Load Balancing in Mobile Ad Hoc Networks: A Survey

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ABSTRACT

Load balancing is a crucial problem in mobile ad hoc networks. Many conventional routing protocols that are developed are not having functionality of coping up load balancing. Hence several kinds of approaches are followed in the design and development of load balancing routing protocols. This paper aims to survey research articles pertaining to load balancing research problem in mobile ad hoc networks. Here various approaches are taken into account and literatures' key ideas are presented.

Keywords / Index Terms*:* Mobile Ad-Hoc Networks, Wireless Multihop Networks, Load Balancing, Survey

1. INTRODUCTION

Mobile ad hoc network is a type of wireless network which contains of mobile nodes having the capability to deploy anytime anywhere without or minimum infrastructure. The applications for mobile ad hoc networks are wide open such as disaster management, emergency operations, rescue operations and many more. One of the major application outcomes of mobile ad hoc network is vehicular ad hoc network. Some important characteristics of mobile ad hoc networks are dynamic topology, peer-to-peer fashion during data transfer, mobility of nodes and in real-time such networks are heterogeneous.

The nodes that are present in the mobile ad hoc network moves arbitrarily that leads to frequent topology changes. Due to this, data transfer suffers from channel loses and reliable transfer is becoming a challenging task. Hence several routing protocols are developed.

The protocols that are designed and developed for mobile ad hoc networks can be classified into three major divisions such as proactive or table-driven, reactive or on-demand and hybrid.

In proactive routing protocols the routes to all the destination nodes are determined at the start up, and maintained by using a periodic route update process. The proactive routing protocols are DSDV [68], WRP [64], GSR [49], FSR [55], STAR [54], DREAM [47], MMWN [62], CGSR [50], HSR [67], OLSR [58], TBRPF [48]. In reactive protocols, routes are determined when they are required by the source using a route discovery process. The reactive routing protocols are AODV [52], DSR [61], ROAM [70], LMR [51], TORA [66], ABR [72], SSA [53], LAR [63], RDMAR [46], ARA [56], FORP [71], CBRP [59]. Hybrid routing protocols combines the properties of the first two classes of protocols into one. Hybrid routing protocols are ZRP [57], ZHLS [60], SLURP [73], DST [69], DDR [65]. That is, they are both reactive and proactive in nature. Each group has a number of different routing strategies, which employ a flat or a hierarchical routing structure.

1.1 Problem Statement

Due to emerging application requirements and also for reliable data transfer, load balancing is one the key research areas in the field of mobile ad hoc networks. In mobile ad hoc network, job completion becomes complex, when huge load is given to the nodes with less processing capabilities and which do not have any means to share the load. The possibility of imbalance of load is due to that the computing/processing power of the systems is non-uniform. There are situations where few nodes maybe 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 keeps idle, the need for over-loaded nodes is objectionable. There are lots of routing approaches developed for load balancing in mobile ad hoc networks. In this research, we had done review of literatures which deals with several routing approaches to the load balancing problem.

2. LITERATURE SURVEY

The authors Yin and Lin propose a multi-path load-balancing mechanism named as MALB. MALB iteratively regulates the traffic rate on each discovered route. Regulating traffic rate is used to minimize the average end-to-end delay of the network [1]. A similar mechanism is proposed in [2] for multi-path source-routing protocols. In [3], Wu and Harms described a connection between two node-disjoint paths as the number of links between nodes on the separate paths. The results shown in [3] exhibit a hypothesis that as the correlation increases, the end-to-end delays along both numbers of routes increases. For decreasing the end-to-end delay a routing protocol that balances traffic across the least-correlated paths is proposed in [3].

In single-path approaches, however, only a path is established between a source–destination pair of nodes. Several uni-path load balancing mechanisms have been proposed, like different routing metrics as in [4], packet caching as in [5], directional antennas as in [6], etc. The authors Zhu and Hassanein [7] presented a novel routing protocol called LBAR. LBAR contains routing metric takes into account the degree of nodal activity, being the number of active paths through the node. In [8] Lee and Riley proposed that overloaded nodes would be given the freedom to forbid additional communications to set up through them unless their overloaded status is dissolved. Hence, each mobile node present in the ad hoc networks maintains a threshold value as a criterion for decision of whether or not to respond to RREQ messages. Some other papers provided a performance comparison between single-path and multi-path load-balancing approaches. In essence,

though multi-path approaches offers numerous advantages as increasing reliability and fault tolerance [9], it appears that single-path approaches are much more efficient when it comes to load-balancing.

In [9], Pearlman et al. demonstrated that multi-path routing mechanism is effective when the alternate paths are disjoint, which is not easy to achieve in mobile ad hoc networks [9,10]. In [12] the authors evaluated the performance of reactive shortest path and multi-path routing mechanism with load balance. Besides, Ganjali and Keshavarzian show that in any ad hoc network with a huge number of nodes multi- path routing can balance the load significantly better than single-path routing only if a very large number of paths is used between any source–destination pair of nodes, typically a 100 paths per node pair in a 500-node network [11]. The authors of [13] proposed load balancing algorithm which takes into consideration of several realistic parameters such as processing and battery powers of each node, and communication cost for the loads being transferred between the overloaded and under loaded nodes.

