Load-balancing techniques in ad-hoc networks

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Abstract— A critical challenge in ad hoc network design is the development of efficient routing protocols that can provide high quality communication between mobile nodes. Many routing protocols have been developed for ad hoc mobile networks. These protocols can generally be categorized as table-driven and on-demand routing.

Indeed, ad hoc network routing protocols tend to use a few "centralized" nodes on a large number of routes. This causes congestion in media access control (MAC), which results in high packet delays. In addition, such nodes would also suffer from high power consumption of their batteries. This is an undesirable effect, which is aggravated by the power limit of mobile node batteries. In fact, a major disadvantage of all existing ad hoc routing protocols is that they have no provisions for transmitting the load of a path during route configuration. As a result, they cannot balance the load on different paths.

It is essential to use efficient routing protocols that provide high quality communication. It is therefore necessary to distribute the traffic between the mobile hosts. A Routing Protocol in ad-hoc networks should distribute routing tasks equitably.

This article describes the different load metrics and summarizes the main existing load-balanced routing protocols. Finally, a qualitative comparison of the different load metrics and load-balanced routing protocols is presented.

Index Terms— ad hoc networks, congestion, load, metrics load-balanced, routing protocols.

I. Introduction

Various load-balanced ad-hoc routing protocols are on-demand protocols. Load balancing strategies are combined with the route discovery phase [1].The term load can be interpreted as:

load-balanced ad-hoc routing protocols are on-demand protocols. Load balancing strategies are combined with the route discovery phase [1].The term load can be interpreted as:

Channel Load: Represents the load on the channel where multiple nodes compete for access to the shared media.

Nodal load: refers to the activity of a node. Specifically, it refers to the activity of a node in processing, computing, and so on.

Neighbor Load: Represents the load generated by the communication activities between neighboring nodes.

Load-balanced ad-hoc routing protocols are based on different load metrics:

Active Path: This is the number of active routing paths supported by a node. Generally, the higher the number of active routing paths, the more active the node is; since it is responsible for the transfer of the data packets.

Traffic Size: This is the traffic load on a node and its associated neighbors (measured in bytes).

Packets in the interface queue: This is the total number of packets buffered on the wireless interfaces.

Probability of access to the channel: This refers to the probability of successful access to wireless media. It is also related to the degree of contention of channels with neighboring nodes.

Node Delay: These are the delays incurred for packet queuing, processing, and successful transmission.

Routing protocols can generally be classified into three types (depending on their load balancing techniques) [1]

Delay-based: where load balancing is achieved by trying to avoid nodes with high link delay. An example is Load-Aware On-Demand Routing (LAOR) [2]

Traffic-based: where load balancing is achieved by evenly distributing the traffic load between nodes in the network. Examples include: Load Balanced Ad Hoc Routing (LBAR) [3] Traffic-Size Aware (TSA) [4]

Hybrid: where load balancing is achieved by combining characteristics of traffic-based techniques and delays. The examples are; Load Aware Routing in Ad Hoc (LARA) [5].

And other classification cited in [6]: Load balancing protocols are grouped into three categories based on the routing strategy:

Single-Path Load Balancing Routing Protocols: During the route discovery procedure, several main routes may be encountered, but only the best one is used for routing traffic such as LBAR [3], LSR [7].

Multiple Path Load Balancing Routing Protocols: Multipath routing has been considered an attractive alternative for ad hoc networks because it is capable of providing breakdown tolerance. The use of backup routes reduces packet loss, extends the duration of communication sessions and enhances mobility such as; NodeCentricLoadBalancingRoutingProtocol (NCLBR) [8]

Balancing load routing protocols based on ClusteringLoadBalancing (LBC) that provides load balancing on selected clusterheads, fuzzylogic-based Clustering Protocol: Clustering is divided into three phases: ClusterHead election, ClusterHead selection, and load transfer from one ClusterHead to another [6].

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II. Load balancing techniques:

A. Load-balancing in MANET shortest- path routing protocols, [2]:

In this article, load balancing mechanisms push traffic further away from the center of the network. New routing metrics that take into account the degree of centrality of the nodes, for proactive and reactive routing protocols is used. The simulations show that the proposed mechanisms improve load distribution and significantly improve network performance in terms of average time and reliability.

