A New Scheme for Computation of Cluster-Head in MANET

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Abstract— A mobile ad hoc network is a collection of wireless nodes that can dynamically be set up anywhere and anytime without using any pre-existing network infrastructure. Several algorithms like Lowest ID, Least Cluster-head Change, Highest in-degree, Weighted Clustering Algorithm, IWCA, neural network based etc. have been projected for collecting of nodes. They do not examine the combined effect of parameters like battery power, neighbours of node and mobility on cluster establishment. Although these features can be measured as contributions to a neural network, training the network and selecting the training algorithm is a computationally intensive hence time consuming step. In this research we address this issue by calculating computing a computationally un-intensive factor for deciding cluster-heads. This factor works in any environment and takes into account environmental changes, hence proving useful when nodes are added or subtracted dynamically from the ad-hoc network. This factor calculation could easily be built into software and can be deployed for cluster-head calculation in any ad-hoc environment with no underlying assumptions. Since we need fast calculations when the clusters change in the ad-hoc environment, coming up with a deciding factor which we can calculate fast and efficiently prevent connection breaks, dropped packets, and routing anomalies.

Keywords— Lowest ID, Least Cluster-head Change, Highest Degree, IWCA, neural network.

I. Introduction

With the exponential increase in the number of computing devices like mobile computers, net-books, PDA's, tablets, cellular phones and the increase in the need for connectivity at all times has magnified the importance of ad-hoc networks. Ad-hoc networks are short range networks which supposedly work without the presence of any central controller, access point or router, and provide connectivity through either single hops or multi-hops[1][2]. Example of ad-hoc networks is Bluetooth, infra-red connections, and other short distance communication. The big advantage of ad-hoc networks is that it operates without any extra circuitry other than the transmitting and receiving circuits. Although access points are also used in ad-hoc networks but such topologies can be considered as hybrid ad-hoc networks and not pure ones [7]. Initial clustering creates the clusters in the ad hoc network at a time when the wireless capable nodes are discovering each other and the cluster management algorithm maintains the clustered architecture by continually adapting to the changing network topology.

A. Terms

1. *Cluster* - It refers to a collection of nodes, grouped for the functioning of the networks
2. *Master* - Every cluster is characterized by a unique node called its master. It has certain extra responsibilities.
3. *Bridge* - Bridge is a node which belongs to more than one cluster .It thus has more than one master.
4. *Slave* - All the cluster nodes other than bridges and master are called slaves. Each slave has only one master. And hence belongs to only one cluster.
5. *State* - A node's state describes whether the node is a slave, bridge, master or none (none means the node is uninitialized, i.e. it does not belong to any cluster).We will also refer to a node as slave, if its state is slave (similarly for bridge, master, none).

In clustered network architecture, the whole network is divided into self-managed groups of nodes called clusters. All the nodes inside a cluster are at maximum two hops away from each other. These clusters continually adapt themselves to the changing network topology and new cluster configurations that are feasible with the current network topology, are created dynamically. Master (or Cluster head) is the node which is only one hop away from all the other nodes in the cluster, and brings positive additional tasks.

B. MANET Concept

A mobile ad hoc network is a collection of wireless nodes that can dynamically be set up anywhere and anytime without using any pre-existing network infrastructure. It is an autonomous system in which mobile hosts connected by wireless links are free to move randomly and often act as routers at the same time. The traffic types in ad hoc networks are quite different from those in an infrastructure wireless network [3], including:

- *Peer-to-Peer*. Communication between two nodes which are within one hop. Network traffic (Bps) is usually consistent.
- *Remote-to-Remote*. Communication between two nodes beyond a single hop but which maintain a stable route between them. This may be the result of several nodes staying within communication range of each other in a single area or possibly moving as a group. The traffic is similar to standard network traffic.
- *Dynamic Traffic*. This occurs when nodes are dynamic and moving around. Routes must be reconstructed. This results in a poor connectivity and network activity in short bursts.

