A Comparative Survey: Classification of Load Balancing Routing Protocols in Mobile Ad hoc Networks

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Abstract: **Mobile Ad hoc Networks (MANETS) are dynamic independent networks which consist of mobile units. Such networks have infrastructure-less mobile topology by having wireless communication between them. A routing protocol in MANET should fairly distribute the routing tasks among the mobile host. An unbalanced traffic/load distribution leads to performance degradation of the network. Due to this unbalancing nature, few nodes in the network are highly loaded with routing duties. This problem lead to the introduction of load balancing routing algorithms. This survey explores various load balancing algorithms for single path routing, multi path routing and cluster based routing. In recent years, multi-path routing protocols have attained more attention in mobile ad hoc networks 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.**

IndexTerms **- MANET, routing, load balancing, congestion.**

I. INTRODUCTION

A mobile ad hoc network (MANET) is a wireless communication network wherever nodes that are not within direct transmission range establish their communication via the help of different nodes to forward data. The nodes in MANET have limited bandwidth, buffer space and battery power. The routers are free to move randomly and organize themselves arbitrarily. Thus, the network's wireless topology may change rapidly and unpredictably. The network layer has received most attention when working on mobile ad hoc networks. Two most important operations at the network layer are routing and forwarding. Data forwarding regulates how packets are taken from one link and put on another. Routing determines that path an information packet should follow from the source node to the destination.

A routing protocol in MANET should fairly distribute the routing tasks among the mobile host. An unbalanced traffic/load distribution leads to performance degradation of the network. Due to this unbalancing nature, few nodes in the network are highly loaded with routing duties. This problem lead to the introduction of load balancing routing algorithms for MANET [1]. Routing protocols are divided into two basic types , which are:

Static routing: In this type of routing the administrator manually assigns the routes in order to forward the data packets in the network, which means there are fixed routes between sources and destinations, these routes are changed by the administrator on demand, since that the router is not responsible for building the routing table.

Dynamic Routing: The router is responsible for building and exchanging the routing table information according to the changes that occur in the network topology, since that the router should be aware of the network status in order to take its decision. There is no doubt that dynamic routing is more flexible than static routing since it can detect the congestion paths [2].

II. CLASSIFICATION OF ROUTING PROTOCOLS IN MANETS

A. 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:

Proactive or table-driven routing protocols: In proactive routing, each node has to maintain one or more tables to store routing information, and any changes in network topology need to be reflected by propagating updates throughout the network in order to maintain a consistent network view. They attempt to maintain consistent, up-to-date routing information of the whole network. It minimizes the delay in communication and allow nodes to quickly determine which nodes are present or reachable in the network.

Reactive or on-demand routing protocols: Reactive routing is also known as on-demand routing protocol since they do not maintain routing information or routing activity at the network nodes if there is no communication. If a node wants to send a packet to another node then this protocol searches for the route in an on-demand manner and establishes the connection in order to transmit and receive the packet. The route discovery occurs by flooding the route request packets throughout the network.

Hybrid Protocols: They introduces a hybrid model that combines reactive and proactive routing protocols. 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.

B. Based on Use of Temporal Information for Routing

The protocols that fall under this category can be further classified into two types:

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.[3]

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. Based on Routing Topology

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.

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.

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.[3]

D. Based on Utilization of Specific Resources

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.

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]

III. CLASSIFICATION OF LOAD BALANCING PROTOCOLS IN MANETs

A vital part of the optimal network is the load balancing. For instance, job completion becomes complex, if huge load is given to the nodes with less processing capabilities and which do not have any means to share the load. There is a possibility of load imbalance due to that the computing/processing power of the systems are non-uniform i.e. few nodes may be idle and few will be overloaded. A node which has high processing power finishes its own work quickly and is estimated to have less or no load at all most of the time. So, in the presence of under-loaded nodes, the need for over-loaded nodes is undesirable [2]. Load Balancing Protocols are classified into three categories depending upon the routing strategy:

A. Single Path Load Balancing Routing Protocols

In single path routing, during the route discovery procedure, more than one prominent route may be encountered but only one – the best one found, according to a criterion is used for traffic forwarding.

1.Load-Balanced Ad hoc Routing (LBAR): "Load-aware destination controlled routing for MANETs" is on-demand routing protocol intended for delay-sensitive applications. It finds out route with least traffic and load so that data packets can be routed with least delay. This algorithm proposes four stages: Route Discovery; Path Maintenance; Local Connectivity Management; Cost Function ; Computation.

