# A SURVEY OF LOAD BALANCING ALGORITHMS IN MANET

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***Abstract*—MANET (Mobile Adhoc Network) is an infrastructure-less network which is composed of dynamic nodes, which are willing to share their wireless transmission power with neighboring mobile nodes. As MANET has no centralized control for distribution of load properly so Load Balancing becomes one of the most important research areas in the field of MANET. Load Balancing is the process of improving the performance of a parallel and distributed network through a redistribution of load among different nodes. If a network is heavily loaded without any load balancing capability, it degrades the performance by causing Congestion, Delay and Power loss in network. A variety of algorithms have recently emerged that meet these requirements and were successfully applied to heavily loaded problems. This survey explores various load balancing protocols for efficient packet transmission and communication in MANETs.**

*Keywords* – Mobile Ad Hoc Network, Nodes Load-Balancing, Routing, Congestion.

## I. INTRODUCTION

Mobile Ad hoc Networks (MANETS) are dynamic independent networks which consist of mobile units (nodes). Such networks have infrastructure-less mobile topology by having wireless communication between them. These networks can be created and used at anytime, anywhere without any pre-existing base station infrastructure and central administration. The units in the network are used to provide connectivity and services anywhere i.e. the nodes communicate directly with one- another in peer-to peer manner. The subsequent sub-sections introduce the MANET applications, issues, and routing protocols.

### A. MANET Applications

MANETs are generally used in situations where fixed networks are very expensive; they are also used in the situations where fixed networks are impractical because of some challenges. MANETs are used in following applications:

1) IN OFFICE: Files and emails are synchronized between the personal digital assistant (PDA) and the office desktop which allow transfer of data in a flexible manner.

2) AT HOME: Two ad hoc devices one with the user and the other in the home can communicate with each other in order to accomplish particular task such as activate lights on getting home.

3) MilitaryApplications: Military communication in battle fields can be considered as one of the most popular application of ad hoc networks. This is because it requires an infrastructure-less network that offers a reliable communication and fast failure recovery in such environments. Ad hoc networks can present a very robust solution to the required communication under such conditions.

4) Other Civil and Commercial Applications: such as car tracking, monitors its mechanical components, and keep in touch with other vehicles in the area. We can also mention the application that detects for road safety messages, navigation purposes, and other peer to peer applications.

### B Issues in Mobile Ad hoc Networks

There are following issues which make managing MANET a challenging task:

- Dynamic network topology and capacity link
- Imprecise state information
- Lack of central administration
- No pre-existing base station / infrastructure less network
- Hidden terminal problem
- Limited resources availability
- Energy constrained operation
- Multicasting
- Variable capacity link
- Weak physical security

### C. Routing for Ad Hoc Networks

Routing is an important component of any ad-hoc network because it is responsible for proper load balancing between the source and destination. Routing is a mechanism to find an optimum route in order to transfer packets. Routing protocols can be classified mainly according to four categories [1] which are based on:

- Routing information update mechanism
- Use of temporal information for routing
- Routing topology
- Utilization of specific resource

***C.1 Based on Routing Information Update Mechanism***

Ad hoc wireless network routing protocols can be classified into three major categories based on routing information update mechanism. They are:

1. *Proactive or table-driven routing protocols*: In table driver routing protocols, every node maintains the network topology information, in the form of routing tables by periodically exchanging routing information. Routing information is generally flooded in the whole network. Whenever a node requires a path to a destination, it runs an appropriate path finding algorithm on the topology information it maintains.

2. *Reactive or on-demand routing protocols:* Protocols that fall under this category do not maintain the network topology information. They obtain the necessary path when it is required, by using a connection establishment process. Hence these protocols do not exchange routine information periodically.

3. *Hybrid routing protocols*: Protocols belonging to this category combine the best features of the above two categories. Nodes within a certain distance from the node concerned or within a particular geographical region are said to be within the routing zone of the given node. For routing within this zone, a table-driven approach is used. For nodes that are located in this zone, on-demand approach is used.

***C.2 Based on Use of Temporal Information for Routing***

Since ad hoc wireless networks are highly dynamic and path breaks are much more frequent than in wired networks, the use of temporal information regarding the lifetime of the wireless links and the lifetime of the path selected assumes significance. The protocols that fall under this category can be further classified into two types:

1. *Routing Protocols using past temporal information*: These routing protocols use information about the past status of the links or the status of links at the time of routing to make routing decisions. For example, the routing metric based on the availability of wireless links (which is the current/present information here) along with the shortest path finding algorithm, provides a path that may be efficient and stable at the time of path finding. The topological changes may immediately break the path, making the path undergo a resource-wise expensive path reconfiguration process.