C. MANET Features

MANET has the following features [3]:

- *Autonomous terminal*. In MANET, each mobile terminal is an autonomous node, which may function as both a host and a router. In other words, besides the basic processing ability as a host, the mobile nodes can also perform switching functions as a router. So usually endpoints and switches are indistinguishable in MANET.
- *Distributed operation*. Since there is no background network for the central control of the network operations, the control and management of the network is distributed among the terminals. The nodes involved in a MANET should collaborate amongst themselves and each node acts as a relay as needed, to implement functions e.g. security and routing.
- *Multihop routing*. Basic types of ad hoc routing algorithms can be single-hop and multihop, based on different link layer attributes and routing protocols. Single-hop MANET is simpler than multihop in terms of structure and implementation, with the cost of lesser functionality and applicability. When delivering data packets from a source to its destination out of the direct wireless transmission range, the packets should be forwarded via one or more intermediate nodes.
- *Dynamic network topology*. Since the nodes are mobile, the network topology may change rapidly and unpredictably and the connectivity among the terminals may vary with time. MANET should adapt to the traffic and propagation conditions as well as the mobility patterns of the mobile network nodes. The mobile nodes in the network dynamically establish routing among themselves as they move about, forming their own network on the fly. Moreover, a user in the MANET may not only operate within the ad hoc network, but may require access to a public fixed network (e.g. Internet).
- *Fluctuating link capacity*. The nature of high bit-error rates of wireless connection might be more profound in a MANET. One end-to-end path can be shared by several sessions. The channel over which the terminals communicate is subject to noise, fading, and interference, and has less bandwidth than a wired network. In some scenarios, the path between any pair of users can traverse multiple wireless links and the link themselves can be heterogeneous.
- *Light-weight terminals*. In most cases, the MANET nodes are mobile devices with less CPU processing capability, small memory size, and low power storage. Such devices need optimized algorithms and mechanisms that implement the computing and communicating functions

D. MANET Challenges

Regardless of the attractive applications, the features of MANET introduce several challenges that must be studied carefully before a wide commercial deployment can be expected. These include:

- *Routing*. Since the topology of the network is constantly changing, the issue of routing packets between any pair of nodes becomes a challenging task. Most protocols should be based on reactive routing instead of proactive. Multicast routing is another challenge because the multicast tree is no longer static due to the random movement of nodes within the network. Routes between nodes may potentially contain multiple hops, which is more complex than the single hop communication.
- *Security and Reliability*. In addition to the common vulnerabilities of wireless connection, an ad hoc network has its particular security problems due to e.g. nasty neighbor relaying packets. The feature of distributed operation requires different schemes of authentication and key management. Further, wireless link characteristics introduce also reliability problems, because of the limited wireless transmission range, the broadcast nature of the wireless medium (e.g. hidden terminal problem), mobility-induced packet losses, and data transmission errors.
- *Quality of Service (QoS)*. Providing different quality of service levels in a constantly changing environment will be a challenge. The inherent stochastic feature of communications quality in a MANET makes it difficult to offer fixed guarantees on the services offered to a device. An adaptive QoS must be implemented over the traditional resource reservation to support the multimedia services.
- *Internetworking*. In addition to the communication within an ad hoc network, internetworking between MANET and fixed networks (mainly IP based) is often expected in many cases. The coexistence of routing protocols in such a mobile device is a challenge for the harmonious mobility management.
- *Power Consumption*. For most of the light-weight mobile terminals, the communication-related functions should be optimized for lean power consumption. Conservation of power and power-aware routing must be taken into consideration.

II. Related Work

Cluster based algorithms are among the most effective routing algorithms due to their scalability [1, 2]. Clustering outperforms other routing algorithms in case of large networks. As all inter-cluster routing in such a scenario is through the cluster head, it is therefore more burdened than its members and tends to be a bottleneck in the system if not chosen appropriately. The objective of any clustering algorithm is to partition the network into several clusters which is the focus of current literature in this area. Several algorithms have been suggested for clustering and Cluster head selection. A number of clustering algorithms have been proposed, some very simple [3, 4, 5] and some with a view of optimally utilizing the critical parameters [6, 7, 8, 9] of ad hoc networks.

The classical problem of clustering involves choosing a particular node as the cluster-head so that it becomes the gateway to other nodes for the nodes of this cluster [3] [4] [7].