B. Node Centering Load Balancing Routing Protocol (NCLBR) [8]

This protocol is similar to the function of AODV. Most of the operations are similar to AODV except minor changes of the RREQ packet format and their broadcast across the network. In the NCLBR protocol there are three distinct roles of nodes namely terminal, junction and normal nodes. Terminal nodes are the nodes that are connected to the rest of the network via a single link. In other words, they have only one neighbor node. Junction nodes are those that connect two distinct network segments. This distinction is purely based on their geographical location.

In NCLBR, each node takes the initiative to avoid congestion because in a MANET environment, it is always likely that there will be alternative routes to a particular destination. Each node is responsible for diverting congestion from itself to other alternative routes that may exist in the network. The main goal of NCLBR is to avoid creating new routes through a congested node. Each node obtains its current congestion state from the size of the interface queue. Each node uses an interface queue size of 60. During the 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 to ignore the new RREQ packets in order not to let new routes pass. Therefore, load balancing is achieved.

C. Load-Aware On-Demand Routing (LAOR) [9]:

A new scheme has been proposed that uses the estimated path delay and the hop number as a path selection criterion.
Since redundant routing information can have a significant impact on MANET's overall performance [10]. The proposed D-LAOR also has a route selection mechanism to avoid a congested node by selectively removing packets route request (RREQ).

Measurement of local time delay:

Where "time stamp" is placed in the header of each packet when the mobile node receives a packet. We denote a_i ,d_i, the transmission and arrival times of the packet i^{th}. After a successful transmission of the packet i^{th} to the node k the average delay of node k estimated q_i^k is calculated as follows:

$$q_i^k = (1-\beta) q_{i-1}^k + \beta(d_i - a_i)$$

for $i > 1$ and $0 \le \beta \le 1$.

The estimated average total delay includes queuing, contention and transmission delays. The authors assumed that the propagation delay is negligible. DP as the total propagation delay of a path P from node 1 to n is represented as follows:

$$D_P = \sum_{k=1}^{n} Q_k$$

Where $Q_k$is the estimated total node delay q_i^k of node k at the time of routediscovery
Discovery and maintenance of the route:

D-LAOR is an extension to the AODV protocol
- 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 (that is, say DP '<DP).

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 updates the total path delay and passes that RREQ packet to their neighbors, and so on, until the destination is reached.
The RREQ packet contains the source and destination addresses, the sequence number, the hop number and the total path delay DP of a path P, which the RREQ packet has traversed. During the process of transmitting this RREQ packet, the intermediate nodes record in their routing tables the total path delay DP of path P.
Any duplicate RREQ packets received later will be relayed if the new P 'path has a smaller hop count and a smaller path delay than the previous path (i.e. DP' <DP).
After the first RREQ packet arrives at the destination, the destination node responds by returning a RREP packet to the neighbor from which it received the corresponding RREQ packet. If the duplicate RREQ packet has a total path delay and a smaller hop count than the previous packet, the destination sends a RREP packet back to the source node to immediately change the route.
D-LAOR does not allow any intermediate nodes to generate a RREP packet except the destination node because the routing delay registration of the intermediate node to the destination may not be accurate.

In addition D-LAOR can route around a congested node and thus reduce control congestion. This is achieved by removing RREQ packets at the congested node which prevents the congested node from becoming an intermediate node of a path. D-LAOR determines the congested node by comparing the estimated total delay of the node to the number of packets queued in the two serial node interface queue in the RREQ packet. D-LAOR deletes a RREQ packet only when both of the following conditions are true:

The estimated total delay of a node A is greater than that of the previous node B.
The number of packets queued in the interface queue of node A represents more than 80% of its buffer size.

D. Load-aware destination controlled routing for MANET

A new Load Balanced Ad hoc Routing (LBAR) protocol for communication in ad hoc wireless networks is described in this paper. LBAR defines a new routing metric known as nodal activity degree to represent the load on a mobile node. In LBAR, the routing information of all paths from the source to the destination is passed through the installation messages to the destination. The installation messages include nodal activity information from all the nodes of the traversed path. After collecting information on all possible paths, the destination then selects the path with the best cost value and sends an acknowledgment to the source node. LBAR also provides an alternative path maintenance technique to repair broken links by diverting traffic to the destination.