2. *Routing protocols that use future temporal information*: Protocols belonging to this category use information about the expected future status of the wireless links to make approximate routing decisions. Apart from the lifetime of wireless links, the future status information also includes information regarding the lifetime of the node (which is based on the remaining battery charge and discharge rate of non replenish able resources, prediction of location and prediction of link availability.

***C.3 Based on Routing Topology***

Routing topology being used in the Internet is hierarchical in order to reduce the state information maintained at the core routers. Ad hoc wireless networks, due to their relatively smaller no. of nodes, can make use of either a flat topology or hierarchical topology for routing.

1. *Flat topology routing protocols*: Protocols that fall under this category make use of a flat addressing scheme similar to the one used in IEEE 802.3 LANs. It assumes the presence of a globally unique (or at least unique to the connected part of the network) addressing mechanism for nodes in an ad hoc wireless network.

2. *Hierarchical topology routing protocols*: Protocols belonging to this category make use of a logical hierarchy in the network and an associated addressing scheme. The hierarchy could be based on geographical information or it could be based on hop distance.

***C.4 Based on Utilization of Specific Resources***

1. *Power-aware routing:* This category of routing protocols aims at minimizing the consumption of a very important resource in the ad hoc wireless networks – the battery power. The routing decisions are based on minimizing the power consumption either locally or globally in the network.

2. *Geographical information assisted routing*: Protocols belonging to this category improve the performance of routing and reduce the control overhead by effectively utilizing the geographical information available.

3. *Routing with efficient flooding*: This category include those protocols which provide efficient flooding either by taking optimal decision for flooding or by adopting on- demand flooding.

## II LOAD BALANCING PROTOCOLS

**Alternate Path Routing [2]** provides load balancing by distributing the data traffic along set of alternative paths. By using set of alternate paths, APR also provide failure protection, i.e. if one path fails to transfer the data, it can use another alternative paths. Due to Route coupling resulted from geographic proximity of different candidate paths between common endpoints (nodes) APR are not fully utilized. Coupling occurs because candidate paths have to share common intermediate nodes. This protocol anyhow works well for multi-channel networks, but this may cause much serious problem in single channel networks.

**Dynamic Load Aware Routing (DLAR**) [3] makes use of number of packets buffered in the interface as main route selection criteria. Source node floods the RREQ packet to its immediate neighboring nodes to discover a new route. When the intermediate nodes along the path to destination receives RREQ for first time, they make an entry for the <source, destination> pair and also record the previous hop to that entry (to proceed Backward Learning).Nodes then also attach their load information and broadcast the RREQ packet After receiving the first RREQ packet, the destination waits for few amount of time so that it can learn about all possible routes. In this protocol, intermediate nodes cannot send a RREPLY back to the source. To minimize the overlapped routes and to utilize the most up-to-date load information when selecting routes, which cause congestion, DLAR does not allow intermediate nodes from replying to RREQ. During the active date session, intermediate nodes periodically piggyback their load information on data packets. With the help of that load information destination node can monitor the load status of the route. If the route is congested, a new and lightly loaded route is selected to replace the overloaded path. Routes are hence reconstructed dynamically in advance.

***Load Aware Routing (LARA)*** [4] networks define a new metric called traffic density, to represent the degree of contention at the MAC layer. The traffic density of a node is the sum of traffic queue qi of node i plus the traffic queues of all its neighbors, formally

$$Q(i) = \sum_{\text{For all } j \in N(i)} q(j)$$

Where N (i) is the neighborhood of node i and q (j) is the size of the traffic queue at node j. Q (i) is the sum of traffic queues of all the neighbors of node i plus that of node i itself. This protocol requires a record in a table (called the neighborhood table) that each node maintain for the latest traffic queue estimations at each of its neighbors. This table is used to keep the load information of local neighbors at each node. This information is gathered with the help of two types of broadcasts. The first type of broadcast occurs when a node attempts to discover a new route to a destination node. This type of broadcast is called Route Request. The second type of broadcasting is the Hello packet broadcasting. If a node has not sent any messages to any of its neighbors within a predefined timeout period, called the hello interval, it broadcasts a hello message to its neighbors. A hello packet contains the sender's identity and its traffic queue (load) status. Neighbors that receive this packet update the corresponding neighbor's load information in their corresponding neighborhood tables. If a node does not receive a data or a hello message from some of its neighbors for a predefined time, it assumes that these nodes have moved out of the radio range of this node and it changes its table accordingly. Receiving a message from a new node is also an indication of the change of neighbor information and is handled accordingly. The traffic queue of a node is defined as the average value of the interface queue length measured over a period of time. For the node I, it is defined as the average of N samples over a given sample interval:

