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A Review to Different Clustering Techniques Applied in MANETs

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Abstract— Clustering is a process of partitioning set of objects (or data) into set of meaningful sub-classes called clusters. Clustering is an unsupervised learning technique used as a pre processing step for other algorithms and allows better routing management in mobile ad hoc networks (MANETs).In this paper clustering techniques for MANET is presented and some concepts for designing clustering algorithms are introduced such as Lowest-ID heuristic, Highest degree heuristic, DMAC (distributed mobility-adaptive clustering), and WCA (weighted clustering algorithm), and other techniques are described.

Keywords— Mobile ad- hoc networks, MANETs, Clustering, Cluster head, DMAC, WCA.

I. INTRODUCTION

Today, The Wireless Technologies are gaining popularity in our daily lives, with the use of portable devices like laptop computers, personal digital assistants (PDAs), and mobile phones. The main concept of a MANET is that a network can be established without the need for any centralized administration or any fixed infrastructure as discussed in[1].Various applications of MANET include military scenarios ,rescue operations etc. In future, it can be deployed by students using (PDAs) or laptops to exchange the information among themselves. As implementation of MANET is not an easy task, a Clustering scheme is proposed to organise a network in well-defined manner. The main purpose of this paper is to discuss basic clustering techniques. Wireless ad hoc networks classified according to their application into the following classifications [2]:

1. Mobile Ad Hoc Networks.
2. Wireless Sensor Networks.
3. Wireless Mesh Networks.

This paper focuses on Mobile Ad Hoc Networks (MANETs) where mobile nodes communicate with each other using Multi hop wireless link.

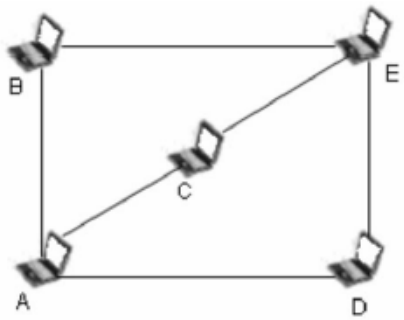


Figure1.Multi hop communication in MANETs

II. CLUSTERING IN MANETS

Clustering is one of the most important techniques that are used for partitioning of network nodes into number of overlapping nodes called as clusters. It deals with process of maintaining MANETs to create an efficient network. Clustering is method of aggregating the nodes into groups [3], which are contained by network called clusters. Clustering provides several benefits in MANETs defined as follows:

- It helps in improving scalability and throughput.
- Improves mobility and routing process.
- It performs resource allocation in more efficient manner.
- Provides hierarchical network architecture.

In Clustering process three types of nodes are defined [4]:

1. *Cluster head*: These are defined as a local coordinator for its cluster. It performs inter-cluster routing process, data transmission and many other operations.
2. *Gateway nodes*: It is a node that can access neighbouring cluster and forward information between clusters.

3. *Cluster Member or Ordinary Nodes*: These nodes is the one neither a Cluster Head nor Gateway.

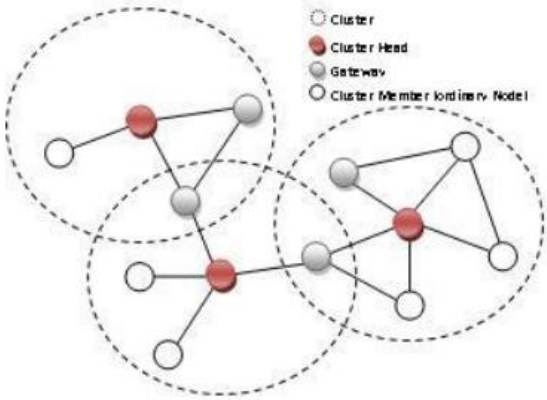


Figure2. Cluster head, gateway nodes and ordinary nodes in MANETs.

III. CLUSTERING TECHNIQUES APPLIED IN MANETS

Clustering techniques are designed by partitioning of the nodes in network as shown in figure 2.Based on the way of aggregating the nodes into groups within clusters several techniques are proposed[5]-[7].Some of the following Clustering techniques are briefly reviewed as follows:

A. Lowest-ID heuristic

It is most simple Clustering technique as shown in figure 3, in which each and every node has been assigned a unique identifier (**ID).** Each node broadcast its (**ID)** to their neighbours and decides to become cluster head (**CH**) if it has minimum (**ID**) among its neighbours (**ID**). The disadvantage of Lowest-ID heuristic is that there is no limitation to number of nodes attached to the same (**CH**).