LBAR focuses on finding a path that reflects the least amount of traffic so that data packets can be delivered with less delay. The algorithm has four steps: Route Discovery, maintenance, Local connectivity management, Calculation of the cost function.

What is new in this protocol is the cost function. The cost function is used to find a path with the least traffic so that data packets can be transmitted to the destination as quickly as possible while achieving the goal of balancing the load on the network. The following definitions are used:

Active Path: The chosen path from source to destination in order to route data packets.

Active Node: A node is considered active if it generates or transmits data packets or if it is a destination.

Inactive node: A node is considered inactive if it is not on an active path.

Activity: The number of active paths across a node is defined as a metric measuring the activity of the node.

Cost: The minimum traffic load plus interference is proposed as the best cost measure.

E. Load Sensitive Routing (LSR) protocol [7]

This protocol is based on the DSR[11]. This protocol uses the network load information as the selection criterion of the main path. The means for obtaining network load information in LSR does not require periodic exchange of load information between neighboring nodes. They are suitable for any existing routing protocol.

Unlike LBAR and DLAR, LSR does not require destination nodes to wait for all possible routes. Instead, it uses a redirection method to find better paths. The source node can respond quickly to a connection call without losing the chance to get the best path. LSR can dynamically search for better parts if the active path becomes congested during data transmission. In route discovery, we use a redirection method similar to the one we developed in multipath routing to dispatch route response messages (RREPs). This method can allow the source node to obtain a better path without increasing the cost of the flood and wait for the delay in the destination nodes. In LSR, we adapt active routes in a path in a different context, using the network load information. When a used path becomes congested, LSR tries to find a light path. The source node continues to send data traffic along congested paths until a better path is found. The route adaptation strategy is based on the initial state and the current state of an active path.

F. Weighted Load Routing (WLAR) [13]

This protocol selects the route based on information from neighboring nodes on the route to the destination.
In WLAR, a new traffic load is defined as the product of the average interface queue size on the node and the number of shared nodes declared to influence the transmission of their neighbors. The protocol (WLAR) adopts the basic AODV[12] procedure and the packet format. In WLAR, each node must measure its average number of packets queued in its interface. Then, it checks whether it is a node shared with its neighbor or not. If it's a sharing node, it has to let its neighbors know. Once each node has its own average packet queue size and the number of its share nodes, it must calculate its own total traffic load.
When a source node initiates a route discovery procedure by flooding RREQ messages, each node receiving a RREQ will rebroadcast it based on its own total traffic load. So that, flooded RREQs that heavily traverse loaded routes are deleted in progress or at the destination node.
The destination node will select the best route and respond with RREP. The average number of packets queued in the interface is calculated by (EWMA) Exponentially Weighted Moving Average.

The reason for using the average number of packets queued in the interface is to avoid router congestion. The shared node is defined as a node whose average queue size is greater than or equal to a certain predetermined threshold value.
If the average queue size is not greater than a threshold value, it is assumed that the node`s effect is negligible to its neighbors. The total traffic load in the node is defined as its own traffic load plus the product of its own traffic load and the number of shared nodes.
The path load is defined as the sum of the total traffic loads of the nodes that include the source node and all intermediate nodes on the route, except for the destination node.

G. Ad Hoc Routing with Simple Load Balancing (SLA) [14]

This protocol is based on the autonomy of each node.It reduces congestion by the load distribution mechanism.It also prevents the excessive consumption of battery power caused by the sending of packets. Each node determines whether it is overloaded.If it is the case it abandons the sending of the packets. As a result, it evenly distributes traffic across the entire network and extends the life of the ad hoc network by ensuring that all MANET nodes consume their energy equitably.

However, there may be "selfish" nodes that can deliberately abandon the packet transfer to save their own energy if appropriate compensation is not given to them. Therefore, in SLA, a credit-based system called (PIFA; Protocol-Independent Fairness Algorithm) to urge nodes to voluntarily participate in the transfer of packets is proposed.

In MANETs using PIFA, nodes earn credits by transferring packets from others only when they have enough credits with them.They are allowed to generate packets. PIFA can detect and isolate the malicious node, which tries to trick others on the number of packets to be transferred in order to acquire more credits than it should actually receive.

SLA is not designed as an entirely new routing protocol, but as an improvement to existing ad hoc routing protocols such as AODV, DSR, and so on.