$$q_i = \sum_{k=1 \text{ to } N} qi(k)$$

Where qi (k) is the kth sample of the queue length. qi is the average of these N samples. During the route discover procedure, the destination node selects the route with the minimum traffic cost, which basically reflects the contention at the MAC level, for the non-TCP source. For TCP sources, it takes into account both the number of hops and the traffic cost of the route. This methodology of route selection helps the routing protocol to avoid congested routes. This also helps to uniformly distribute the load among all the nodes in the network, which in turn leads to better overall performance. Hop cost factor captures the transmission and propagation delay along a hop. Traffic Cost is the traffic cost of a route is defines as the sum of the traffic densities at each of the nodes and the hop costs on that particular route.

***Load-Balanced Ad hoc Routing (LBAR)*** [5] is an on-demand routing protocol developed for delay-sensitive applications where users are concerned with packet transmission delay mostly. Hence, this protocol focuses on how to find an optimal *path*, which would reflect least traffic load, so that data packets can be routed with least delay. LBAR defines a new metric for routing known as Degree of Nodal activity to represent load on a metric node. The route discovery process is initiated whenever a source node needs to communicate with another node for which it does not have a known route. The process is divided into two stages: forward and backward. The forward stage starts at the source node by broadcasting setup messages to its neighbors. A setup message carries the cost seen from the source to the current node. A node that receives a setup message will forward it, in the same manner, to its neighbors after updating the cost based on its nodal activity value. In order to prevent looping when setup messages are routed, all setup messages are assumed to contain a route record, including a list of all node Ids used in establishing the path fragment from the source node to the current intermediate node. The destination node collects arriving setup messages within a route-select waiting period, which is a predefined timer for selecting the best-cost path. The backward stage begins with an ACK message forwarded backward towards the source node along the selected path, which we call the active path. The cost function is used to find a path with the least traffic so that data packets can be transmitted to the destination as fast as possible which achieves the goal of balancing loads over the network. In this protocol, Active path is a path from a source to a destination, which is followed by packets along this selected route. Active node is considered active if it originates or relays data packets or is a destination. Inactive node is considered inactive if it is note along an active path. Activity is the number of active paths through a node is defined as a metric measuring the activity of the node. Cost is the minimum traffic load plus interference is proposed as the metric for best cost. Unlike wired networks, packet delay is not caused only from traffic load at the current node, but also by traffic load at neighboring nodes. We Load Aware protocol (WLAR) [7] is proposed. This protocol selects the route based on the information from the neighbor nodes which are in the route to the destination. In WLAR, a new call this traffic interference. In the contest of traffic interference, the best cost route is regarded as a path, which encounters the minimum traffic load in transmission and minimum interference by neighboring nodes. To assess best cost, the term node activity is used as an indirect means to reflect traffic load at the node. Such activity information can be gained at the network layer, independent of the MAC layer. Traffic interference is defined as the sum of neighboring activity of the current node. During the routing stage, nodal activity and traffic interference are calculated at every intermediate node along path from source to destination. When the destination received routing information, it chooses a path, which has minimum cost.

***Load Sensitive Routing (LSR) protocol*** [6] is based on the DSR protocol. This protocol utilizes network load information as the main path selection criterion. The way to get load information of network in LSR need not periodic exchange of load information among neighboring nodes and is suitable for any existing routing protocol. Unlike LBAR and DLAR, LSR does not require the destination nodes to wait for all possible routes. Instead, it uses a re-direction method to find better paths effectively. The source node can quickly respond to a call for connection without losing the chance to obtain the best path. Based on the initial status of an active path, LSR can search for better paths dynamically if the active path becomes congested during data transmission. In route discovery we use a redirection method similar to we developed in Multi path routing to forward Route Reply (RREP) messages. This method can let the source node *to* obtain better path without any increase in flooding cost and waiting delay on the destination nodes. In LSR, we adapt the active routes in a route in a different context, by using network load information. When a used path becomes congested, LSR tries to search for a lightweight path. The source node continues to send data traffic along the congested paths until a better path is found. Route adaptation strategy is based on the initial status and current status of an active path.

