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Load Balancing in MANETS: A Review

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Abstract— Mobile ad hoc networks (MANETs) can be arranged in various situations but the presence of variable degree of resources, movement of nodes and the lack of load-balancing competences in MANETs (Mobile Ad Hoc Networks) poses a large challenge for such networks to scale. Load imbalance is one of the critical issues in these networks and network performance can be reached by fairly allocating load among nodes within the network. In the given paper, special devotion has been given to the load balancing and congestion control in network. The various load-balancing schemes are discussed gives an ability to improve congestion by distribution of traffic of excessive load and to support better performance, taking different parameters into consideration.

Keywords— Load Balancing, Clustering, Efficient Routing, Congestion, MANETs

I. INTRODUCTION

Ad hoc networks have gained more attention these last decades, with the explosion of mobile processing stages and small sized wireless tools. MANETs hold the promise of future, with the ability to launch networks at anytime, anywhere without assistance of any central authority. All the nodes are mobile but possess their own set of capabilities including their communication and computation power, energy resources etc, thus offer heterogeneity among nodes. Thus, a mobile ad hoc network (MANET) can be defined as an autonomous distributed system where node communicates over moderately bandwidth-constrained wireless links with other nodes which resides within its transmission range. Multi-hoping improves the problem of limited radio spread range and thus is an imperative feature of mobile networks. Limited security, dynamic topology, variable rate and limited bandwidth of connections and power consumption are some of the new limits imposed by ad hoc networks. Packet transmissions suffer from interference and fading due to the shared wireless channel and dynamic topology. As the demands for the support of multimedia communication has been increasing recently, bandwidth intensive, large amount of real time traffic tends to be in bursts and is liable to congestion [1].

II. LOAD BALANCING AND MANETS

MANETs enable one or more mobile units to communicate with each other without the survival of physical connection and any established infrastructure. All nodes have to make decisions jointly. In such environments imbalance of load over the nodes can occur. The competences of a MANET node is a function of its resources, battery power etc. A powerful node finishes its allotted jobs quickly and becomes idle before a less powerful node, allotted with extra work load or engaged most of the time, consuming more energy. The flow of data between the source and the destination nodes could be speed up if its efficiency split on multiple paths between them. Load balancing is surely one of the solutions for refining the efficiency of the applications and the life of the network nodes i.e. network lifetime. The significance of an efficient load balancing technique is to minimize the difference between the overloaded and underloaded nodes in terms of their workload by keeping other parameters in consideration. As these parameters changes time to time using different parameters, the process of balancing the network becomes more complicated [2]. Imbalance of load in mobile networks results in packet dropping, end to end delay, inefficiency and imbalanced energy consumption. MANET has a dynamic network topology, and constraint resources, such as bandwidth, buffer space, battery and transmission power and so on. Distributing traffic fairly among the mobile hosts, based on measurement of path statistics, is beneficial in order to take full advantage of the limited resources and to use network resources better so that the congestion and end-to-end delay are minimized. Load balancing schemes allocate the network loads, which can prevent network from getting into the state of congestion, and avoid the resources of congested node to be drained. The routing algorithms in MANET that choose the shortest route to build up the communication path may incur traffic imbalanced problems in the network. During data communication the interference between two or more multiple paths located physically close enough to interfere with each other, refers to route coupling [3].

III. PURPOSE OF LOAD-BALANCING SCHEMES AND CLASSIFICATION OF LOAD-BALANCING PROTOCOLS

The overall purpose of various load-balancing schemes is to:

- Select non-congested paths or to disseminate excessive load
- of a node to its neighbors

- Balances energy consumption of the network
- Ensure efficiency and robustness
- Reduce end to end delay and number of packet lost by queue overflow
- Enhance the utilization of resources (buffer, radio channel)
- Improve the overall network performance and reduce collision by load distribution.

