor network:

As sensor nodes [10] have very limited battery power and they are randomly deployed it is impossible to recharge the dead battery. So the battery power in WSN is considered as a scarce resource and should be efficiently used. Sensor node consumes battery in sensing data, receiving data, sending data and processing data. Generally, a sensor node does not have sufficient power to send the data or message directly to the base station. Hence, along with sensing the data the sensor node act as a router to propagate the data of its neighbor. In a large sensor network, the sensor nodes can be grouped into small clusters. Clustering has numerous advantages like it reduces the size of the routing table, conserves communication bandwidth, prolongs network lifetime, decreases the redundancy of data packets, reduces the rate of energy consumption etc. There are many load balancing algorithm in WSN in order to overcome this load imbalance issue like Load balancing clustering in WSN, A load

balanced Clustering Algorithm For WSN for Data Gathering, Multi-hop clustering Algorithm For Load Balancing in WSN, etc.

3.3. Load balancing in cloud computing:

Cloud computing is one of the platforms to share data and provide with many resources to users. Users are given freedom to pay only for those resources as much they used.[11] Cloud computing stores the data and distributed resources in the open environment and if a particular node is overloaded then the cloud environment will be more critical. So, load balancing is the main challenge in cloud environment. Load balancing in cloud environment is explained as to distribute the dynamic workload across multiple nodes and to ensure that no single node is overloaded. With the help of Load balancing fair allocation of computer resources, proper utilization of resources, etc. is been achieved. In cloud computing environment Load balancing algorithms are classified into different groups Batch mode heuristic scheduling algorithms, online mode heuristic algorithms, and Static and Dynamic approach. There are many load balancing algorithms namely, Task Scheduling based on LB, Opportunistic Load Balancing, Round Robin, Randomized, Honeybee Foraging Behavior, Lock-free multiprocessing solution for LB, etc. and it also deals with the cost-effective, scalable, reliable and priority.

3.4. Load balancing in web application:

There are several approaches to load balancing on web applications [12] server clusters. A cluster is a group of servers running a Web application simultaneously, appearing to the world as if it were a single server. To balance server load, the system distributes requests to different nodes within the server cluster, with the goal of optimizing system performance and this results in higher availability and scalability necessities in an enterprise, Web-based application. There are many methods to balance a server load but there are two major load balancing techniques DNS Round Robin and Hardware load balancers. Load balancing HTTPs requests is also one of the most important parts of the web application.

3.5. Load balancing in MANET:

Load balancing is emerging as a key tool to better use of Manet resources and improves its performances.[13,14,15.16] Load balancing is a methodology to distribute work across many devices; network links etc. processing and communications activity evenly across a computer network so that no single device is overwhelmed. It can help to minimize traffic congestion and load imbalance, as a result, an end-to-end delay can be minimized, and mobile nodes life can be maximized. It is one of the major issues in time critical and information-intensive applications for increasing the performance of distribution on the dynamic network.

3.5.1 Need for Load balancing in MANET:

The major part of the optimal network is the load balancing. Job completion will become difficult if the huge load is given to the nodes with less processing capabilities and which do not have any means to share the load.

The load imbalance in MANET is due to that the computing and processing power of the systems is non-uniform because few nodes may be idle and few will be overloaded. In the presence of underloaded nodes, the need for overloaded nodes is undesirable.

Multi-path routing is considered to be better than the single path routing. This is possible only for the networks having a huge number of nodes, but it is not feasible to build such systems in real-time environment. Load balance is not improved by using multiple shortest path routes instead of a single path. So, for a better load balanced network distributed multi-path load splitting strategies need to be carefully designed.

3.5.2. Purpose of load balancing techniques in MANET:

1. Non Congested paths are selected so as to distribute the load on the paths that remain idle.
2. It ensures efficiency and robustness.
3. End-to-end delay and packet loss can be reduced.
4. There will be balanced energy consumption of the nodes in the network.
5. The resources utilization is enhanced.
6. The overall performances are been increased.
7. By the distribution of load, collision can be reduced.

The difference between an overloaded and underloaded node is effectively improved by the load balancing technique. An unbalanced traffic or load distribution leads to performance degradation of the network. Load balancing is typically done by multipath routing procedures such as AOMDV. When the information is sent over numerous routes the energy depletion of the nodes gets consistently dispersed as they have to forward a smaller quantity of information consequently improving the lifespan of the nodes. [19] Routing protocols in MANET is classified into three types they are

Proactive (Table driven) routing protocol

Reactive (On-demand) routing protocol

Hybrid routing protocol

Proactive (Table driven) routing protocol:

In Proactive protocol, a network maintains routing information for each and every node. Routing tables are been periodically updated where the routes information is kept and this is done because of the frequent change in topology.