***Weighted Load Aware Routing(WLAR)*** However, the above mentioned routing protocols neither reflect burst traffic nor transient congestion. To solve out this problem, Weighted term traffic load is defined as the product of average queue size of the interface at the node and the number of sharing nodes which are declared to influence the transmission of their neighbors. This protocol adopts basic AODV procedure and packet format. In WLAR, each node has to measure its average number of packets queued in its interface, and then have to check whether it is a sharing node to its neighbor or not. If it is a sharing node itself, it has to let its neighbors know it. After each node gets its own average packet queue size and the number of its sharing nodes, it has to calculate its own total traffic load. Now when a source node initiates a route discovery procedure by flooding RREQ messages, each node receiving an RREQ will rebroadcast it based on its own total traffic load so that the flooded RREQ's which traverse the heavily loaded routes are dropped on the way or at the destination node. Destination node will select the best route and replies RREP. Average number of packets queued in interface is calculated by Exponentially Weighted Moving Average (EWMA). Sharing node is defined as nodes whose average queue size is greater than or equal to some predetermined threshold value. Sharing node is expected to give some transmission influence to its neighbors. If its average queue size is not greater than a threshold value, it is assumed that its effect is negligible. Total traffic load in node is defined as its own traffic load plus the product of its own traffic load and the number of sharing nodes. Path load is defined as sum of total traffic loads of the nodes which include source node and all intermediate nodes on the route, except the destination node.

**Simple Load-Balancing Ad hoc Routing (SLAR)** [8] protocol is based on the autonomy of each node. Although it may not provide the network-wide optimized solution but it may reduce the overhead introduced by load balancing and prevent from severe battery power consumption caused by forwarding packets. In SLAR, each node determines whether it is under heavy forwarding load condition, and in that case it leaves forwarding packets and lets some other nodes take that role. In MANETs, since nodes have limited resources, the message overhead for load balancing is more critical than that of the wired network, i.e., in the ad hoc network, the network-wide optimized load balancing approach of the wired network may be inappropriate. SLAR is designed not as an entirely new routing protocol but as an enhancement of any existing ad hoc routing protocols like AODV, DSR etc.

**Simple Load-balancing Approach (SLA**) [9] resolves the traffic concentration problem by allowing each node to drop RREQ or to give up packet forwarding depending upon its own traffic load. SLA tries to extend the expiration of mobile node power by preventing the traffic concentration on a few nodes, which may frequently occur under low mobility situations. AODV and DSR do not search for new routes as long as current routes are available. In the case with low mobility, this feature may cause the nodes on the current routes to be congested. Hence, this approach allows each node to determine whether it is under heavy load conditions or not and to take some other nodes to take its place by explicitly giving up packet forwarding or implicitly dropping RREQ from other nodes in case of heavy loads. Consequently it spreads the traffic uniformly over the complete network and enhances the lifetime of an entire ad hoc network by making all MANET nodes to consume their energy properly. However, there may be some selfish nodes that may deliberately give up packet forwarding to save their own energy, if an appropriate compensation is not given to them. Therefore, in SLA a credit-based scheme called Protocol-Independent Fairness Algorithm (PIFA) for urging nodes to voluntarily participate in forwarding packets is proposed. In MANETs using PIFA, nodes earn the credits by forwarding other's packets and only when they have enough of the credits with them, they are allowed to originate packets. PIFA can detect and isolate a single malicious node, which tries to cheat others on the number of forwarding packets to acquire more credits than it should actually receive. Similar to SLAR, SLA is not an independent protocol but a supplementary part to any existing ad hoc routing protocol like AODV and DSR.