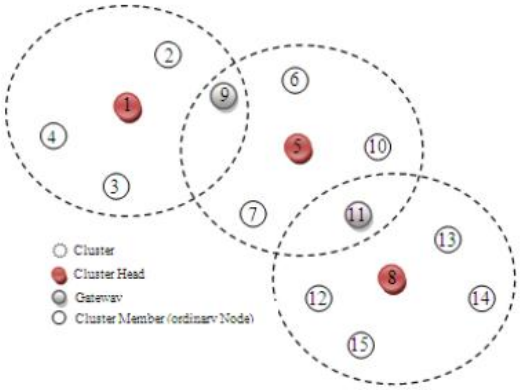
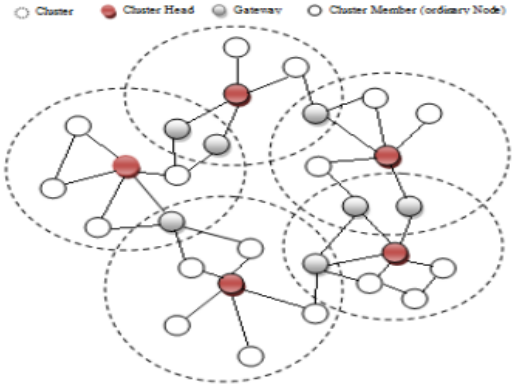


Figure3. Lowest- ID heuristic Clustering.

B. Highest degree heuristic

This Clustering technique is based on connectivity between node and its neighbours. Each node floods its connectivity to its neighbours within their transmission range. A node decides to become cluster head (**CH**) by comparing the connectivity value of its neighbours with its own value as shown in figure 4 and if it has highest connectivity value in its neighbourhood.



Fifure4. Highest -degree heuristic Clustering.

C. K-CONID

This technique combines both Lowest-ID heuristic and highest degree heuristic techniques [8]. K-CONID technique is named (K-hop Connectivity ID). For the selection of Cluster heads (**CHs**) Connectivity is taken as first criterion and Lowest-ID as second criterion. The main purpose of K-CONID is to minimize number of Clusters formed in network. The Clusters are formed by Cluster head (**CH**) and all nodes at distance of at most K-hops from Cluster head (**CH**). The algorithm begins by allowing a node to start a Flooding process in which a Clustering request is sent to all other nodes. K-hop Connectivity ID generalizes Connectivity for K-hop neighbourhood. In this algorithm, each and every node is assigned a pair **DID= (D, ID)** where **D** is the Connectivity of node and **ID** is node identifier. A node is selected to be **CH** if it has highest Connectivity and lowest ID.

D. (α , t) cluster framework

It is simple algorithm that determines Path availability which is a random process determined by nodes mobility lies along certain path in order to make Clustering decisions. In this approach, paths are evaluated using two parameters α and t, where α controls the stability of Cluster while t manages the size of Cluster. In this Clustering algorithm, each node is provided with Cluster identifier (**ID**) and makes use of α timer that establishes maximum time t for which a node guarantees that particular path is available with (probability ≥α). The (α, t) Clustering algorithm characterizes Link probability and Path availability as random walk mobility model.

E. Max-Min D-Cluster

In many algorithms the election of Cluster head (**CH**) is done in such way that prevents nodes to be far more than one-hop from its Cluster head (**CH**). Therefore, in Max-Min heuristic algorithm Clusters are formed by those nodes that are far away at most d-hops from (**CH**) [9], where d value is maximum number of hops the node is away from nearest Cluster head (**CH**) (P≥1). The algorithm guarantees good control over message complexity and density of (**CH**) in network. Every node has two arrays **WINNER** and **SENDER**. The first array implement winner node (**ID**) where second array corresponds to node of particular round that send winner node (**ID**) for particular round. Each node has **WINNER** value that is equal to its own node (**ID**).