Reactive (On-demand) routing protocol:

In reactive protocol, if a particular node wants to send data it needs to search for the route in an on-demand manner and it should establish the connection in order to transmit and receive the packet. There is no any need of maintaining any routing information at the network nodes.

Hybrid routing protocols:

This is the combination of best features of the above two protocols. A node within the certain distance from the node concerned, or within a particular geographical region, are said to be in routing zone. For routing within zone, proactive approach and for routing beyond the zone, a proactive routing protocol is used.

3.5.3. Classification of Load balanced routing protocols in MANET:

Various load balanced ad hoc routing protocols given in figure 1. are on-demand-based protocols; i.e. load balancing strategies are combined with route discovery phase.

In a border context, the term load can be interpreted as:

- Channel load
- Nodal load
- Neighboring load

1. **Channel load:** Represents the load on the channel where multiple nodes contend to access the media.

2. **Nodal load:** Relates to a nodes activity specifically, it refers to how busy a node is in processing, computation and so on.

3. **Neighboring load:** Represents the load generated by communication activities among neighboring nodes.

Load balanced routing protocols are based on different load metrics:

- Active path
- Traffic size
- Packets in interface queue
- Channel access probability
- Node delay

1. **Active path:** The number of active routing paths supported by a node.

2. **Traffic size:** The traffic load present at a node and its associated neighbors.

3. **Packets in interface queue:** The total number of packets buffered at both the incoming and outgoing wireless interface.

4. **Channel access probability:** The likelihood of successful access to the wireless media. It is also related to the degree of channel contention with neighbor nodes.

5. **Node delay:** The delays incurred for packet queuing, processing and successful transmission.

The difference between an overloaded and an under loaded node is effectively improved by the load balancing technique. An unbalanced traffic load distribution leads to performance degradation of the network. Load balanced routing protocols are generally classified into three types

- Delay based
- Traffic based
- Hybrid based

1. **Delay based**: Load balancing is achieved by attempting to avoid nodes with high link delay.

2. **Traffic based**: Load balancing is achieved by evenly distributing traffic load among network nodes.

3. **Hybrid based**: Load balancing is achieved by combining the features of traffic and delay based techniques.

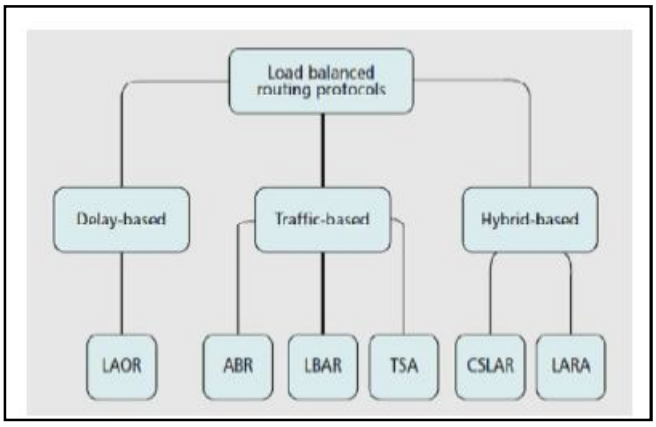

Figure1.Classification of load balanced routing protocol[14]

As said before load balancing is typically done by multipath routing. In recent years, multipath routing protocols have attained more attention in MANET as compared to other routing schemes due to their abilities and efficiency in improving bandwidth of communication, increasing delivery reliability, responding to congestion and heavy traffic. In MANET, to improve the performance, it is very essential to balance the load. Load balancing is used to increase throughput of the network. There are many proposed algorithm like EALBM, M-EALBM, LARA, etc. Table 1 discusses the advantages and disadvantages of these algorithms.

4. PROPOSED SYSTEM

In Manet there are many challenges which is need to be addressed but load balancing and energy consumption are issue which is need to be considered in order to perform a good routing. There are many problems due to load imbalance like overhead of route, traffic, end-to-end delay, energy consumption, bandwidth wastage, congestion control etc. There are many load balancing techniques such as Energy aware load balancing multipath routing, Modified energy aware load balancing multipath, Energy efficient and load balanced geographic routing, techniques using genetic algorithm such as ACO –PSO etc. Even though there are many solutions for these problems but

there are some requirements which are need to be concentrated.