H. Load-Related Routing (CLAR) [15]:

A new Correlated Load-Aware Routing (CLAR) protocol that considers the traffic load, across and around neighboring nodes, as the primary routing selection metric: The traffic load on a node is considered the principalroute selection metric. This load depends on the traffic passing through that node and the traffic in the neighboring nodes.

Mathematically, the traffic load in a node is thus defined as the product ofthe queue average size at the node level and the number of sharing nodes. The average size of the queue waiting time is calculated with the method (EWMA: exponentially weighted moving average) of the previous queue lengths. The advantage of an EWMA is to filter the transient congestion at the router. An exponentially weighted moving average is a low-pass filter and the equation of it is:

$$avg = (1 - w_q)\ avg + w_q q$$

The q is the size of the current queue and avg is the estimation of the average queue. The weight (w <1) determines the constant time of the low-pass filter.

If the W_q is too large, the averaging procedure calculation will not filter the transient congestion. On the other hand, if w_q value is too low, the average also responds slowly to changes in the actual size of the queue. The calculation of the average queue size can be effectively implemented when w_q is a (negative) power of two. The value 0.2 for w_q is recommended to represent a newer number of packets in a queue.

CLAR is an on-demand routing protocol and consists of two phases: Road Discovery and Road Maintenance. Most of the route discovery and maintenance features in CLAR are inherited from the (AODV) protocol because CLAR is an extension of AODV. In addition to the load balancing capability, CLAR inherits all the benefits of AODV.

The use of Hello messages in a CLAR is modified in order to allow mobile nodes to exchange their load sharing information (SL). When a node sends a Hello message, it informs its neighbors whether it is the sharing node or not.

CLAR does not allow intermediate nodes to generate a RREP packet at the source node to avoid providing unstable path load information; This prohibition ensures the use of recent load information.

CLAR allows intermediate nodes to support disjoint multiple paths. If the intermediate node receives duplicate RREQ packets which includes a path load lower than that of the path in the previous received RREQs, it redistributes the received RREQ instead of deleting it. Although this mechanism can increase the routing load, it allows the destination to choose the optimal route.

The destination node must select the best path between multiple paths because CLAR supports multiple paths between source and destination.

When the RREQ reaches the destination node, it selects the path with the smallest sum among the multiple paths as the best route.

If there are one or more routes with the same traffic load, the destination selects the route with the least number of distance hops.

I. Adaptive load balancing in mobile ad hoc networks [16]

This mechanism is based on the multi-path routing protocol and the prediction of ad hoc network traffic. PALB locates at the source node. Its purpose is to minimize traffic congestion and load imbalance by adaptively distributing traffic between multiple disjoints

Paths based on traffic prediction. The source node periodically predicts the cross traffic of each node in the multiple disjoint paths and adjusts the distribution of traffic across multiple disjoint paths. The data packets first enter to a packet filtering model whose purpose is to facilitate the transfer of traffic between multiple paths in a manner that reduces the possibility that packets arrive at the destination in disorder. In PALB, a flow filtering method is used. The packet distribution model then distributes traffic from the packet filtering model over multiple paths. Traffic distribution is based on a load balancing model that decides when and how to forward traffic among multiple paths. The load balancing model operates on the basis of evaluating path stability and measurement of the statistical path. The load balancing model consists of three phases:

balancing off: when the paths are unstable.

balancing-on: when the paths are stable.

imbalance detection.

In the balancing-off phase, paths will go into balancing-on phase if the they become stable.

In the balancing-on phase, the load balancing algorithm attempts to equalize the congestion measurements between multiple paths. The path congestion measurement is a function of the path traffic load. Once the measurements are equalized, the phase moves to the imbalance detection phase.

In the imbalance detection phase, if it is detected that the congestion measurements are unequal, the phase returns to the balancing-on phase. In the balancing detection and balancing-on phases, if the paths become unstable, they move to the balancing-off phase.

J. The load balancing approach in Ad-Hoc networks [17]

A new approach has been proposed called: Simple Load-Balancing Ad-hoc Routing (SLAR). It is based on the autonomy of each node which may not be the optimized solution for the entire network, but it may reduce congestion caused by load balancing and prevent excessive energy consumption of the batteries. SLAR is independent of the unicast routing protocols of ad hoc networks. The technique is that each node determines whether or not it is suffering from the traffic concentration. It tries to reduce the traffic load by dropping some packets. To do this, the abandoning node changes its state to GIVE-UP and sends GIVE-UP message to the source node in order to warn it to discover a new route deviating the abandoned node.

