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REVIEW ARTICLE

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Load Balancing in Mobile Ad-Hoc Networks: A Review

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Abstract: Mobile Ad Hoc Network are wireless network consisting of a collection of mobile nodes with no fixed infrastructure due to their decentralization, self-configuring add dynamic nature MANET offer many advantages and are easy to install. But with this dynamic topology, mobile adhoc network have some challenges like design of an efficient routing protocol and controlling the congestion, hence balancing the load in MANET is important since nodes with high load will deplete their batteries quickly, thereby increasing the probability disconnecting or partitioning. This paper discusses the various load metrics and summarizes the principals behind several existing load balancing adhoc routing protocols.

Keywords: AODV-Ad hoc on demand distance vector, VPR-Virtual path routing, LOAR-Load aware on demand routing, ABR-Associatively based routing, LBAR- Load balancing adhoc routing, TSA-traffic size aware, CSLAR-content sensitive load aware routing, LARA-load aware routing in ad hoc

I. INTRODUCTION

A Mobile Ad Hoc Network is a Collection of Wireless Mobile nodes dynamically forming a temporary network without the use of fixed network infrastructure of centralized administration and operating on limited amount of battery energy consumed mostly in transmission and reception. MANET has known a great success. They are opening up to various applications of Quality of service, Such as delay, throughput. Packet loss and network lifetime. The mobility of nodes and the error prone nature of the wireless medium pose many challenges, including frequent route changes and packet losses, in the way of meeting the requirements of QoS. Such Challenges increases packet delay, decreases throughput and reduce network failure. The network performance degradation gets worse as traffic load increases. Despite there are large amount of effort invested in routing protocols, improving TCP performance and medium access control (MAC) for MANET [5]. MANET is one of the most important technologies that have gained interest due to recent advantages in both hardware and software techniques. MANET technology allows a set of mobile uses equipped with radio interfaces (Mobile nodes) to discover each other and dynamically form a communication network [2]. MANET provisioning of real time multimedia services such as voice and video over ad-hoc networks is problematic since wireless links are unreliable and are of limited bandwidth [8].MANET incorporates routing functionality into mobile nodes so that they become capable of forwarding packets on behalf of other nodes and thus effectively become the infrastructure . Providing multiple routing paths between any source-destination pair of nodes has proved to be very useful in the context of wired networks. The general understanding is that dividing the flow among number of paths in a better balancing of load throughout the network [2]. The multipath routing appears an efficient solution for the ad hoc networks. It can provide load balancing and route failure protection by distribution traffic among a set of diverse paths. Load balancing mechanism allowing the traffic through the less congestion route [3]. Load balancing is distributing processing and communications activity evenly across a computer network so that no single device is overwhelmed .Load balancing is a methodology to distribute workload across multiple computers or a computer cluster, network links, central processing units, disk drives, or other resources, to achieve optimal resource utilization, maximize throughput, minimize response time, and avoid overload. Using multiple components with load balancing, instead of a single component, may increase reliability through redundancy [12]. Load balancing is iterative in nature. Local iterative load balancing algorithms were first proposed by Cybenko. These algorithms iteratively balance the load of a node with its neighbors until the whole network is globally balanced. There are mainly two iterative load balancing algorithms: the diffusion algorithms and the dimension exchange algorithms. Diffusion algorithms assume that a processor simultaneously exchanges load among all neighbor processors, whereas DE algorithms assume that a processor exchanges load with only one neighbor at each time step [10]. With Load balancing, MANET can minimize traffic congestion and load imbalance, as a result, end to end packet delay can be minimized, mobile nodes lifetime can be minimized [11]

II. ADVANTAGE OF MANETs & LOAD BALANCING

A. Advantage of MANET

a. MANET provide multiple routing paths between any source to destination for transferring the packets[1,2]
b. MANET Provide shortest path and adaptive routing for transferring the packets from source to destination [1]
c. MANET consists in a collection of wireless nodes, which form a temporary network without relying on any existing infrastructure or centralized administration [3]
d. MANET Provide some wireless mobile nodes which move arbitrarily and dynamic exchange data without fixed base stations [6].
e. MANET used in various practical applications such as military applications, emergency operations and wireless sensor networks [7]

