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RESEARCH ARTICLE

An Effective Method for Load Balancing in MANET

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Abstract— ***A mobile ad hoc network (MANET) is a collection of wireless mobile hosts forming a temporary network without the aid of any stand-alone infrastructure or centralized administration. Mobile Ad-hoc networks are self organizing and self-configuring multichip wireless networks where, the structure of the network changes dynamically. A routing protocol in MANET should fairly distribute the routing tasks among mobile hosts. Most current routing protocols for mobile Adhoc networks consider the shortest path with minimum hop count as optimal route without any consideration of any particular node's traffic and thus degrading the performance by causing serious problems in mobile node like congestion, power depletion and queuing delay. Therefore it is very attractive to investigate Routing protocols which use a Routing Metric to Balance Load in Adhoc networks. We present various load Balanced Routing protocols for efficient data transmission in MANETs.***

Keywords— ***Load Balancing, Mobile Adhoc Networks (MANETs), Routing***

I. Introduction

In Ad hoc networks, it is essential to use efficient routing protocols that provide high quality communication. To maintain portability, size and weight of the device this network has lot of resource constrain. The nodes in MANET have limited bandwidth, buffer space, battery power etc. So it is required to distribute the traffic among the mobile host. 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 which causes the large queue size, high packet delay, high packet loss ratio and high power consumption. This problem leads to solution of load balancing routing algorithm for MANET.

MANET consists of mobile hosts equipped with wireless communication devices. The main characteristics of MANET is, it operate without a central coordinator ,Rapidly deployable, self configuring, Multi-hop radio communication, Frequent link breakage due to mobile nodes ,Constraint resources (bandwidth, computing power, battery lifetime, etc.) and all nodes are mobile so topology can be very dynamic. So that the main challenges of routing protocol in MANET is , it should be Fully distributed, Adaptive to frequent topology change ,Easy computation & maintenance, Optimal and loop free route, Optimal use of resources, It provide QoS and Collision should be minimum.

Classification of routing protocols in MANET*:-*

The routing protocols in MANET are classified depending on routing strategy and network structure. According to the routing strategy the routing protocols can be categorized as Table-driven and source initiated, while depending on the network structure these are classified as flat routing, hierarchical routing and geographic position assisted routing Based on the routing strategy the routing protocols can be classified into two parts.

Proactive (Table driven) routing protocol:-

Each and every node in the network maintains routing information to every other node in the network. Routes information is generally kept in the routing tables and is periodically updated as the network topology changes. DSDV and WRP are the examples of proactive protocols

Reactive (On-Demand) routing protocol:-

This protocols, don't 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. DSR, AODV are the examples of reactive protocols

Hybrid routing protocol:-

This is combination of best features of above two protocols. Node within 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.

II. RELATED WORK

Load balanced Routing Protocols Routing with load balancing in wired networks has been exploited in various approaches. In ad hoc networks, only Associativity-Based Routing (ABR) *considers* the loads the metric. ABR, however, uses the routing load as the secondary metric. Furthermore, the load is measured in the number of routes a node is a part of, and hence the protocol does not account for various traffic loads of each date session.

Alternate Path Routing Protocol:

Alternate Path Routing (APR) protocol provides load balancing by distributing traffic among a set of diverse paths. By using the set of diverse paths, it also provides route failure protection. However, Alternate path Routing protocols potential is not fully realized in ad-hoc networks because of route coupling resulting from the geographic proximity of candidate paths between common endpoints. In multiple channel networks, coupling occurs when paths share common intermediate nodes. The coupling problem is much more serious in single channel networks, where coupling also occurs where one path crosses the radio coverage area of another path. *DLAR, Dynamic Load Aware Routing* DLAR, Dynamic Load Aware Routing uses the number of packets buffered in the interface as the primary route selection criteria. The source floods the ROUTE REQUEST packet to discover a route. When nodes other than the destination receive a non-duplicate ROUTE REQUEST, they build a route entry for the <source, destination> pair and record the previous hop to that entry (thus, backward learning). Nodes then attach their load information (the number of packets buffered in their interface) and broadcast the ROUTE REQUEST packet. After receiving the first ROUTE REQUEST packet, the destination waits for an appropriate amount of time to learn all possible routes. In this protocol, intermediate nodes cannot send a ROUTE REPLY back to the source. To utilize the most up-to-date load information when selecting routes and to minimize the overlapped routes, which cause congested bottlenecks, DLAR prohibits intermediate nodes from replying to ROUTE REQUESTS. During the active date session, intermediate nodes periodically piggyback their load information on data packets. Destination node can thus 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 of congestion.

