LOAD BALANCING AND EFFICIENT CLUSTERING FOR IMPROVING NETWORK PERFORMANCE IN AD-HOC NETWORKS

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ABSTRACT

Information gathering is a fast emergent and challenging field in today's world of computing. Sensors are tiny devices that are capable of gathering physical information like heat, light or motion of an object or environment. Sensors are deployed in an ad-hoc manner in an area of interest to monitor events and gather data about the environment. Sensors in such systems are typically disposable and expected to last until their energy drains. Therefore, energy is a very scarce resource and has to be managed wisely in order to extend the life of the sensors in order to provide dependable operation for the duration of a particular task. Mobile ad-hoc networks consist of freely moving nodes which are responsible of not only forwarding packets for other nodes but can also perform extensive computations. One of the most critical issues in these networks is the significant differences in term of processing and energy capacity between the nodes, inducing a load imbalance. Thus, sharing the load between the overloaded and idle nodes is a necessity in ad hoc networks. In this paper, we present a new load balancing algorithm based on clustering where a subset of nodes 'cluster heads' is elected to maintain some balance within their respective clusters while minimizing the overall communication cost. Our primary goal is to minimize the total execution time of the tasks by distributing the work load among nodes. Another goal is to extend the overloaded nodes lifetime inducing a stability of the network. The simulation results have shown that network performance can be reached by distributing load to idle nodes within the network.

***Keywords:** Ad-hoc network, Cluster head selection, Clustering, Load balancing, MANET*

I. INTRODUCTION

Ad hoc is Latin meaning "for this purpose." Ad hoc networks therefore refer to networks created for a particular purpose. They are often created on-the-fly and for one-time or temporary use. Often, ad hoc networks are comprised of a group of workstations or other wireless devices which communicate directly with each other to exchange information. An ad-hoc network is one where there are no access points passing information between participants. In Fig.1, Infrastructure networks pass information through a central information hub which can be

a hardware device or software on a computer. Office networks, for example, generally use a server to which company workstations connect to receive their information. Ad hoc networks, on the other hand, do not go through a central information hub.

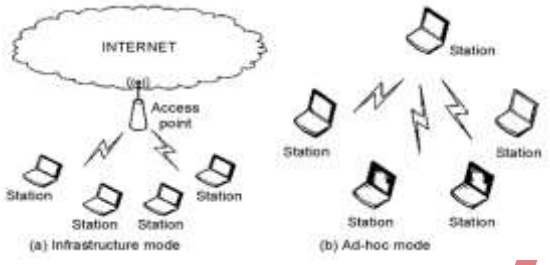

Fig.1: Infrastructure node and Ad-hoc network

An ad hoc network is defined as "an autonomous system of routers connected by wireless links the union of which forms an arbitrary graph. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet operating as a hybrid fixed/ad hoc network." The areas of application range from school classes over well-known services like chat rooms to online shopping, but they are also used in places that do not come to mind immediately, like in the military. Furthermore, it is not even necessary to have a human interaction factor: ad-hoc networks can also be used to link together research computers or moving vehicles that exchange information "on the road".

II. AD-HOC NETWORK

Mobile Ad-Hoc Networks are wireless networks which do not require any infrastructure support for transferring data packet between two nodes. In these networks, nodes also work as a router that is they also route packet for other nodes. Nodes are free to move, independent of each other, topology of such networks keep on changing dynamically which makes routing much difficult. Therefore routing is one of the most concern areas in these networks. Normal routing protocol which works well in fixed networks does not show same performance in Mobile Ad Hoc Networks. In these networks routing protocols should be more dynamic so that they quickly respond to topological changes.