Protocol	ABR	D LAOR
Route Selection Criteria	Associatively states that imply periods of stability	Packet buffered in queue and hop count
Extension of	DSDV	AODV
Category	Traffic based	Delay Based
Single path/Multipath	Multipath	Multipath
Advantages	This protocol is free from loops, deadlock and packet duplicates. Problems associated with stale routes are absent and it also ensure the transmission integrity ABR can also be used to support adaptive mobile multi-media applications.	Increases packet delivery fraction and decreases end-to-end delay in a moderate network scenario in comparison to AODV and other LAOR protocols.
Limitations	ABR, however, relies on the fact that each node is beaconing periodically. The beaconing interval must be short enough to accurately reflect the spatial, temporal, and connectivity state of the mobile hosts. This beaconing requirement may result in additional power consumption.	Routing overhead is comparatively high.

LARA	DLAR	APR
Traffic density and traffic cost	Least loaded route	Disjoint node
DSR	DSR	ZRP
Traffic based	Traffic based	Traffic based
Single path	Single path	Multipath
Uniformly distributes the load among all the nodes in the network, leading to better overall performance. This protocol makes enhanced route selection attempt based on traffic density and traffic cost which leads	DLAR periodically monitors the congestion states of active data sessions and dynamically reconfigures the route that are being congested using the least loaded routes helps balance the load of the network nodes and utilize the network resources efficiently.	Alternate path routing has been applied to telephone networks, ATM and the internet to support load balancing and survivability. The potential benefits of APR make it appear to be an ideal candidate for bandwidth limited and dynamic MANETS.
Route conditions are not considered once it is selected.	Interface queue length doesn't give a true picture of actual load.	The network topology and channel characteristics limit on APR. APR provides less benefit in single channel ad hoc network.

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Table 1: Pros and Cons of Load Balancing Techniques [14]

Protocol	LSR	LBAR	ECLB	CLAR	SLA	WLAR
Route Selection Criteria	Network load Information	Minimum traffic load and minimum interference.	Energy consumption on rate of each node.	Traffic load of node and neighboring nodes.	Traffic load at node (Forwarding load)	Total traffic load
Extension of	DSR	DSR	DSR	AODV	AODV + DSR	AODV
Category	Traffic Based	Traffic based	Delay based	Traffic based	Traffic based	Delay based
Single path/Multipath	Single path	Single path	Multipath	Multipath	Single path	Multipath
Advantages	LSR does not require periodic exchange of load information among neighboring nodes. LBAR, DLAR and LSR do not require the destination nodes to wait for all possible routes. Instead, it uses redirection method to find better path effectively.	Intended for delay-sensitive applications. In addition, in order to keep up with frequent topology change, LBAR provides quick response to link failure by patching up the broken routes in use, thus guaranteeing reliability of data transmission.	Mobile hosts have limited battery lives. This protocol balances the energy consumption rate so as to maximize the network life.	Better suited for the heady load networks with low mobility.	Minimizes the traffic concentration by allowing each MS to drop RREQ or to give up packet forwarding depending on its own traffic load.	Avoids the influence of burst traffic.
Limitations	No consideration for burst traffic or transient traffic.	Mainly used for connectionless applications.	Used only in the environment of lower power level.	Note suited for mobility environment.	Requirement of CM i.e., Credit Manager.	Overhead of route request packets.

TSAR	WBALB	PALB
Size of the packets over route.	Load status of each node	Predicting the cross traffic of each node in the multiple disjoints paths.
VPR (Virtual Path Routing)	AODV	AODV
Traffic based	Traffic based	Traffic based
Multipath	Multipath	Multipath
A more accurate method is to measure the traffic size in bytes. TSA distributed the traffic among the network nodes in a way to avoid the creation of highly congested area.	Reduces packet latency as well as routing overhead for AODV-type On-demand protocols, where RREQ's dominate the entire routing messages.	PALB is a general framework which can cooperate with any kind of multipath source routing protocols. PALB mechanism is effective, end-to-end delay is decreased and energy consumption are balanced by applying PALB with multipath routing together.
Prohibition guarantees the utilization of nearly current load information.	Determination of correct threshold value is difficult in dynamic environment.	Specific pattern is required to predict the network traffic.

In line with the above mentioned techniques a new technique for load balance and energy conservation is been proposed with the help of Bayesian optimization algorithm along with link aware on-demand multipath load balancing and MAC based state transition for preserving node life span. Here the work of Bayesian optimization is to produce a pre optimal solution. This Pre optimal solution is obtained if the given input and their constraints are unbiased. Here the inputs will be the load and energy and their constraints will be congestion and node states. The algorithm will process these inputs and it will find the best solution with the help of fitness solution.