IV. LOAD BALANCE SCHEMES: A SOLUTION FOR IMPROVING THE NETWORK PERFORMANCE

The two parameters which can be used to balance the load in clusters by allotting the role of clusterhead among normal nodes are Node ID and Node Degree. These different methods assign the responsibility of being a cluster head among different nodes in the cluster thus distributes the load so as to avoid the demise of overloaded nodes. Node ID load balancing heuristic operates on the principal of a circular queue as the virtual IDs of the member nodes cycles through the circular queue at a rate of 1 unit per run. The mobile nature of the node causes the node to move often, results in unpredictable cluster head changes, where node can be detached from a cluster and induces re-affiliations. Thus, as an enhancement to the above schemes, we may consider another parameter i.e. mobility value of a node for the selection of clusterhead, which can be determined by computing the speed average of a mobile node or through random way point model. This removes the need of insignificant updates [5]. [13] Used the routing capability of the ant system paradigm to good effect in the problem of dynamic routing of micro-cellular systems. Their approach was computationally quick and reliable in terms of how close to optimal a given replication is likely to be. With the use of three test problems from the literature, they produced decidedly better results.

A. Distributed Load Balancing Scheme

This approach of balancing of load is employed with each node collects the information about the present load of other nodes by a query messaging which repeat itself and then computes the average system load, μ.

Where, $\mu = \frac{1}{N}\sum_{v \in V} lv$

Load at a node v is denoted by lv and N is the no. of nodes. A node is said to be underloaded if the load at the node is less than the average system load, overloaded otherwise. Then it starts screening its immediate (1-hop) neighbors to distribute the load. As an improvement to this method, to describe whether the node is heavily weighted or lightly weighted, a threshold upon the node's queue can be applied; this can be resolute by calculating the average system load. Thus, this approach will not lead to regular exchange of query messages. It is not desirable to share a small amount of load with a node that is quite a few hops away. Average system load changes often due to the dynamic environment. Thus, μ varies rapidly, which increases the rate of query message exchange among the mobile nodes. Nodes compute the average load after a given interval of time and set their thresholds for queues [1].

B. Balancing in Clusters

The two parameters which can be used to balance the load in clusters by allotting the role of cluster head among normal nodes are Node ID and Node Degree. These different approaches assign the duty of being a cluster head among different nodes in the cluster thus dispenses the load so as to avoid the passing of overloaded nodes. Node ID load balancing empirical operates on the principal of a circular queue as the virtual IDs of the member nodes cycles through the round queue at a rate of 1 unit per run. The minimum value of 1 and a maximum value of MAX_VAL are assigned to the round queue. Once a node is elected as a head, its VID is sponsored to a value larger than MAX_VAL. A cluster head will maintain this value until it has exhausted its cluster head duration, which is a user defined constraint and meet the exclusive characteristics of the system. Degree based heuristic elects cluster head with a different policy than Max-Min heuristics. The node degree heuristic monitors the change in the degree of an elected cluster head from the time it is elected a cluster head. If the amount of change outstrips an input value MAX_CHANGE, then the cluster head will be downgraded as a normal node. One of the basics for these schemes to work efficiently is to handle well with elastic topology [7]. A new clustering strategy to perform topology management and energy conservation was proposed in [11]. The performance comparison was made between the original algorithms and two new algorithms, which were namely an improved weighting clustering algorithm and a novel Genetic Annealing based Clustering Algorithm (GACA), in the aspects of average cluster number, topology stability, load-balancing and network lifetime. The experimental results showed that their clustering algorithms have a better performance on average.