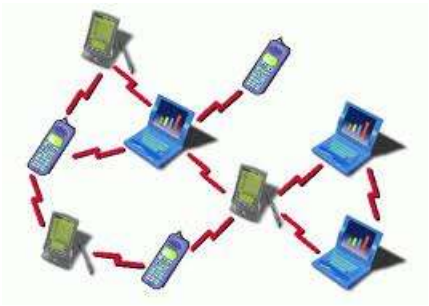

Fig.2: MANET

Mobile Ad hoc Network (MANET) is a collection of independent mobile nodes that can communicate to each other via radio waves is shown in Fig.2.The mobile nodes that are in radio range of each other can directly communicate, whereas others need the aid of intermediate nodes to route their packets. These networks are fully distributed, and can work at any place without the help of any infrastructure. This property makes these networks highly exile and robust.

The characteristics of these networks are summarized as follows:

- Communication via wireless
- Nodes can perform the roles of both hosts and routers.
- No centralized controller and infrastructure.
- Frequent routing updates.
- Autonomous, no infrastructure needed.
- Can be set up anywhere.
- Energy constraints

Despite the innumerable applications of Ad-Hoc Networks, these networks have several restrictions, e.g., limited energy supply, limited computing power, and limited bandwidth of the wireless links connecting sensor nodes. One of the main design goals of Ad-Hoc Networks is to carry out data communication while trying to prolong the lifetime of the network and prevent connectivity degradation by employing aggressive energy management techniques. The design of routing protocols in Ad-Hoc Networks is influenced by many challenging factors. These factors must be overcome before efficient communication can be achieved in Ad-Hoc Networks.

III. RELATED WORK

This section briefly outlines the related works taken in the area of Ad-Hoc networks challenges and issues. MANET's enable one or more mobile units to communicate with each other which can be done without using any physical connection. In such cases, load imbalance occurs in MANET nodes. This will cause packet dropping, end-to-end delay, energy consumption, etc. Load balancing improves the execution of tasks and better energy management. Many load balancing algorithms are used to improve the efficiency of the network. Two parameters such as Node ID and Node degree are used to balance the nodes in cluster with the help of cluster heads [1]. Many conventional routing algorithms are not supported with load balancing. So some kinds of load balancing algorithms are used [2].

The execution time improvement, energy, impact of mobility on energy, balance factor, communication cost threshold value are other important factors which are to be considered in case of Mobile Ad-hoc networks [3]. By this, the load is distributed among the idle nodes and overloaded nodes lifetime is extended by inducing the stability of the network. If the size of the network is large, then scalability issues can be increased which can increase the single-point bottleneck failures. So weight-based cluster head election strategy can be used [4]. Routing and scheduling of packets should be efficient to reduce the congestion [5]. Clustering should also be efficient to improve the network lifetime. Based on the residual energy, cluster head is elected. The cluster

members are selected without considering the length of the base station [6]. Energy-efficient multi-hop hierarchical routing algorithm is used to improve the lifetime of the network [7].

IV. PROPOSED SYSTEM

In an ad-hoc network, with a decentralized and heterogeneous structure, some nodes may have different capabilities of processing and batteries, imbalances of load can occur. Indeed, a more powerful node in term of processing capacity can become idle, because it has finished its work quickly while the others, less powerful, are occupied most of the time, consuming more energy. Powerful nodes capacity can be exploited by overloaded nodes if a fraction of their load is shared with them. If the difference between the heaviest loaded and the lightest loaded nodes is minimized, the average work execution time can be reduced, the energy of the nodes will be better exploited and the nodes lifetime can be extended. It is what contributes to the stability of the network topology that plays a principal role in different problems like: routing, scheduling, resource reservation etc. Load balancing is certainly one of the solutions for increasing the efficiency of applications and the network life time.

Load Balancing algorithms are designed essentially to distribute equally the load on nodes and maximize their utilization while minimizing the total task execution time. This issue has been of considerable interest in the network research community when it comes to wired and wireless networks. It aims to guarantee that no node is under loaded or overloaded. It looks at setting up a uniform load on all nodes. Then, it is expanded in order to take into account new environments and new applications (large scale applications, multimedia applications, etc.). Compared to the wired networks, the mobile environments introduce new highly variable parameters such as limited resources, wireless link communication and mobility.