B. Advantage of Load Balancing.

a. Load balancing can minimize traffic congestion and load imbalance, as a result, end to end packet delay can be minimized, mobile nodes lifetime can be minimized [11].
b. Load balancing distributes the load among the nodes [2]
c. Load balancing is used in multiple routing and provide more than one path for transferring the packets from source to destination [1, 2]
d. Load balancing is a major issue in time critical and information intensive applications for increasing performance of distribution applications on dynamic networks [10].
e. Load balancing is used to utilize network resource more efficiently and minimized congestion and it also adjust the distribution of traffic among multiple disjoint paths based on the measurement of network traffic [11].

III. SYSTEM ARCHITECTURE FOR ROUTING WITH LOAD BALANCING

The communication in mobile ad hoc networks comprises two phases, the route discovery, and the data transmission. System architecture for routing with load balancing is shown in Figure 1, which consists of agents with predefined policies [9]

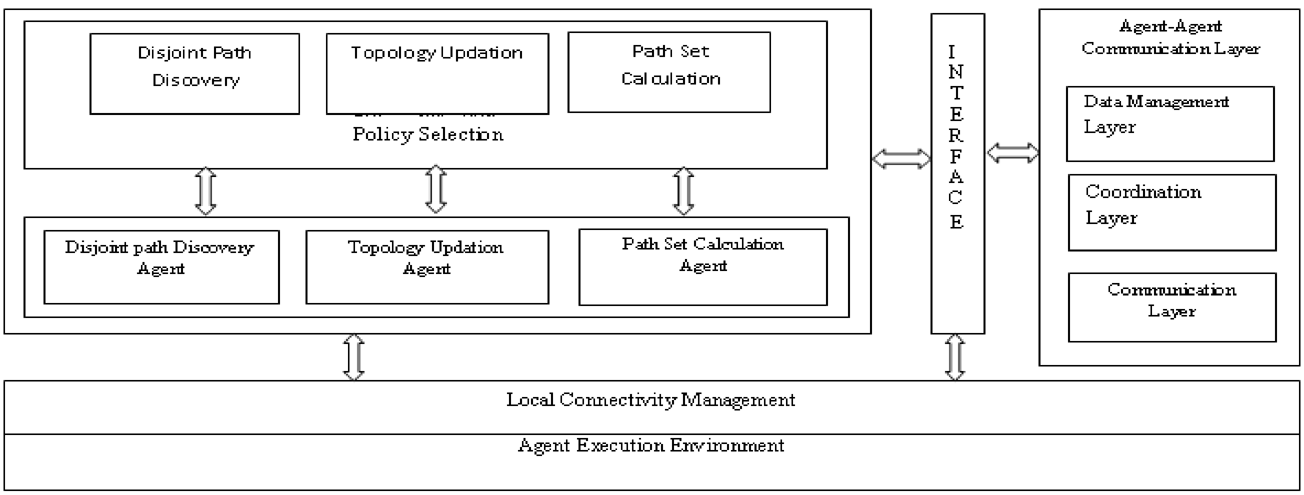

Figure 1: System Architecture for Routing with Load Balancing.

A. Policy Selection

[a]. Disjoint Path Discovery:

This policy is to find the suitable route before actual transmission of data begins. The goal is to choose as many paths as possible and at the same time include paths that are as reliable as possible.

[b]. Topology Updation:

This policy when executed dynamically updates the topology of the existing network during link breakage. In wireless networks, nodes are allowed to move freely, which causes dynamic topology

[c]. Path Set Calculation:

This policy is used to find a path with the least traffic so that data packets can be transmitted to the destination as fast as possible while achieving the goal of balancing load over the network. A set of paths to achieve high reliability in aggregate, the correlation of failures between the paths in the set should be as low as possible.

B. Agent Selection

The following agents are chosen for above defined policies-

[a] Disjoint Path Discovery Agent (DPDA)

Each path is associated with two ratings: a short-term and a long term rating. These rating are defined by two parameters namely as availability and stability.

[b] Topology Updation Agent (TUA):

The main task of this agent is to execute the topology update policy, because in ad hoc network if new node joins the APS then topology automatically changes. So each node maintains a list of its neighbors by sending TUA containing hello message to them. Whenever a node receives a broadcast from a neighbor, it updates its local connectivity information in its Neighborhood table to ensure that it includes this neighbor.