C. An approach based on Clustering

The point of this method is to find the most appropriate nodes to share the load for avoiding, or at least falling imbalances with a minimum or engendered overhead. The algorithm is begged each time that the imbalance occurs by respecting a load threshold. The parameter for performance assessment is in terms of work implementation time and node's energy consumption. A node with high energy and low mobility will be selected as the cluster head. Mobility is the measure of a node's speed average. The load balancing algorithm here is a central algorithm since the global members load information of each cluster is collected by their cluster heads, which confirms load balance between its member nodes. The cluster creation begins with finding the neighbors of each node where the distance between a node and its neighbor will be less than or equals to the transmission range of the particular node. Select the node which has the lowest value of mobility and the larger value of battery power as a cluster head and designate all its neighbors as its members. After reaching a minimum threshold of energy, cluster head again invokes the election procedure.

D. Ant-Based Load Balancing Scheme

This scheme uses an ant-based algorithm for efficient data transfer in the network. The basic idea of Ant Colony Optimization (ACO) meta-heuristic generated from the food searching behavior of real ants. Ant agents can be separated as Forward Ant (FANTs) and Backward Ant (BANTs). BANTs use the useful information collected by FANTs on their trip time from source to destination [9]. Stack is the memory area in which data gathered by FANTs is stored. Stack pointer keeps track of no. of visited nodes. The field Fwd is a 1 bit field and set to 1 when ant is FANT and 0 for BANT. The congestion update message as an improvement detects the load imbalance at a node and is send by the destination to the source after receiving a data packet. The message notifies the source of the congestion at that route. The value will be set to 1 if the route is overloaded, for an underloaded route value will be -1 and 0 as a normal value. The pheromone value will be reduced with a assured value if the path is overloaded; on the contrary it is increased if it is underloaded. For a normal/balanced route the pheromone will vanish as per the vanishing equation. Thus the congestion on a certain path can be avoided if multiple paths are followed with equal probability. This approach does not offer ideal paths to the destination but avoids congestion and reduces the chances of load imbalance by distributing traffic [3].

E. Multi-agent Load Balancing Scheme

The proposed algorithm Multi-agent load balanced ACO (MALBACO) presents a new routing technique having two colonies of ants. Initially the ants are initialized as arrays [000….0] and [111….1]. A LOCK array is used to check the available links and initialized as [000…….0]. A HELLO message is sent by the source node after every fixed time interval. A cost table is maintained which consists of the cost of reaching nodes in the next hop. Cost is measured in terms of the time required for sending the HELLO message and receiving an ACK message. LOCK[m][n] is used for congestion control in the system. If LOCK[i][j]=1 means lock is acquired and the path from i to j has pheromone value which has exceeded the Maxpheromone value. The value maxphr(t) is equals to the sum of the maximum red pheromone and the maximum blue pheromone value at that path. The pheromone updating and evaporation on a path between nodes depends on the cost of data transmission through that path. Initially it is estimated by sending a HELLO message and corresponding ACK message and measuring the time delay between the sending and receiving of these messages. After the selection of the route to forward data across it, the cost table will be updated according to the cost information in the data packet and the acknowledgement of the data packet. This prevents the need of periodically sending HELLO and ACK messages [4].

F. Energy –Aware Clustering Algorithm

This algorithm takes four factors into consideration for making the selection of cluster head and maintenance of cluster more reasonable. These are node degree difference, distance summation to its neighboring nodes, battery power and velocity of node. Here, nodes having neighbor number greater than a fixed threshold will be given a chance to select as a clusterhead. If Ni is the practical degree of a node i and M is the maximum degree, then $\Delta i = |Ni - M|$. Smaller values of Δi are preferred [8].

G. Load-Balancing Scheme for supporting QoS in MANETs

Whenever the offered traffic load exceeds the available capacity in a network, can leads to the problem of congestion and causes overall channel quality to degrade and increases packet loss rates. In the load-balancing algorithm given below, the messages used are: QUEUE_INFO, REPLY and INFORM. When a node receives data packet, it broadcasts a