V. MODULE DESCRIPTION

CLUSTER FORMATION

In our work, a cluster head is elected for its relatively high energy capacity and its low mobility. Energy is a critical resource in ad-hoc networks. A cluster head consumes more energy than an ordinary node since it has other functionalities: coordination between its members, cluster maintenance and load balancing. Mobility is also an important factor for a cluster head election. Indeed, to avoid frequent cluster head changes, it is important to choose the one that has a low mobility. If the cluster head moves quickly, the nodes can be detached from it, inducing re-affiliations which cause significant updated information exchanges.

CLUSTER FORMATION PROCEDURE

1. Find the neighbors of each node i (nodes within its transmission range). They are defined as follows: $V(i) = \{i\_ \; ! = i / dist(i, i\_) \leq txrange\}$ where *txrange* is the transmission range of node i.
2. Compute the speed average for every node. This gives a measure of its mobility.
3. Compute the battery power for each node
4. Choose the node which has the smallest value of mobility and the highest value of battery power as clustered. All its neighbors are designated as its members and they can no longer participate in the election procedure.

5. Repeat steps 2-4 for the remaining nodes not yet assigned to any cluster.

The following characteristics are considered in the cluster head election procedure:

- The nodes mobility causes changes in the network topology. If at a given time a node is detached from its current cluster and is attached to another, the corresponding cluster heads will update their members' tables.
- If a node leaves its cluster and doesn't find any other cluster to attach itself, the cluster heads election procedure is invoked.
- A cluster head keeps the information concerning its members (identifier ID, status, load, energy). It can detect if another cluster head is entered in its cluster. In these cases, one of them is constrained to give up its cluster head's role. In our case, it is the one which has less energy.
- Because of the additional functionalities for which the cluster head is intended, its energy is likely to be exhausted. A minimum threshold of energy is defined for each cluster head. If it is reached, the cluster heads election procedure is invoked.

When the network is set up, each node diffuses its identifier (ID) through a HELLO message which is recorded by all the other nodes in its transmission range. Once the neighbors list of each node is ready, the clustering procedure is executed. Each node maintains a record of its status: (cluster head or member). If it is not a cluster head, it must know the cluster head to which it is affiliated (CID: Cluster head Id).

Considering the dynamic nature of the system, the nodes and the cluster heads tend to move in various directions, causing a disorganization of the network configuration. The system must be updated from time to time. The updates are made in two cases:

- When renewing cluster formation.
- When a node changes its affiliation from one cluster head to a new one, in the existing cluster heads set; in this case, we speak about re-affiliation.

If a cluster head doesn't receive any message from a node, it updates its members list. When a node is attached to another cluster head, it updates its CID and the corresponding cluster head updates its members list. When the cluster head doesn't receive any more messages of a node, it updates its members list. It is important to note that, in this work, we make some assumptions. The number of nodes per cluster is limited to avoid the cluster head congestion and for better resources utilization .In all the analyses carried out on the proposed algorithm, we assumed that all nodes are cooperative and trusted. Considering these conditions allowed us to study only the characteristics specific to the proposed algorithm.

LOAD BALANCING ALGORITHM AT THE LEVEL OF EACH CLUSTER

As mentioned previously, a principal role of a cluster head is the maintenance of load balancing in each cluster. It is the principal coordinator of its cluster; it collects periodically information about each member node of its cluster, such as energy and load values. These data are collected in the members table. When a node reaches an overloaded or low energy state, a discharge message will be transmitted to its cluster head. The latter consults its members table and chooses the one which has the smallest load and the highest energy capacity. Then it sends a response to the concerned node.

Whenever a new node joins a cluster, or an existing node exits it, the members table is updated. The bases of our load balancing algorithm are as follows:

- Cluster head nodes maintain their member's tables in order to control their member's loads. Periodically, each node, member of a cluster, sends a HELLO message and communicates its energy and load values to the cluster head which updates its table.
- Two thresholds are defined for each node: the maximum load that a node is able to carry out and the minimum energy. When this is reached, the node knows that it is going to die soon, so it decides to transfer its load to another node.
- Periodically, each node checks its load and its energy and compares them with the two thresholds. Two cases are considered:

First case: the two thresholds are not reached, in this case nothing happens and the load balancing algorithm is not invoked.