In the literature [14], Saigal et al. have presented a protocol called Load Aware Routing in Ad hoc (LARA) networks protocol. A new metric called traffic density is used in LARA in order to represent the degree of contention at the medium access control layer. At the time of route setup, the traffic density metric is used to select the route that has the minimum traffic load.

Pham and Perreau conducted a performance analysis [15]. The authors of [15] provided some insight into choosing the right trade-off between increased overheads and better performance. A novel end-to-end approach for achieving the dual goal of enhanced reliability under path failures, and multi-path load balancing in mobile ad hoc networks (MANETs) is proposed by Argyriou and Madisetti in [16]. The authors of [16] achieved their objective by fully exploiting the presence of multiple paths in mobile ad hoc networks in order to jointly attack the problems of frequent route failures and load balancing. In [17] Chakrabarti and Kulkarni modified the way to construct alternate routes that are maintained and used in DSR. In routing protocol proposed in [17] load balancing is done among the number of alternate routes. The approach in [17] also enabled to provide QoS guarantees by ensuring the appropriate bandwidth which is available for a flow even when nodes are under mobility. Souinli et.al [18] proposed load-balancing mechanisms that push the traffic further from the center of the network. They provided a novel routing metrics that take into account nodes degree of centrality, for both proactive and reactive routing protocols.

Pham et.al [19] proposed a wireless multi hop networks. The internet gateway (IGW) mechanism is used which provides Internet connectivity, linking the wireless network with the global Internet. However in order to take advantage of the capacity provided by multiple gateways, the routing protocol [19] utilized must efficiently load balance the traffic among available IGWs by which the network performance is optimized.

In [20] the authors Yoo et.al proposed a load balancing approach called Simple Load Balancing Approach (SLBA). SLBA can be transparently added to any current reactive routing protocol .SLBA [20] minimizes the traffic concentration by allowing each mobile node to drop RREQ or to give up packet forwarding depending on its own traffic load. In [21] Guodong et . al proposed a novel geographic routing algorithmic approach, named energy-efficiency and load-balanced geographic routing (ELGR). ELGR [21] is presented for lossy MANETs. ELGR combines energy efficiency and load balance to make routing decisions. First, a link estimation scheme for the PRR is presented that increases the network energy efficiency level. Second, a learning method is proposed to adaptively sense local network loads, allowing enhanced whole network load balance.

Khamayseh et.al [22] proposed a Mobility and Load aware Routing scheme (MLR) to reduce the effects of the broadcast problem. MLR controls the flooding process by restricting the rebroadcast messages on the slow speed and low loaded nodes. Each node decides whether to forward or drop the received request message based on several factors (such as speed and routing load) using Markovian Decision Process tool.

In [23] the authors Cheng et.al tried to formulate the dynamic load balanced clustering problem (DLBCP) into a dynamic optimization problem. They proposed to use a series of dynamic genetic algorithms (GAs) to solve the DLBCP in MANETs. In this dynamic GAs, each individual represents a feasible clustering structure and its fitness is evaluated based on the load balance metric.

Meri et.al [24] developed a table-driven/proactive routing protocol that is capable to balance the local node's load. They [24] introduced the notion of proactive routing: after a short pre-processing phases in which nodes build their routing tables by exchanging messages with neighbors which require that nodes decide the relay of each message without any further interaction with other nodes.

The authors of [25] proposed multipath routing protocol with load balancing provides a solution for the congestion network and increases its capacity. To consider that the use of multiple paths simultaneously for transmission data allows improving the network performance, they proposed a new protocol LB-AOMDV (Load Balancing-AOMDV), a solution to achieve better load balancing mechanism is proposed. In [26] proposed protocol (AODV-Multipath) preserves the higher hop count routes in the routing table and utilizes it as alternate path as link failure occurs. AOMDV does not provide any means to avoid congestion and load balancing in the network. Queue Length detects congestion in the network. Queue Length and Hop Count value are together used to select a route from source to destination that avoids congestion and load balancing. When Queue length crosses a certain threshold value then Load balancing via alternate paths is carried out. The proposed protocol in [26] avoids congestion, balance the load and to an extent avoid link failure.

In [27] the authors proposed a load balancing mechanism called multipath adaptive load balancing (MALB). To distribute the traffic among multiple paths dynamically, based on measurement of path statistics, and to use network resources better, the congestion and end-to-end delay are minimized. MALB [27] is a common framework and can be embedded with any multipath source routing protocol.