[c] Path Set Calculation Agent (PSCA):

This agent executes the path set calculation policy.

C. Agent-Agent Communication Layers

Communication and Coordination Layers: Agents in the system communicate with each other or with users using mobile group approach for coordination of Mobile Agents.

D. Local Connectivity manager and Data Management Layer

This manager manages the local connectivity of nodes at the management layer. Nodes learn about their neighbors in one of two ways. Whenever a node receives a broadcast from a neighbor, it updates its local connectivity information in its Neighborhood table to ensure that it includes this neighbor

IV. CATEGORIZATION OF LOAD BALANCING

Over the years, several load balanced ad hoc routing protocols have been proposed. Most of the approaches are on-demand-based protocols; that is, they combine load balancing strategies with route discovery. A route with the least load among multiple possible routes from source to destination is usually chosen. As shown in Figure.2, these routing protocols can generally be categorized into three types [4].

Delay based: Where load balancing is achieved by attempting to avoid nodes with high link delay. An example protocol using this approach is Load-Aware On-Demand Routing (LAOR).

Traffic based: Where load balancing is achieved by evenly distributing traffic load among network nodes.

Examples of traffic-based load balanced routing protocols are Associatively Based Routing (ABR), Load Balanced Ad Hoc Routing (LBAR) and Traffic-Size Aware (TSA) scheme Hybrid based: Where load balancing is achieved by combining the features of traffic- and delay-based techniques. Examples are Content sensitive load aware routing (CSLAR) and Load aware routing in Ad Hoc (LARA)

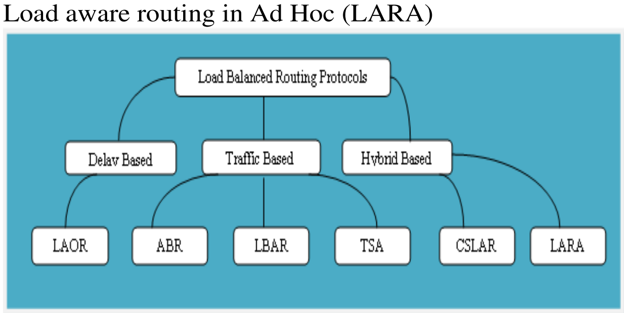

Figure 2: Categorization of load balancing routing protocols.

To classifying protocols based on their load balancing techniques, one should also consider the load metrics used by these protocols. The term load metric reflects how busy a node is engaged in receiving and forwarding packets over the wireless media. It also refers to processing, memory, bandwidth, and power load on the node. As shown in Figure 3, different load balanced ad hoc routing protocols use different load metrics [4]

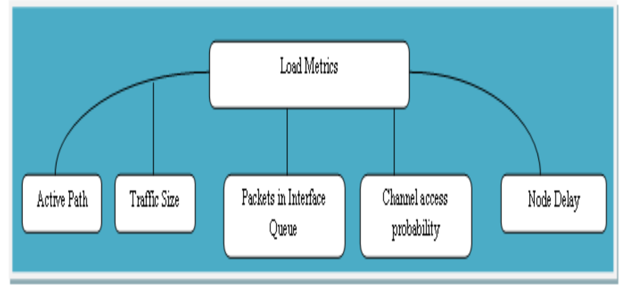

Figure 3: Load metrics used by existing load balanced adhoc routing protocols

Active Path: This refers to the number of active routing paths supported by a node. Generally, the higher the number of active routing paths, the busier the node since it is responsible for forwarding data packets from an upstream node to a downstream node.

Traffic Size: This refers to the traffic load present at a node and its associated neighbors.

Packets in Interface Queue: This refers to the total number of packets buffered at both the incoming and outgoing wireless interfaces.

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

Node Delay: This refers to the delays incurred for packet queuing, processing, and successful transmission.

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

Nodal Load. Relates to a node's activity. Specifically, it refers to how busy a node is in processing, computation, and so on.