Second case: if one of the two thresholds is reached (possibly both of them), the node sends a message (DR. Discharge Request) to its cluster head. This one consults its members table; it chooses the one which has the smallest load and the highest energy capacity.

- If one node is found, the cluster head sends a positive response (message RESPONSE) to that node indicating the address of the new node that will receive the extra load.
- If several nodes are found, it chooses one arbitrarily.
- If no node is found, the cluster head diffuses a solicitation message to its different neighbors cluster heads. If it is positive, a receiving node is designated and a quantity of work is transferred to it. If the response is negative, the node is constrained to execute the work locally.

VI. RESULT ANALYSIS

In this paper, we have implemented load balancing algorithm with efficient cluster head formation for ad-hoc networks. The implementations are carried out in NS-2.

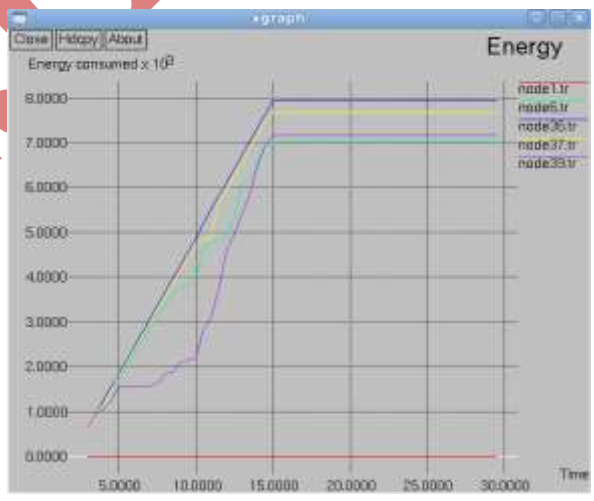

Fig. 3: Energy level graph

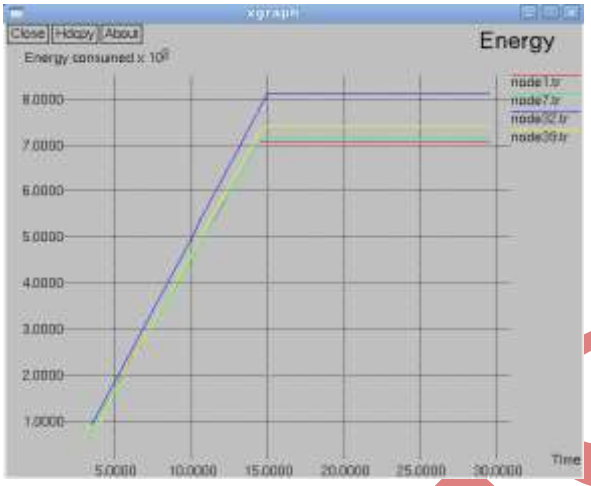

Fig. 4: Energy level graph

The energy level graph for the existing system is shown in the fig.3. The energy level graph for the proposed system is shown in the fig.4. Here we are taking node 1 and node 39 as common and this explains the improvement in energy efficiency which increases the life-time of the ad-hoc network.

VII. CONCLUSION

Load balancing is an important solution to improve the execution time of tasks and better management of the energy by reducing load imbalances in ad hoc networks. In order to take into account the limitations of these networks in terms of bandwidth and energy, clustering techniques have been suggested. In this paper, we have presented a new load balancing algorithm based on clustering where a subset of nodes 'clusterheads' is elected to coordinate their respective clusters.

The simulation results show a significant improvement of execution time (30%) and a good energy management for a great number of nodes and big sizes of work. This work is principally based on the clustering. We plan to use various clustering algorithms presented in the literature. The presented algorithm has implicitly assumed that all nodes are cooperative. In future, Cluster head selection can be more effective by choosing inner nodes of the cluster as cluster head to improve the network efficiency. If the border node of the cluster is chosen as cluster head then the data gathering in the border areas will be affected.

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