This algorithm maintains 2-d rounds of Flooding. In this way each node exchanges their node (**ID**). The first d –round initiates (Flood max) procedure in which every node broadcast its **WINNER** value to all its 1-hop neighbours, and second d-round initiates (Flood min) procedure which follows Flood max procedure and begin with value that exist after first d-round. In this procedure in each round, a node chooses for its new **WINNER** value the lowest value among its received **WINNER** values and its own values.

A node can declare itself if and only if it has received original node (**ID**) after 2-d rounds of Floods. Elsewhere every node should look for node pairs, defined as any node (**ID**) which results as **WINNER** at least once in first d-round of Flood max as well as in second d-round of Flood min for individual node. After all pairs are detected, the node will choose minimum node pair as Cluster head (**CH**). The second array **SENDER** array is used to decide who will be next to send this information.

F. Least Change Algorithm (LLC)

LLC is an important over both Lowest-ID heuristic and highest degree heuristic Clustering algorithms [5]. In most of Clustering techniques the maintenance cost of Cluster is taken into account to satisfy the characteristics of Cluster heads (**CHs**).LLC is classified into two phases as follows:

1). *Cluster formation phase*

This phase is applied to Lowest-ID heuristic by selecting the mobile nodes with Lowest-ID in their neighbourhood as Cluster heads (**CHs**).

2). *Cluster Maintenance phase*

This phase is performed as an Event-Driven and is called under two conditions:

a. When a node is unsuccessful in accessing any Cluster head (**CH**), then it call Cluster Formation phase to reconstruct the structure of Cluster with Lowest-ID heuristic techniques.
b. Whenever more than one node reaches over transmission range of each other thus requires removing of CH roles except one which become a **CH**.

Therefore, LLC increase stability of Clustering in MANET by giving up all the requirements that a **CH** reserved some characteristics and features within its local area.

G. DMAC

DMAC is a Distributed Clustering algorithm in which Cluster heads (**CHs**) are selected during a weight –based criterion in which highest value of weight among one-hop neighbour is considered, which depends on mobility of node related parameters. DMAC is used to manage highly mobile networks. This algorithm overcomes the major drawback of presented algorithms that nodes can even move during the Clustering set-up. At the time of executing this algorithm it is assumed that every node is assigned weights which represent node mobility parameters and each node has unique **ID** associated with it.

DMAC is called Message-Driven algorithm which uses two kinds of messages as follows:

a. If node joins a Cluster then it will send **JOIN** message.
b. If node becomes a Cluster head (**CH**) then it will send a CH message.

In DMAC, five procedures are executed at each node:

- Init Routine procedure
- Link-failure procedure
- New-link procedure
- Procedure that depends upon reception of **CH** message.
- Procedure that depends upon reception of **JOIN** message.

Whenever, a **CH** receives **JOIN** message from ordinary node, then it checks whether sending node is joining its own Cluster or some other Cluster.

H. WCA

DMAC algorithm is based on weight values, which have been proposed [10]. In WCA (Weighted Clustering Algorithm) Cluster heads (**CHs**) are selected by considering main aspects related to efficient functioning of system components. In order to optimize usage of battery, the concept of Load Balancing and MAC functionality, a node is chosen to be CH according to number of nodes it can handle, mobility, battery and transmission power.

WCA algorithm is not periodic to avoid communication overhead and selection of CH is done based on mobility of node. To ensure that Cluster heads (**CHs**) will not get overloaded a predefined Threshold parameter is established to specify number of nodes that each CH can support. This Threshold parameter corresponds to $\boldsymbol{\delta}$.

WCA elects **CHs** according to value of weight associated to a node. The node with minimum value of weight is elected as **CH.**

There is an interesting work presented regarding WCA in which WCA is optimized by advanced research algorithms as Genetic algorithms [11], Simulate annealing [12] and Particle swarm [13].

IV. CONCLUSIONS

In this paper, we have reviewed several Clustering techniques which organize mobile ad hoc networks (MANETs) in hierarchical manner and also present some of their main characteristics. These Clustering techniques improved Network scalability, topology and routing management, Energy consumption of mobile nodes, control overhead of Cluster maintenance and construction of MANETs.

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