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

V. LOAD BALANCED ADHOC ROUTING PROTOCOLS

As shown in Fig. 2, most of these protocols are traffic -based (ABR, LBAR, TSA), while LAOR is delay-based. CSLAR and LARA are considered hybrid-based, exhibiting features of both traffic- and delay-based protocols [4].

A. Delay based Protocols

LAOR is an extension of ad hoc on-demand distance vector (AODV) routing. It has two phases: route discovery and route maintenance. LAOR achieves load balancing by minimizing the estimated total route delay and route hop count. LAOR implements congestion monitoring during the route discovery process. It determines if a node is congested by first comparing the estimated total node delay and the number of packets buffered at the interface queue of two serial nodes on the RREQ packet forwarding path.

B. Traffic based Protocols

ABR is a source-initiated on-demand routing protocol. It includes three phases: route discovery, route reconstruction, and route deletion. Load balancing is employed during the route discovery phase. LBAR is also an on-demand routing protocol.

LBAR's load metric is similar to ABR, which is based on active path activity. However, unlike ABR, LBAR considers the activities of neighboring nodes. LBAR has two phases: route discovery and route maintenance.

TSA is an extension to the virtual path routing protocol (VPR). It combines source and table routing. VPR is a distributed on demand routing protocol that comprises two phases: path creation and path maintenance. Load balancing is performed during the path creation phase. Multiple routes are discovered from source node to destination by flooding path discovery packets. Every intermediate node that receives a path discovery packet calculates its current total load by summing the traffic size at this node and its neighboring nodes. It then adds the total load to the value of the load field of the incoming packet.

C. Hybrid based Protocols

CSLAR is an extension of Dynamic Source Routing (DSR), which also uses route discovery and route maintenance. As stated earlier, the route load metric used in CSLAR combines information related to the number of packets in the interface queue, channel access probability, and hop count information. Load balancing in CSLAR is also performed during route discovery. When a node has packets to send and there is no available route, a route request packet is flooded throughout the network.

LARA is another hybrid load balanced routing protocol. LARA requires each node to maintain a record of the latest traffic queue estimation of its neighbors. The traffic queue is defined as the average value of the interface queue length measured over a period of time. Traffic density, on the other hand refers to the sum of traffic queues at a node plus the traffic queues of all the node's neighbors. The traffic cost of a route in LARA is defined as the sum of traffic densities at each node in the route and the hop costs on that route.

VI. PERFORMANCE METRICS IN LOAD BALANCING

Three key performance metrics are evaluated [5, 8, 9]

A. Goodput: the ratio of the data packets delivered to destinations to those generated by the CBR sources.
B. Average End to end Delay: includes all possible delays caused by buffering during discovery, queuing at the interface queue, re-transmission delays at the MAC, propagation and transfer times.
C. Normalized Routing Load: the number of routing packets transmitted per data packet delivered at the destination. Each hop wise transmission of a routing packet is counted as one transmission

Figures 4,5 shows the packet delivery fractions for variations of the pause time for RLBMA, AODV, and DSR. Note that with 30 and 40 sources RLBMA outperforms AODV and DSR. In fact, RLBMA achieves the highest packet delivery fraction for all pause time values. For 30, 40 sources, RLBMA achieve up to 20% higher packet delivery fractions than both AODV and DSR [9].

Figures 6, 7 shows that RLBMA has a better average end-to-end delay than both AODV and DSR. For 30 and 40 sources, RLBMA achieves significantly lower delay than AODV and DSR. Moreover, the delays decrease with lower mobility for RLBMA in both cases while it increases for both AODV and DSR. RLBMA adopts a mechanism for load balancing, which tries to route packets along a less congested path to avoid overloading on some nodes [9].

Figures 8, 9 results show that the routing load increases with increasing the number of sources. This is because of increase in the number of source nodes causes a greater number of request messages flooding. RLBMA demonstrates a low routing load than both AODV and DSR. RLBMA will almost always have an alternative path to route packets in case of link failure. This enables RLBMA to achieve higher packet delivery fractions and lower average end-to-end delay [9].