***Delay-based Load-Aware On-demand Routing (D-LAOR)*** *[10]* protocol that utilizes both the estimated total path delay and the hop count as the route selection criterion. D-LAOR allows the intermediate nodes to relay duplicate RREQ packets if the new path (P') to the source of RREQ is shorter than the previous path (P) in hop count, and DP' is smaller than DP (i.e., DP' < DP). Each node updates the route entry only when the newly acquired path (P') is shorter than the previous path (P) in hop count, and DP' is smaller than DP (i.e., DP' < DP).D-LAOR does not allow the intermediate nodes to generate a RREP packet to the source node to avoid the problem with stale path delay information. We define DP as the total path delay of a path P from node 1 to n. When a source node does not have a valid route to a destination, it initiates a route discovery process. The source node broadcasts a

RREQ packet to its neighbors, which then update the total path delay and forward this RREQ packet to their neighbors, and so on, until the destination is reached. Once the first RREQ packet has arrived at the destination, the destination node responds by unicasting a RREP packet back to the neighbor from which it received the corresponding RREQ packet. If the duplicate RREQ packet has a smaller total path delay and hop count than the previous one, the destination sends a RREP packet again to the source node to change the route immediately. When an established path is broken due to node mobility, a RERR packet is sent to the source node. The source node reinitiates the route discovery process as described above. Moreover, proposed DLAOR can route around a congested node and thus can reduce the control overhead. This is achieved by dropping the RREQ packets at congested nodes, which prevents the congested node from becoming an intermediate node of a path. D-LAOR determines the congested node by comparing the estimated total node delay and the number of packets being queued in the interface queue of two serial nodes in a RREQ packet-forwarding path. DLAOR drops a RREQ packet only when the following two conditions are satisfied simultaneously:

1) The estimated total node delay of a node A is greater than that of previous node B.

2) The number of packets being queued at the interface queue of a node A is more than 80% of its buffer size.

**Correlated Load-Aware Routing (CLAR)** [11] protocol is an on-demand routing protocol. In a CLAR, traffic load at a node is considered as the primary route selection metric. The traffic load of a node depends on the traffic passing through this node as well as the traffic in the neighboring nodes. The traffic load in a node is thus defined as the product of the average queue size at the node and the number of sharing nodes, which is that its average queue size is over one packet. The average queue size is calculated with an exponentially weighted moving average (EWMA) of the previous queue lengths. Traffic load of surrounding nodes is defined as number of sharing nodes. When a source node desires to send packets to some destination node and does not have a valid route to that destination, it broadcasts a RREQ packet to its neighbors. Once the destination node receives the RREQ, it first searches its forwarding route table for the originator. If the matching route is not found, it inserts the forwarding route entry to its routing table. Otherwise, it compares the path load in new RREQ with that in its route cache. If the path load in the RREQ is less than that in route cache, it updates routing table and responds by unicasting a RREP packet back to the neighbors from which it received the RREQ. As the RREP is routed back along the reverse path, intermediate nodes along this path set up forwarding route entries in their route tables. When an originator receives the RREP, it can begin to transmit data packets to the destination through the received route. If a source node moves, it is able to re-initiate the route discovery protocol to find a new route to the destination. If a node along the route moves, its upstream neighbor notices the movement and propagates a link failure notification message to each of its active upstream neighbors to inform them of the failure of that part of the route. The destination node must select the best route among multi-paths since CLAR supports multi-paths between the source and the destination. When the RREQ reaches the destination node, it selects the path with the least sum among multi-paths as its best route. If there are one more routes, which have same traffic load, the destination selects the route with the shortest hop distance. When there are still multiple paths that have the least load and hop distance, the earliest path arrived at the destination is chosen.

***Energy Consumption Load Balancing (ECLB)*** *[12]* In existing On-Demand routing method, message transmission occurs after forming the optimal route, however successive message transmission occur with particular nodes acting as routes when the network topology alteration is small. As a result, excessive traffic makes transmission delay and excels the energy consumption in the node used as a router, which means that most of energy is spent in the routing function. As it were, traffics are concentrated into a particular node when the mobility of node is low. When network topology is relatively stable, the energy deficient nodes are included in the routing path, which could shorten the lifespan of the whole network. To solve this problem, a routing method which concerns power consumption rate is proposed. ECLB makes balanced energy consumption available by calculating energy consumption rate of each node and choosing alternative route using the result to exclude the overburden-traffic-conditioned node in route directory. The point is that not only main path but also alternative path can be formed on the basis of the measure energy consumption rate using present packet amount per unit and mean packet throughput of the past.

By forming route in advance and conversing into performed alternative path when route impediment occurs, transmission for route rediscovery and control traffic overhead can be decreased.