In the GIVE-UP message, the source node and the list of destinations whose routes cross the abandon node are specified. When the source receives the GIVE-UP message, it starts the route discovery mechanism to specified destinations. The "abandon" node ignores received "RREQ" messages while it is in the GIVE-UP state. By doing this, any new route through the drop node will be prevented from being established, so that the traffic passing through the drop node will eventually be reduced. SLAR can be implemented as additional modules to existing routing protocols and it is independent of any ad hoc routing protocol.

An adaptive load balancing technique based on workload for mobile ad hoc networks [18]: A new load balancing technique for ad hoc on-demand routing protocols is presented.

In the new scheme, the RREQ messages are selectively transmitted according to the state of charge of each node. Overloaded nodes do not allow additional communications to be added so that, they can be excluded from the requested paths in a specific time period. Each node begins to allow additional traffic flows whenever its overloaded status has changed. The new scheme uses the interface queue occupation and the workload to control RREQ messages adaptively. Each node maintains a threshold value which is a criterion to decide whether to answer or not a RREQ message. The threshold value dynamically changes according to the node`s state of charge based on both, the occupation of the interface queue and its workload in a specific period.

The new scheme allows a node to transfer RREQ selectively. Each node maintains a threshold value. This threshold value is a criterion for deciding whether to send or delete the RREQ message. Thus, overloaded nodes are excluded from the new requested paths. The threshold value is initially set to a predetermined value. The threshold value changes depending on the node`s state of charge.

Load balancing routing via virtual paths: highly adaptive and efficient routing scheme for ad hoc wireless networks [4] : Load balancing based on traffic size in packet number. A more accurate method is to measure the size of the traffic in bytes. The node maintains an entry for each active virtual path. This entry contains the time the entry was created, the number of packets, and the amount of traffic that was routed using this entry.

In this scheme, the network nodes keep track of the traffic size (in bytes) being routed. The nodes are aware of the traffic size that is dispatched towards their neighbors. For any path that consists of multiple hops; the load metric which is the sum of all traffic dispatched towards all the hops that make up that path, is calculated,.

K. Load balancing routing in mobile ad hoc networks [5]

For efficient data transmission in mobile ad hoc networks, a new protocol called LARA (Load Aware Routing in Ad hoc) was introduced in this paper. LARA defines a new metric for routing called traffic density in order to represent the contention level at the media access control layer. During route discovery, this metric is used to select the route with the minimum traffic load.

This protocol requires that each node maintains a record of the last "traffic queue estimations" of each of its neighbors in a table called the neighborhood table. This information is collected using two types of programs. The first type of broadcast occurs when a node tries to discover the route to a destination node. This type of broadcast is called a route request. The second type of broadcast is hello packet broadcasting. In the case where a node has not sent any message to one of its neighbors during a predefined timeout period, called the Hello interval, it broadcasts a Hello message to its neighbors. A Hello packet contains the identity of the sending node and its status of "Traffic queue". Neighbors receiving this packet update the corresponding neighbor's load information in their neighborhood tables.

If a node does not receive data or a hello message from some of its neighbors for a predefined time, it assumes that those nodes have moved out of that node's radio range. Thus, it changes its neighborhood table. A message derived from a new node is also an indication of the neighborhood information change and it is appropriately handled.

"Traffic queue": of a node is defined as the average value of the interface queue length measured over a period of time. For node i, it is defined as the average of N samples over a given sample interval.

$$q_i = \frac{\sum_{k=1}^{N} q_i(k)}{N}$$

Where q_i (k) is the k sample of the queue length and q_i is the average of these N samples. The higher the value of N is; the better is the traffic estimation.

Traffic density: The traffic density of a node i is the sum of "traffic queue" q_i of the node i plus "traffic queues" of all its neighbors.

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

L. Multi-path routing with load balancing and QoS in an ad hoc network [19]

In this article, a combination of a multipath routing protocol with a QoS-based load balancing mechanism results in a new protocol called QLB-AOMDV (QoS and Load Balancing-AOMDV). It is a solution to achieve a better distribution of the load respecting the QoS in terms of the end-to-end delay.