Bayesian optimization algorithm gives a pre optimal solution for the given network. Bayesian networks (BNs), also known as belief network, belong to the family of probabilistic graphical models (GMs). [17, 18] BN also corresponds to another GM structure known as Directly Acyclic Graph (DAG). The structure DAG is defined by set of nodes and the set of edges. In Bayesian optimization algorithm the number of suboptimal solution will be less. The feasible solution is built upon both predominant and dominant sets. The probability of obtaining a feasible solution requires minimum chance of failure. The pre optimal solution is been obtained with the help of two inputs and the inputs will be paths which is been selected with the respective to load handled by the node and the energy consumed by the node. The work is first the best paths for data transmission is been selected with respect to load and energy. Here the node with respect to load will be selected with the help of link aware on-demand multipath load balancing and for energy MAC based state transition for preserving node life span.

The node which is been selected by link aware on-demand multipath load balancing. Link stability can be said as the measure of capacity of the links for how much time that link can withstand in that network without any breakage. Link stability helps to route the packet without any load imbalance. It helps to fore handled information retrieval that assists. There will be congestion free link adaptation. Despite uneven data handling load is optimally distributed over the available path. It works based on the congestion which occurs while transmission and the node which can handle maximum load that is the capacity of the node. The first condition will be performed with some constraints they are there should be less congestion or no congestion.

The node which is been selected by MAC based state transition for preserving nodes life span using a duty cycling concept. The primary objective is to reduce the energy consumption of the nodes and to increase the overall network longevity as a consequence. It helps to maintain prolonged lifetime that improves network life span. Enduring energy of a node is retained at an appreciable manner. The number of alive node in a network is considerably high. The work done by this algorithm is to find the node which consumes lesser amount of energy. Here the input will be the node state and the residual energy. The nodes will be shifted from active state and sleep state for preserving the node lifespan by less energy consumption. This node switching will be done by comparing the remaining energy of the node with the threshold energy. This will happen for each transmission. Remaining energy calculated by

$$R_e = E_0 - E_c$$

Where,

E_0 is initial energy

E_c is energy consumed

Threshold energy is calculated by

$$E_{Th} = (1/3 * E_0)$$

With the help of these technique different sets of solution is generated and it is been given as a input to Bayesian optimization algorithm. Here the algorithm will process the input with the inequality constraints which means it will select the node which can handle both load and energy at the same time, next it will go for variant selection. This will be done for several iterations and finally it will give the optimal solution. This will be performed in group of nodes and its performance evaluation will be discussed.

For example, let us consider a network of 13 nodes here in this network the best nodes will be selected in terms of maximum load and minimum energy and the best will be fed into the bayesian. Then the bayesian will process the input by selecting the nodes which can handle both load and energy and generates the new optimal path. For example, let us take nodes 3, 7, and 11 which can handle maximum load and nodes 6, 9, and 10 which consume lesser energy. From these nodes the bayesian will select the nodes which can handle both load and energy simultaneously and generates a path which is said to be an optimized path which is shown in the figure 2.

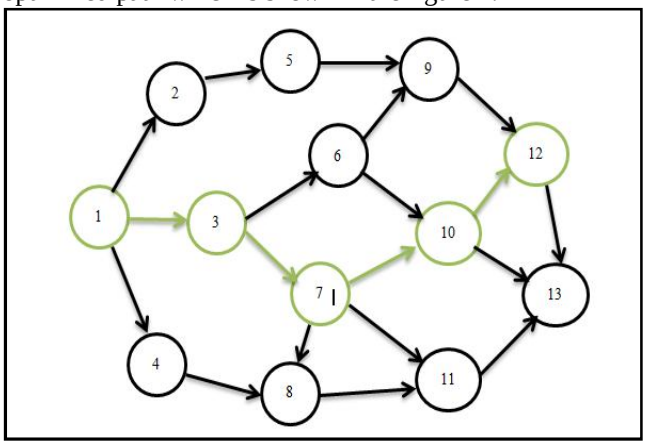

Figure 2. A Network with Optimized Path

5. CONCLUSION

Several literature are studied and it is been concluded that load balancing is one of the major area in all sorts of networks. In MANET load balancing and minimum energy conservation are the key areas of research. In this work various load balancing approaches and energy conversation algorithms have been studied out of which the efficient link aware on demand multipath load balancing for routing and MAC based state transition for preserving nodes lifespan for energy are chosen. The
outcome of these algorithms is given as an input to the bayesian optimization algorithm for providing better optimal paths in a Manet network. In continuation with this work, the notion of the proposed system will be implemented in the second phase of my work on a larger number of nodes. In order to analyze the performance of the proposed work, the results will be compared with the existing algorithms.

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