***Prediction based Adaptive Load Balancing (PALB)*** This mechanism is based on multipath routing protocol and traffic prediction [13]. It is assumed that several disjoint paths between source and destination node have been established by a multiple path routing protocol such as [14] [15] [16]. PALB locates at source node and its objective is to minimize traffic congestion and load imbalance by adaptively distributing the traffic among multiple disjoint paths based on traffic prediction. Source node periodically predicts the cross-traffic of each node in the multiple disjoint paths and adjusts traffic distribution across multiple disjoint paths. Data packets first enter into packet filtering model whose objective is facilitate traffic shifting among multiple paths in a way that reduces the possibility that packets arrive at the destination out of order. In PALB, a per-flow filtering method is used. The packet distribution model then distributes the traffic out from packet filtering model across the multiple paths. The distribution of traffic is based on load balancing model which decides when and how to shift traffic among the multiple paths. The load balancing model operates based on evaluation of paths stability and measurement of paths statistics. The load balancing model consists of three phases: balancing-off (when paths are unstable), balancing-on (when paths are stable) and imbalance detecting. In balancing-off phase, if the paths turn to be stable, it transits to balancing-on phase. In the balancing-on phase, the load balancing algorithm tries to equalize the congestion measures among multiple paths. The congestion measure of path is a function of path traffic load. Once the measures are equalized, the phase moves to imbalance detecting phase. In imbalance detecting phase, if it is detected that congestion measures are unequal, the phase returns balancing-on phase. In both balancing-on phase and imbalance detecting phase, if the paths turn to be unstable, it transits to the balancing-off phase.

***Workload-Based Adaptive Load Balancing (WBALB)*** [17] protocol makes each node react to RREQs according to a simple rule based on the local information of the node and it runs on top of existing routing protocols. This protocol is motivated by the observation that ad hoc on-demand routing protocols flood route request (RREQ) messages to acquire routes, and only nodes that respond to those messages have a potential to serve as intermediate forwarding nodes. In other words, a node can completely be excluded from a path if the node drops the RREQ in a route discovery phase for the path. This protocol enables a node to join the RREQ forwarding action selectively. It utilizes interface queue occupancy and workload to control RREQ messages adaptively. Each node maintains a threshold value which is a criterion for each node's decision of how to react to a RREQ message. If the interface queue length of a node is greater than the threshold value, the node simply drops the RREQ. Otherwise, the node forwards the RREQ by re-broadcasting it. By doing so, additional traffic flows are not allowed to set up through overloaded nodes, and therefore, the overloaded nodes are naturally excluded from the newly requested paths. The threshold value is initially set to a pre-determined value. The threshold value keeps changing according to the load status of a node. If a node experiences overload to an extent, its threshold value decreases. When the node senses that its load has been low for a long enough period, it is considered as an indication that the node's overloaded status is dissolved, and its threshold value returns to the initial value. From that time on, the node allows additional communications to set up through it as long as not overloaded.

***Traffic Size Aware Routing (TSAR)*** The "Traffic-Size" based load balancing routing Protocols like DLAR, LARA, LBAR, LSR etc measure the traffic size in number of packets. Measuring the load by the number of packets is inaccurate since the size of the packets may differ.A more accurate method is to measure the traffic size in bytes. This protocol [18] is an extension to the Virtual Path Routing Protocol (VPR) [19]. Every node maintains an entry for every active virtual path it services. The creation time of any entry (i.e., the creation time of a virtual path) is recorded in the entry itself by the node. The node also accumulates the number of packets and the size (in bytes) of every packet that it routes using a particular entry. Thus, any given entry contains the time at which the entry was created, the number of packets, and the size of the traffic that was routed using that entry. Traffic-Size Aware routing scheme that uses the size of the traffic, through and around the network nodes, as the main route selection criterion. In this scheme, the network nodes keep track of the size of traffic (in bytes) being routed.

The nodes are also aware of the size of the traffic that is routed through their neighbors. For any path that consists of multiple hops, the load metric of the path is the sum of all the traffic that is routed through all the hops that make up that path.

**Load Balanced Dynamic Source Routing (LBDSR)**[20] Existing approaches try to improve the performance of routing protocols with respect to traffic balancing or energy consumption balancing.In this paper author improve the well known Dynamic Source Routing (DSR) protocol to the so called Load Balanced DSR (LBDSR) protocol. We modify the RREQ (Route Request) and RREP (Route Reply) messages in DSR in order to maintain the remaining energy of intermediate nodes which forward RREQ and RREP. Route structure, available in the nodes cache, is modified so that the remaining energy of nodes can be calculated. LBDSR shows better traffic balancing and energy consumption balancing, end-to-end delay and route reliability metrics than DSR. Furthermore, LBDSR can also be customized to achieve better performance with respect to each of these metrics instead of being a trade-off between them. It modified the control packets, routing tables, and the route selection method resulting in enhanced LBDSR performance with respect to traffic load balancing, energy consumption balancing, average end-to-end delay, and route's reliability metrics. LBDSR shows a 15% improvement in balancing (traffic and energy consumption), 10% reduction in average end-to-end delay, and a decrease in the network node failure rate resulting in better route reliability. Additionally, LBDSR can be customized to focus on one of these metrics. In this case LBDSR shows an improvement of up to 25% with respect to these metrics.