In Route Discovery there are two stages, forward and backward. In forward phase setup message is broadcasted which carry cost information, seen from the source to the current node. In backward phase the ACK message is send via the selected path (active path). Due to mobility if the path breaks, destination pick up alternative best-cost partial route and send the ACK message in Path Maintenance phase. In local connectivity management phase, each node send 'Hello' message to neighbor to The best path is calculated based on minimum traffic load in transmission and minimum interference by neighboring nodes. To find out minimum traffic load, activity (number of active path passes through node i) i.e Ai and also Traffic interference (sum of activities of neighboring node) is calculated i.e TIi Where as the cost of route is sum of Ai and TIi. Path is chosen which has minimum cost[1].

2. Load Sensitive Routing (LSR) protocol : "Load Sensitive Routing for Mobile Ad Hoc Networks" is based on the DSR. This protocol utilizes network load information as the main path selection criterion. The way to obtain network load information in

LSR does not require 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 part, LSR can search dynamically for better paths 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 obtain better path without an increase of flooding cost and waiting delay in the destination nodes. In LSR, they 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[1].

3. Dynamic Load Aware Routing Protocol: *(DLAR).* "Dynamic Load Aware Routing in Ad Hoc Networks" uses the number of packets buffered in the interface as the primary route selection criteria. There are three algorithms in selecting the least loaded route. DLAR scheme adds the routing load of each intermediate node and selects the route with the least sum. If there is a tie, the destination selects the route with the shortest hop distance. DLAR scheme 2 uses the average number of packets buffered at each intermediate node along the path. DLAR scheme 3 considers the number of congested intermediate nodes as the route selection metric. In DLAR protocol only the sum of the lengths of instantaneous interface queues are considered but the instantaneous queue length doesn't give exact traffic at a node.

4. Weighted Load Aware Routing Protocol(WLAR): Weighted Aware Routing (WLAR) Protocol in Mobile Ad Hoc Network" is an extension of AODV, it distribute the traffics among ad hoc nodes through load balancing mechanism. They have used total traffic load, as a route selection metric. Queue size and sharing nodes (those avg. queue length is greater than threshold value) are used to find the total traffic. The total traffic is the product of average queue size and number of sharing nodes. 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. In route discovery phase, when RREQ messages come at intermediate node, it 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[1].

TABLE 1: SINGLE PATH LOAD BALANCING PROTOCOLS

Protocol	Extension of	Goal	Main Characteristics
LBAR	AODV	Designed for delay sensitive applications	A metric that accounts for the shared medium. Best route is the one with min load and min interference from neighboring nodes
LSR	DSR	Prevention of power depletion of nodes	Statistical information to distribute traffic load evenly. Accounts for the shared nature of medium
DLAR	AODV	Efficient utilization of network resources	Monitoring without additional overhead. Destination supported reconstruction of a route in advance
WLAR	AODV	Evenly Load Distribution over paths	Total traffic load on node is calculated .Path load found selects the main path for data transmission

B. Multi Path Load Balancing Routing Protocols

Multipath routing has been regarded as an attractive alternative for ad hoc networking because it is able to provide fault tolerance. The use of back up routes leads to less packet loss, makes communication sessions last longer and provides robustness to mobility and fading.

1. QoS and Load Balancing AOMDV(QLB-AOMDV): Mohamed Tekaya et al [4] proposed a load Balancing approach called QLB-AOMDV (QoS and Load Balancing-AOMDV), a solution to achieve better load balancing with respect to the end-to-end QoS requirement.To build the LB-AOMDV protocol, they redefine the structure of RREP packet by adding a new field called buffer_size which take into account the traffic load on the route. This traffic load is expressed as the sum of buffer_size of intermediate nodes for each route between source and destination. When an intermediate node receives a RREP packet, it increments the new field with the size of occupation of its buffer. On the other hand, when the source receives RREP packet, it divides the value of the buffer_size field by the hopcount of each route between source and destination in order to have congestion level.In this part, they added QoS to proposal LB-AOMDV protocol which includes delay and throughput parameters called QLB-AOMDV. A node can estimate the link delay by using the information in the RREQ message. For this reason, we redefine the structure of RREQ message by adding two new fields which indicates received time of packet (Tr) and transmission delay of packet (Delay).