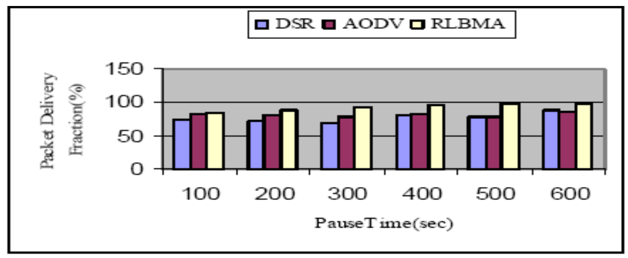

Figure 4: Packet Delivery Fraction for 30 sources with DSR, AODV,RLBMA

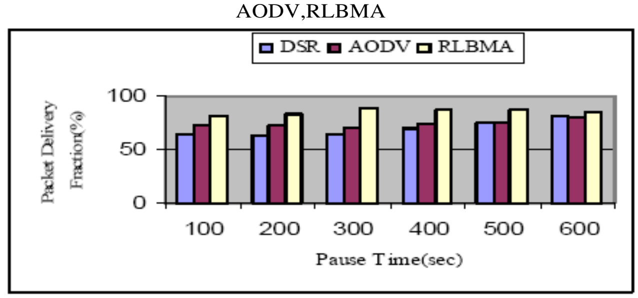

Figure 5: Packet Delivery Fraction for 40 sources with DSR,AODV,RLBMA

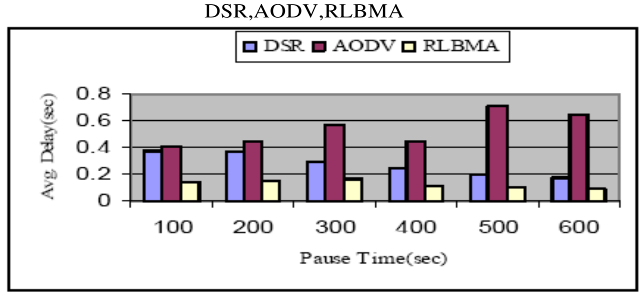

Figure 6:Average End to End delay for 30 sources

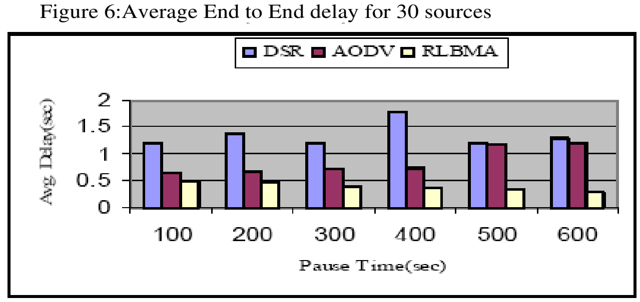

Figure 7: Average End to End delay for 40 sources with

with DSR,AODV,RLBMA DSR,AODV,RLBMA

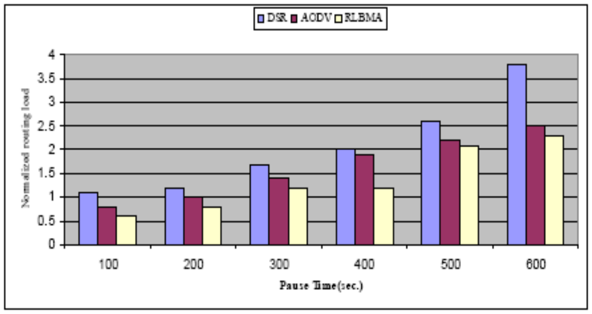

Figure 8: Normalized routing load for 30 sources with

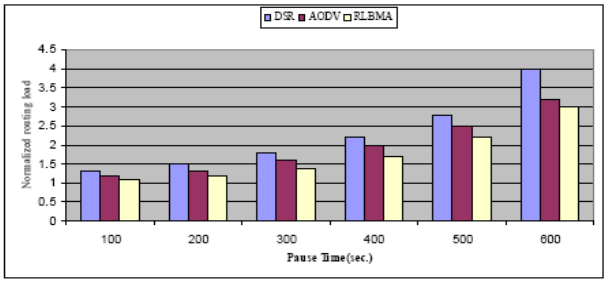

Figure 9: Normalized routing load for 40 sources with DSR, AODV, DSR, AODV, RLBMA RLBMA