In [28] the authors proposed an Alternate path routing (APR) that is capable enough to provide load balancing and route failure protection by distributing traffic among a set of diverse paths, APR appear to be an ideal candidate for the bandwidth limited and mobile ad-hoc networks. In multiple channel mobile ad hoc networks, coupling occurs when paths share common intermediate nodes.

In [29] proposed an approach by finding multiple routing backbones from source mobile node to destination mobile node via intermediate nodes that have better communication and processing capabilities to take part in the mobile routing backbones and efficiently participate in the routing process. In addition to enhanced load balancing, the approach [29] also provides better Quality of Service (QoS) support and congestion control according to current network traffic levels and nodes' processing loads. The authors of [30] proposed a multipath routing protocol which uses all discovered paths simultaneously for transmitting data. By their approach [30], data packets are balanced over discovered paths and energy consumption is distributed across many nodes through network.

In [31] the authors proposed a congestion adaptive multipath routing protocol for increasing the throughput and avoid congestion in MANETs. In this approach [31] the average load of an existing link increases beyond a defined threshold and the available bandwidth and residual battery energy decreases below a defined threshold, traffic is distributed over fail-safe multiple routes to reduce the traffic load on a congested link.

In [32] the authors proposed a multipath DSR with load-aware and load-balancing approaches, which monitor the current and future congestion status of active routes and distribute the data on each path evenly. The authors of [33] proposed an approach Multipath Load Balancing and Rate Based Congestion Control (MLBRBCC) based on rate control mechanism for avoiding congestion in network communication flows. The proposed approach [33] contains an adaptive rate control based technique in which the destination node copies the estimated rate from the intermediate nodes and the feedback is forwarded to the sender through an acknowledgement packet. Since the sending rate is adjusted based on the estimated rate, this technique is better than the traditional congestion control technique.

In [34] the authors proposed a scheme to distribute load between multiple paths according to the congestion status of the path. The authors of [35] proposed a routing scheme which balances the load over the network by selecting a path based on its mean load-square, the proposed routing metric can reflect not only the load of the path, but also the load distribution along the path. In [36] the authors proposed a distributed shadow-price-based approach to dynamic load balancing in wireless data networks. In the scheme [36], examine two related problem versions: (i) minimizing a convex function of the transmitter loads for given user throughput requirements; and (ii) maximizing a concave function of the user throughputs subject to constraints on the transmitter loads. In [37] the protocol uses forward nodes to apply QoS multicast routing from source(s) to a group of destinations and support load balancing. The authors of [38] proposed a new routing protocol which uses the load balancing and multi-path solution to send data with a probabilistic dispersion. The total load on a route is evaluated based on the relay node's queue size.

In [39] an adaptive load balancing scheme in ad hoc networks is proposed. The scheme [39] can be applied in most on-demand routing protocols resulting in significant performance improvement. The scheme [39] is applied to the ad hoc on-demand distance vector (AODV) routing protocol.

In [40] the authors proposed a load balancing approach called Simple Load-balancing Approach (SLA), which resolves the traffic concentration problem by allowing each node to drop RREQ or to give up packet forwarding depending on its own traffic load. In [41] proposed a new load balance mechanism and a novel bandwidth estimation method for ad hoc on-demand routing protocols is presented. The destination mobile node chooses the optimal path via the route information carried by RREQ, whilst congested intermediate nodes dropped RREQs to avoid RREQ storm.

In [42] the routing scheme named FDAR (Free-Degree Adaptive Routing), it is intended to deliver data packets circumventing congested routes, and to realize a short end-to-end delay and a moderate load balancing of the overall network is proposed.

In [43] the authors proposed a Type of Service and Load Aware routing protocol (TSLA), an enhancement to AODV which uses both the traffic load and the type of service as additional metrics. TSLA [43] is the first to avoid congestion by distributing the load over a potentially greater area and conducting the traffic through less busy nodes and, therefore, less congested routes. The authors of [44] have proposed an efficient routing protocol known as PCRM (Packet Count based Routing Mechanism) .PCRM [44] finds the least used path for sending data packets rather than selecting minimum hop count as in DSR.

Suggested a dynamic cache monitoring scheme and suppress RREP on heavily congested node to achieve load balancing and also defined appropriate queue threshold values and parameters for congestion resolution and proposed a solution for RREP storm problem which is another side effect of the route cache is proposed in [45].

3. FINDINGS

Several literatures are reviewed and this section gives the gist of the findings. Major research works are carried out by approaching the load balancing problem through congestion estimation and traffic control. Some of the approaches using energy and power metrics for making routing decision for load balancing. Also clustering based approaches exists. Very few literatures used queue size, hop count and bandwidth metrics for load balancing in mobile ad hoc networks.

4. CONCLUSIONS

Load balancing is one of the key areas pertaining to research in the field of mobile ad hoc networks. This paper presented various load balancing approaches and researches in design and development of routing protocols for mobile ad hoc networks. The conventional routing protocols are not dealt much since several papers has been published through surveys and performance analysis. The findings of the survey are also presented.

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