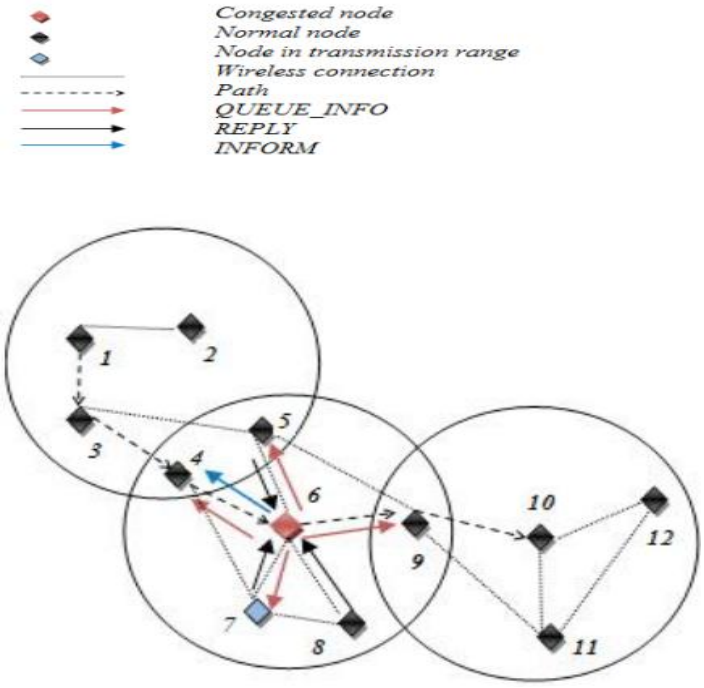

Fig.1: Exchange of messages when congestion occurs.

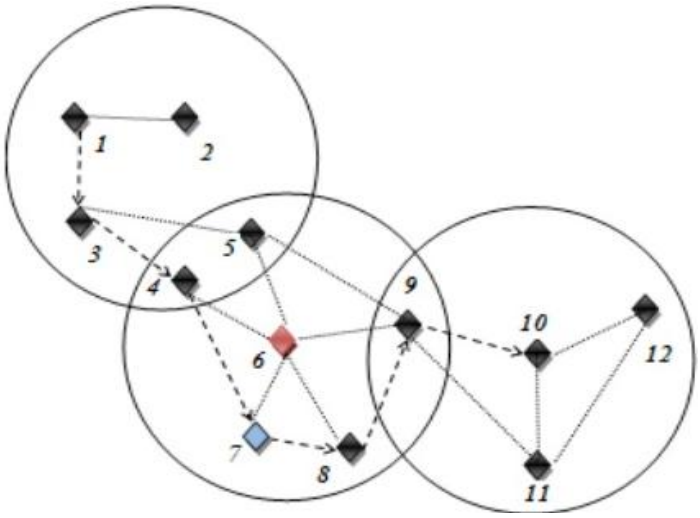

Fig. 2: Route through less congested node.

QUEUE_INFO message to its neighbors if this node is congested, node 6 here (in fig.1). All its neighbor nodes, after receiving the message send a REPLY message only if they have the available buffer space. The congested node chooses the one within the transmission range of the sender node, and having least load among all, node 7 (in fig.1) and preserve the rest of the information for further assistance for a particular time period and send INFORM message to the sender node, 4 to inform the address of the selected node, node 7. The new route will be constructed, excluding the congested node as shown in fig.2 [6].The authors of [10] 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 [12] the protocol uses forward nodes to apply QoS multicast routing from source(s) to a group of destinations and support load balancing.

V. CONCLUSION

In this paper, we described various efficient and improved load-balancing mechanisms for mobile ad hoc networks. The basic goal is to attain a balanced network to achieve better performance in terms of the processing time of the loads, nodes' stability, throughput and lifetime of the network. Load-balancing is an essential solution to improve the execution time of tasks and better management of energy by eliminating or at least reducing load imbalances. This paper also presented some of the load-balancing schemes which perform fairly well in controlling congestion and efficient optimization techniques used to find the optimum route in the ad hoc network. The central idea is to exhibit better performance in both static and dynamic situations.

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