The responsibility of this node would then be to maintain routes, update routes, direct transmissions, calculate which all nodes fall in this cluster and others. This multi-level hierarchy prevents duplication of information and facilitates the scalability problem. Several algorithms like Lowest ID, LCC, Highest in-degree, WCA, neural network created etc. have been projected for clustering of nodes but none of them take into account the environment specific dynamic nature of a heterogeneous ad-hoc network. They do not observe the common effect of parameters like battery control, unit of node and mobility on cluster formation [7]. We try to solve this issue by computing a factor for deciding cluster-heads. This factor is self-determining of the underlying situation, computationally un-intensive and takes into account environmental changes.

The algorithms that are considering the different attributes in the network such as node mobility, degree of Cluster head, distance between nodes, node battery power etc. result in selecting more stable Cluster head with lesser reaffiliations and increased network lifetime. For networks with highly mobile nodes, mobility should be the critical parameter and for network with high traffic energy could be a critical parameter for Cluster head selection. Highly mobile nodes lead to more volatile clusters and should not be used as critical nodes. It can be concluded that the importance to the different parameters should be according to the network environment. Soft computing techniques can be applied to achieve clustering using existing algorithms or new algorithms and these techniques can lead to improved results [7].

III. Proposed Model

The need arises for a new factor calculation which takes care of the scenario described in the previous section and is independent of the underlying ad-hoc environment yet taking into account the changes occurring in it. Further its behaviours should remain and nodes changes, respectively.

We can define a new factor F, which will consider all the factors which are required in different cluster-head selection.

$$F = Bi * \{SNR(t+\Delta t)/SNR(t)\} * Ni \ /£$$

Bi: Remaining battery power at node i

SNR (t+Δt): Signal strength at time (t+Δt)

SNR (t): Signal strength at time t

Ni: Number of neighbours of node i

£: Past history of node i

IV. Our Motivation

The factor F that we calculate is a combination of several factors namely Battery power, signal-to-noise/signal strength at time t, signal-to-noise ratio at time t+Δt, the number of nodes which are neighbours of node i and a factor which describes the past history of a node remaining the cluster-head. A high value of F would indicate a higher probability of a node being declared as a cluster-head.

The theoretical correctness can be taken as follows: The battery power if becomes 0% nullifies the effect of all the other factors because the node does not function at all hence a lower battery power is not desirable for a node to qualify as a cluster-head. We measure the signal strength at two times: t and t+Δt, since we want to measure the degree of movement of a nodes all around a particular node hence we can take this measure for all the nodes around the node i. A higher value is desired, as it would indicate that the node has not moved away. The direction of motion is not important as clearly the nodes are all fitted with an Omni-directional transmitter and receiver. The next factor is the number of nodes in the neighborhood of a node i and clearly indicate the approach taken by highest degree algorithm in choosing a cluster-head. Very clearly we need to choose a node as a cluster-head if the nodes that are at 1-hop distance away are high. The last factor that we can call as the trust factor stores the past history of a node being a cluster head. This factor has a value greater than 0 and less than or equal to 1. For example if a node became a cluster-head 5 times out of the 25 times it participated in cluster-head election, the factor is 0.2. But if a node never became a cluster-head then we keep a value of one for this factor, as it does not affect the factor F when it divides the numerator. Very clearly this factor cannot be zero and hence does not let the numerator approach infinity. Hence we prove by argument that the stated heuristic is correct to the best of our knowledge.

V. Conclusion

It is observed that for all clustering algorithms the number of clusters decrease with increase in transmission range, as more nodes are within range of other nodes for longer periods of time. Therefore, less number of clusters, which are larger in size, is formed, and mobility causes lesser number of nodes which are at the border to move in and out of range of each other. This results in decrease in the number of Cluster head changes. We will try to calculate a new clustering factor which is computationally un-intensive, considers all factors affecting change in cluster-heads in a combined fashion and also overcomes interference anomaly by including the measurement of round trip times. One of the beauties of this factor is the simplicity in calculating the associated parameters. Since this is a newly proposed idea, no tool is directly applicable to show its implementation. So a detailed simulation study needs to be conducted to experimentally prove the validity and usefulness of the proposed clustering factor. A comparison laid out against the already existing algorithms for calculating the cluster-heads would further show its usefulness in heterogeneous environments.

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