Load Aware Routing (LARA):

Another network protocol for efficient data transmission in mobile ad hoc networks is Load Aware Routing in Ad hoc (LARA) networks protocol. LARA networks define a new metric called traffic density, to represent the degree of contention at the MAC level. 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

$$Q(i) = \sum_{\forall j \in N(i)} qj$$

Where N (i) is the neighborhood of node i and qj 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. LARA protocol requires that each node maintain a record of the latest traffic queue estimations at each of its neighbors in a table called the neighborhood table. This table is used to keep the load information of local neighbors at each node. This information is collected through two types of broadcasts. The first type of broadcast occurs when a node attempts to discover route to a destination node. This type of broadcast is called route request. The second type of broadcasting is the hello packet broadcasting. In the event that 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 node's identity and its traffic queue status. Neighbors that receive this packet update the corresponding neighbor's load information in their 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 neighborhood table accordingly. Receiving a message from a new node is also an indication of the change of neighbor information and is handled appropriately. 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:

$$qi = \frac{\sum k=1 \ qi(k)}{N}$$

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 helps to uniformly distribute the load among all the nodes in the network, leading 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.

III. PROPOSED APPROACH

Load-Balanced Ad hoc Routing (LBAR):

The Load-Balanced Ad hoc Routing (LBAR) is an on-demand routing protocol intended for delay-sensitive applications where users are most concerned with packet transmission delay. Hence, LBAR focuses on how to find a 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.

Load Sensitive Routing (LSR) protocol:

Load Sensitive Routing (LSR) protocol 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 parts 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, 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, these routing protocols reflect neither burst traffic nor transient congestion. To work out this problem, Weighted Load Aware Routing (WLAR) protocol is proposed. This protocol selects the route based on the information from the neighbor nodes which are on the route to the destination. In WLAR, a new 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.(WLAR) 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 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. 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):
Simple Load-Balancing Ad hoc Routing (SLAR) 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 incurred 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 gives up forwarding packets and lets some other nodes take over the 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):
SLA 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, SLA 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. Consequently it spreads the traffic uniformly over the complete network and extends the lifetime of an entire ad hoc network by making all MANET nodes to fairly consume their energy. 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):
Delay-based Load-Aware On demand Routing (D-LAOR) 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. 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.

Energy Consumption Load Balancing (ECLB):
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. It is assumed that several disjoint paths between source and destination node have been established by a multiple path routing protocol such as. 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.