2. Ad Hoc On-Demand Multipath Distance Vector Routing Protocol Based on Node State(NS-AOMDV): Jieying Zhou et al [5] proposed a new load balancing approach. In NS-AOMDV, they introduce node state to improve AOMDV's performance in selecting main path. In route discovery process, the routing update rule calculates the node weight of each path and sorts the path weight by descending value in route list, and we choose the path which has the largest path weight for data transmission. Updating node weight occurs in the time of routing updating. Meanwhile, we can get path weight of every path.. NS-AOMDV also uses the technology of route request (RREQ) packet delay forwarding and energy threshold to ease network congestion, limit the RREQ broadcast storm, and avoid low energy nodes to participate in the establishment of the path. They first defines residual energy rate , which refers to the residual energy level of the node at a certain time . Then excessive power consumption means large node density of one node in the case of common communication ser-vice. As a result, it can be concluded that it's under heavy load in the process of communication. The idle rate of buffer queue is expressed means the maximum length of the buffer queue. This reflects the congestion status of the network. The smaller available buffer queue length means more data packets need to be processed and worse network congestion.

3. Node Centric Load Balancing Routing Protocol(NCLBR): Amjad Ali, et al [6] propose a new load balancing routing protocol NCLBR with the emphasis on adding as little routing overhead as possible to the operation of this protocol. In NCLBR each node takes it upon themselves the task of avoiding congestion in a greedy fashion. Each node obtains its current congestion status from the interface queue size. Each node uses an interface queue size of 60. During operation a queue size of 50 is considered the congestion threshold. When a node notices that the congestion threshold has been reached, it automatically starts ignoring new RREQ packets so as to not allow any new routes passing through it and adding to the current congestion level of the node in question.

4. Balanced Reliable Shortest Routing Protocol(BRSR): D.Maheshwari et al [7] proposes a new mechanism to achieve Balanced Reliable Shortest Routing (BRSR) in Ad Hoc On-Demand Multipath Distance Vector Routing Protocol (AOMDV) with Three-way Filter (TF) mechanism. The selection of BRSR between source to destination is done based on energy, link quality and inference noise in order to improve the data transmission and load balancing. They proposed a new field to find the link quality ratio and remaining energy for the entire path. Based on this value we have to select a reliable path. The estimation of link quality and interference ratio assure the reliable path.

TABLE 2. MULTI PATH LOAD BALANCING PROTOCOLS

Protocol	Extension of	Goal	Main Characteristics
QLB-AOMDV	AOMDV	Designed for better end-to-end QoS requirements	A new field called buffer_size is used which take into account the traffic load on the route.
NS-AOMDV	AOMDV	To ease the network congestion	Path weight is calculated and updated at the time of routing information update.
NCLBR	AOMDV	Uses greedy fashion to avoid congestion	Congestion threshold is set. If threshold reaches, RREQ is not forwarded any more.
WLAR	AOMDV	Estimation of link quality and interference	A new field to find the link quality ratio and remaining energy for the path is calculated.

C. Clustering Based Load Balancing Routing Protocols

1. Load Balancing Clustering (LBC): It provide a nearby balance of load on the elected clusterheads. Once a node is elected a clusterhead it is desirable for it to stay as a clusterhead up to some maximum specified amount of time, or budget. The budget is a user defined restriction placed on the algorithm and can be modified to meet the unique characteristics of the system, i.e., the battery life of individual
nodes. In this algorithm each mobile node has a variable, virtual ID (VID), and the value of VID is set as its ID number at first. Initially, mobile nodes with the highest IDs in their local area win the clusterhead role. LBC limits the maximum time units that a node can serve as a clusterhead continuously,
so when a clusterhead exhausts its duration budget, it resets its VID to 0 and becomes a non-clusterhead node. When two clusterheads move into the reach range, the one with higher VID wins the clusterhead role. when a clusterhead resigns, a non-clusterhead with the largest VID value in the neighborhood can resume the clusterhead function. The newly chosen mobile node is the one whose previous total clusterhead serving time is the shortest in its neighborhood, and this should guarantee good energy level for being a new clusterhead.

2. Fuzzy Logic based Clustering Protocol: The Clustering is divided into three phases: Election of the ClusterHead, Selection of the ClusterHead, and Load Transfer from one ClusterHead to another The election of the ClusterHead is done using the LID algorithm. The selection of the ClusterHead is based on a Fuzzy decision made by the nodes that will be coming under different

ClusterHead. Load Transfer part of the enhancements is done to reduce the effect of increased load when a new node gets admitted into the cluster. The above algorithm works well, but if the node tries to join at alater stage, the ClusterHeads tends to transfer this node to another ClusterHead which is relatively under loaded.

IV CONCLUSION

Load balancing is one of the key areas pertaining to research in the field of mobile ad hoc networks In this work, Load balancing protocols are surveyed and classified in three categories which are single path based protocols, multi path based protocols and clustering based load balancing routing protocols. We have grouped and summarized these protocols and then compared them with respect to our described comparison framework.

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