VII. RELATED WORK

In this Paper [1], Authors propose two methods for improving the AODV Protocol. A new multipath routing Protocol that uses all discover path simultaneously for transmission data, by using this approach data packets are balanced over discovered paths and energy consumption is distributed across many nodes through network. This protocol also increased the packet delivery ratio in mobile adhoc networks. This Paper[2] introduce a traffic estimator which makes calculation based on previously sent packets and a new model for evaluating the load balance under multi path routing. Traffic load estimator method based on an exponential decreases function is also proposed. This article [4] discusses the various load metrics and summarizes the principles behind several existing load balanced ad hoc routing protocols. A qualitative comparison of the various load metrics and load balanced routing protocols is presented. This paper [5] presents a novel priority queue scheduling algorithm named Energy efficient and load balanced queue scheduling algorithm for mobile ad hoc networks was introduced. In this paper [5, 8, 9] Performance metric for load balancing was introduced i.e. Goodput, Average end to end delay and Normalized routing Load. This paper [9] introduces routing with load balancing using mobile agents (RLBMA). The concept of mobile agent (MA) for route discovery and balance the traffic load on the route. This mobile agent (MA) selects the disjoint path called active path set (APS) for reliable transmission to avoid congestion.

VIII. REFERENCES

[1]. Mehdi EffatParvar, MohammadReza EffatParvar, Amir Darehshoorzedeh, Mehdi Zarei, "Load Balancing and Route Stability in Mobile Ad Hoc Networks base on AODV Protocol", 2010 International Conference on Electronic Devices, System and Applications(ICEDSA2010), 2010 IEEE, pp 258-263

[2]. Maysam Hedayati, Hamid reza hoseiny, Seyed Hossein Kamali, Reza Shakerian, " Traffic Load Estimation and Load Balancing in Multiple Routing Mobile Ad Hoc Networks", 2010 International Conference on Mechanical and Electrical Technology(ICMET 2010), 2010 IEEE, pp 117-121

[3]. Mohamed Tekaya,Nabil Tabbane, Sami Tabbane, " Multiple Routing Mechanism with Load Balancing in Ad Hoc Networks

[4]. Chai Keong Toh, Anh Ngoc, You Ze Cho, " Load Balanced Routing protocols for Ad Hoc Mobile Wireless Networks",IEEE Communications Magazine , August 2009, pp 78-84

[5]. Jiangtao Yin, Xudong Yang, " An Energy Efficient and Load Balanced Queue Scheduling Algorithm for Mobile Ad Hoc Networks", 2009 International Conference on Communication and Mobile Computing, 2009 IEEE, pp 121-126.

[6]. Zhang XiangBo, Ki Il Kim, " Load Aware Metric for Efficient Balancing on Multipath DSR Protocol in Mobile Ad Hoc Networks", 2008 International Conference on Advance Technologies for Communications, 2008 IEEE, pp 395-398

[7]. Amir Darehshoorzadeh , Nastooh Taheri Javan, Mehdi Dehgan, Mohammad Khalili, " A New Load Balancing Multipath Routing Algorithm for Mobile Ad Hoc Networks", Proceedings of IEEE 2008 6th National Conference on Telecommunications and IEEE 2008 2nd Malaysia Conference on Photonics, 26-27 August 2008, Putrayaja, Malaysia, pp 344-349

[8]. Haseeb Zafar, David Harle , Ivan Andonovic , Mahmood Ashraf," Shortest Multipath Source Routing for Mobile Ad Hoc Networks" 2007 IEEE international Conference on Signal Processing and Communications (ICSPC 2007), 24-27 November 2007, Dubai, United Arab Emirates, pp 97-100

[9]. Neeraj Nehra, R.B. Patel, V.K. Bhat, "Routing with Load Balancing in Ad Hoc Network: A Mobile Agent Approch", 6th IEEE/ACIS International Conference on Computer and Information Science (ICIS 2007), 2007 IEEE

[10].Aakanksha , Punam Bedi, " Load Balancing on Dynamic Network Using Mobile Process Groups", 15th International Conferences on Advance Computing and Communications, 2007 IEEE, pp 553-558.

[11].Shouyi YIN, Xiaokang LIN, "MALB: MANET Adaptive Load Balancing', 2004 IEEE, pp 2843-2847.

[12].http://www.farpost.net/glossary/load-balancing.php