**Congestion Avoidance Based Load Balanced Routing (CALBR)** The QoS of Mobile Ad hoc Network is mostly affected by the congestion at any intermediate node in a selected routing path. In this paper, we propose a congestion avoidance based load balanced routing scheme for mobile ad hoc network. Each node keeps track of the number of data packets transmitted by him as well as the data packets transmitted by its one hop neighboring nodes along with their flag bit status for the current time interval. The proposed approach is attempts to avoid the congestion of a node by selecting the disjoint paths. This is achieved by setting a flag bit with the time limit TTL, at the node. On exceeding of this value, the flag bit is reset. By this approach we have attempted to limit the flooding and congestion of the node along with effective balancing of the traffic load.

**Distributed Load Balanced Routing (DLBR)** [21] is a new distributed load based routing algorithm intended for a variety of traffic classes to establish the best routing paths. The proposed algorithm calculates the cost metric on the basis of the load on the links. The dynamic traffic can be classified as multimedia and normal traffic. Multimedia traffic is considered as high priority and normal traffic as low priority. The routing of high priority traffic is performed over the lightly loaded links, in such a manner that the links with lighter loads are chosen instead of links with heavier-loads. In addition, the resources can be shared between the high priority traffic's path and low priority traffic. In the absence of multimedia traffic, the lightly loaded path can be utilized by normal traffic. As a future work, we will evaluate more metrics like delay and jitter. Also including the Voice over IP (VoIP) as an additional traffic class is another work to be done as future work.

**Node Centric Load Balancing Routing Protocol (NCLBR)** [22] is similar to how AODV operates. Most of the operations are similar to AODV apart from minor changes to the format of RREQ packets and its subsequent dissemination through the network. There are three distinct roles for nodes in NCLBR protocol, namely, terminal (nodes that are connected to rest of network by a single link), trunk (nodes that connect two different network segments) and normal (nodes other than trunk or terminal).Here each node itself avoids congestion in a greedy manner. It's node's responsibility to divert congestion away from itself onto other alternative paths that may exist in the network. This protocol's main objective is to avoid new path formation through a congested node. Current congestion status of each node can be determined from the interface queue size. If a congestion threshold has been reached, it automatically starts ignoring new RREQ packets to avoid new path formation.

**Ant based Algorithm** (**ACO)** [23] make use of Swarm Intelligence (which is a technique to solve problems by using the intelligence followed by insects and other small creatures. Ant colony Optimization (ACO) algo have following properties:

- ACO algo are dynamic in nature by making use of continuous path sampling and stochastic ant forwarding.

- ACO algo are more robust as routing information is based on direct measurement of real world network situations.

This algo is hybrid in nature, i.e. pro-active some time and reactive other time. Data packets are routed stochastically according to stigmergical taught pheromone tables (which are stored locally at each node).Each node also maintain a Neighbor Node table to keep track of nodes having wireless links to. Load balancing is achieved by making use of multiple paths and then selecting optimal path mostly for transmission of packets from source to destination. These algo have been widely used to solve many optimization problems like routing, assignment etc.directly.

**Fibonacci Multipath Load Balancing Protocol (FMLB)** [24] MANET is a temporary network with a group of wireless infrastructure less mobile nodes that communicate with each other within a rapidly dynamic topology. The FMLB protocol distributes transmitted packets over multiple paths through the mobile nodes using Fibonacci sequence. Such distribution can increase the delivery ratio since it reduces the congestion. The FMLB protocol's responsibility is balancing the packet transmission over the selected paths and ordering them according to hops count. The shortest path is used frequently more than other ones. The simulation results show that the proposed protocol has achieved an enhancement on packet delivery ratio, up to 21%, as compared to the Ad Hoc on-demand Distance Vector routing protocol (AODV) protocol. Also the results show the effect of nodes pause time on the data delivery.

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