In order to transfer the data ,AOMDV protocol selects the route with the least number of hops. However, less congested roads can provide a short end-to-end delay than roads that provide a lower hop count.

To choose the least congested routes, a new metric that allows the source node to select the less congested routes is used. This metric performs load balancing between selected routes according to the following equation:

$$Min\left[\frac{1}{n_p}\sum_{i=1}^{n_p}(buffer\ \_size(i))\right]$$

Where buffer size (i) is the size of the link buffer occupation i through an intermediate node participating in the route p. The division with np hops, forming the route p, guarantees that the metric takes into account the hop number to estimate the traffic load.

Road maintenance is similar to AOMDV:

QoS extensions have been added to the AOMDV protocol that include delay and rate parameters in the RREQ message. The purpose of its additions is that each node in the network can estimate its link quality with its hop neighbors.

To build the LB-AOMDV protocol, the RREP packet structure is redefined by adding a new field called buffer size that takes into account the traffic load on the road. When an intermediate node receives a packet RREP, it adds its buffer size to the new field. On the other hand, when the source receives the RREP packet, it divides the value of the buffer size field by the hop number of each route between the source and the destination in order to have the congestion level. Thanks to the algorithm for calculating the congestion level between the source and the destination, the least congested route is chosen.

III. COMPARISON BETWEEN LOAD BALANCING ALGORITHMS

TABLE I
Comparison between load balancing techniques

Protocol	Route Selection Criteria	Category	Protocol Extension	Path Type	Protocol Advantages	Protocol Limits
LAOR [9]	Estimation of the total path delay and hop count	Based on delay	AODV	Multi path	Reduce end-to-end delay, and increases packet delivery rate	Congestion exists
LBAR [3]	Degree of nodal activity	Based on traffic	DSR	Single path	Intended for sensitive applications to delay. rapid response to link failure	
LSR [7]	Network load information	Based on traffic	DSR	Single path	LSR does not require periodic exchange of load information between neighboring nodes.	No consideration for burst or transient traffic
WLAR [13]	Total traffic load	Based on delay	AODV	multi-path	- Uniform distribution of load on paths -Avoid the influence of traffic on exploding	-the congestion of RREQ packets.
SLA [14]	Node traffic load	Based on traffic	AODV + DSR	Single Path	-Extends Network Lifetime -prevent excessive consumption of battery power	
CLAR [15]	LA Traffic load across and around neighboring nodes	Based on traffic	AODV	Multi-path	-reduced congestion thanks to its mechanism and also reduces control messages since it forbids the intermediate nodes to generate RREPs to the new source	Is not efficient in a network with high mobility
PALB [16]	Predicting Network Traffic	Based on Traffic	AODV	Multipath	adaptively distributing traffic across multiple disjoint paths	- In order to accurately predict traffic, a special traffic pattern is required.
SLAR[17]	Load	Based on traffic	AODV + DSR	Single Path	SLAR can be implemented as additional modules to existing routing protocols and is independent of any ad hoc routing protocol.	Mobile nodes can drop transfer packets to save their own energy
WBALB [18]	Queue Interface and Workload	Based on Traffic	AODV	Multipath	Overloaded nodes do not allow additional communications to be	Determining the correct threshold value is difficult in a dynamic

					placed so that they can be excluded from the requested paths in a particular time period.	environment
TSAR [4]	Traffic Size, Through and Around Network Nodes	Based on Traffic	VPR (Virtual path routing)	Multipath	A more accurate method is to measure the traffic size in bytes. TSA distributes traffic between nodes in the network to avoid creating highly congested areas	Does not guarantee the use of current load information
LARA [5]	Traffic density and traffic cost	Based on traffic	DSR	Single path	Distributes load evenly across all network nodes, improving performance. this protocol allows for better route selection based on traffic density and traffic cost, which leads to better performance than LAOR and DSR	
QLB-AOMDV [19]	Road Traffic Load	Based on Traffic	AOMDV	Multipath	Designed for Better QoS Requirements in End-to-End Delay	

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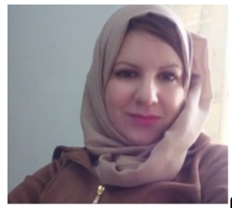

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