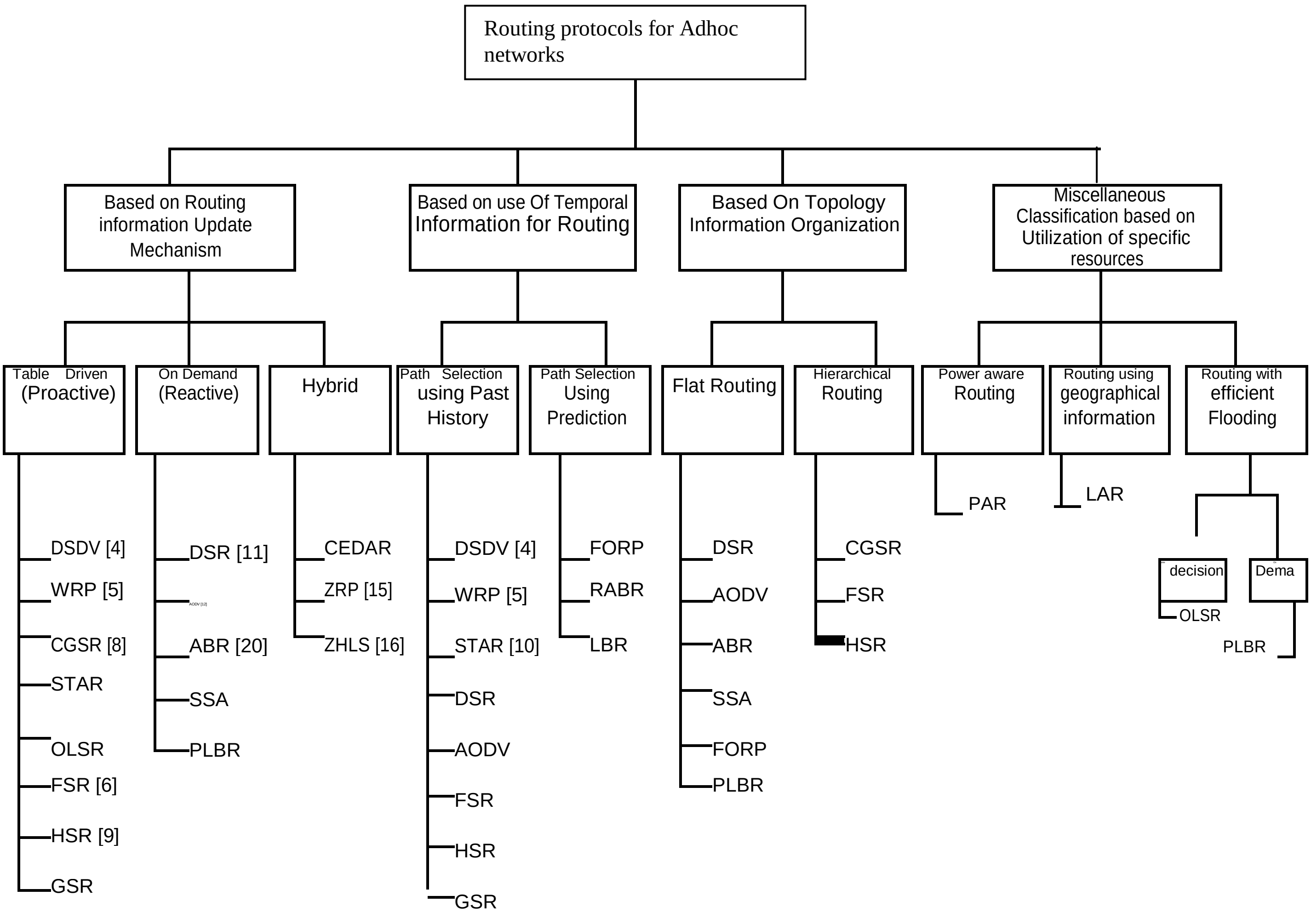

Fig 1: Classifications of Ad hoc Routing protocols [3]

TABLE 1:
CHARACTERISTICS OF LOAD BALANCED AD HOC ROUTING PROTOCOLS

S.No	LBR Protocol	RSC	Category	TPU/ Extension of	RPU	LBE	RS	BR	Limitation
	DLAR [22]	No. of packets buffered in interface	Traffic Size	DSR	Single path	Network	F	Y	Interface queue length doesn't give a true picture of actual load
	LARA [23]	Traffic Density	Traffic Size	DSR	Single path	Network	F	Y	Condition of the route is not considered, once it has been selected for data transmission
	LBAR [24]	Degree of nodal activity	Traffic Size	DSR	Single path	Network	F	Y	Mainly intended for connectionless applications
	LSR [25]	Network load information	Traffic Size	DSR	Single path	Network	F	N	No consideration for burst traffic or transient traffic
	WLAR [26]	Total traffic load	Delay based	AODV	Multi path	Network	F	Y	Overhead of route request packets
	SLAR [27]	Forwarding Load	Traffic Size	AODV+ DSR	Single path	Node	F	F	Mobile nodes may deliberately give up forwarding packets to save their own energy
	SLA [28]	Own Traffic Load	Traffic Size	AODV+ DSR	Single path	Node	F	F	A reliable server node called Credit Manager (CM) is required which manages nodes
	D-LAOR [29]	Estimated total path delay and hop count	Delay Based	AODV	Multi path	Network	F	F	Routing overhead is comparatively high
	CLAR [30]	Traffic load through and around neighboring nodes	Traffic Size	AODV	Multi path	Network	F	Y	More useful for high load network with low mobility
	ECLB [31]	Energy consumption rate of each node		DSR	Multi path	Network	F	N	Outperforms only in the environment of lower power level
	PALB[33]	Prediction of network traffic	Traffic Based	AODV	Multi path	Network	F	Y	In order to predict traffic correctly, a special traffic pattern is required.
	WBALB [37]	Interface queue occupancy and workload	Traffic based	AODV	Multi path	Node	F	Y	Determining the appropriate threshold value
TS	TSAR[38]	Size of traffic, through and around the network nodes	Traffic Based	VPR	Multi path	Node	F	Y	Do not guarantee the utilization of nearly current load information.

LBR Protocol- Load Balanced Routing Protocol RSC-Route Selection criteria
TPU- Traditional Protocol Used RPU-Routing Path Used, LBE-Load Balancing Effect

CONCLUSION

Some important issues related to the load-balanced routing protocols for mobile ad hoc networks Load balanced routing protocols have different Load metrics as route selection criteria to better use MANET resources and improves MANET performance. With Load Balancing, MANET can maximize mobile nodes lifetime, packet delivery ratio, throughput, and minimize traffic congestion and load unbalance, as a result, end-to-end packet delay can be minimized, and network energy consumption can be balanced.

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