A stable election protocol for clustering in power constrained wireless mesh networks

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Abstract:

The Wireless Mesh Network (WMN) is a collection of Mesh Routers (MR) and Mesh Clients (MC) which are organized in a mesh topology. Each device is directly connected to other devices in the same network and constitute what is called mesh topology. Wireless Mesh Network is a dynamic and infrastructure less network. Due to its dynamic nature, it has many constraints like CPU, Battery, Mobility and Bandwidth. To efficiently manage some of those constraints in wireless mesh network, we use clustering technique. Clustering makes the network fast, more efficient and reliable. We will use Stable Election Protocol for clustering and to select a cluster head on the basis of battery power, the battery power is defined by the user. Only the cluster heads are allowed to connect and communicate with other nodes, which significantly reduces the extra computation on nodes in connection.

Keywords: Wireless Mesh Networks, Mesh Topology, Stable Election Protocol, Clustering.

2. INTRODUCTION

A wireless mesh network is a form of Ad hoc networks. A WMN consists of two types of components -wireless mesh routers (MR) and mesh clients (MC). A WMN is also typically interconnected with the Internet through a gateway, which is an MR that performs the gateway or bridge function. The mesh clients are often laptops, cell phones and other wireless devices while the mesh routers forward traffic to and from the gateways which may need not connect to the Internet. Wireless Mesh Networks, an emerging technology, are considered as the promised choices for wireless Internet communications since they allow fast, easy, and low-cost network deployment. Wireless Mesh Networks represent a good solution to provide wireless Internet connectivity in a sizeable geographic area. This new and promising network allows network deployment at a much less cost than with classic wireless networks. In WMNs, it is possible to cover the same area, as compared to Wi-Fi, with less wireless routers, which makes the use of WMNs a compelling economical case. WMNs are thus suitable for areas that do not have existing data cabling or for the deployment of a temporary wireless network.

WMNs are extremely reliable, as each node is connected to several other nodes. If one node drops out of the network, due to hardware failure or any other reason, its neighbors simply find another route. Extra capacity can be installed by simply adding more nodes. Mesh networks may involve either fixed or mobile Devices. The basic high level security issues in wireless mesh network have, such as availability, authenticity, integrity and confidentiality. We plan to use a Stable Election Protocol for clustering and to select a cluster head in each cluster on the basis of energy levels in a typical wireless mesh network. The cluster head avoids the extra computation on each node and also saves the battery power of the nodes. The cluster head increases the connection time. The simplest meaning of clustering is grouping. Grouping the similar or different types of nodes by applying proper and appropriate techniques or methods. There are many types of clustering techniques used in networks. Cluster analysis is an unsupervised process that divides a set of objects into homogeneous groups. There have been many clustering algorithms scattered in publications in very areas such as Pattern Recognition, AI, Computer Science, Networks, Image processing, Biology, Psychology, and Marketing. Basically clustering is divided into two types.

2.1. Hard Clustering

Basically hard clustering has each document belongs to exactly one cluster. In hard clustering, we make a hard partition of the data set Z.

\[ \bigcup_{i=1}^{n} A_i = \text{Z and } A_i \cap A_j = \emptyset \text{ for all } i \neq j \]

Also none of the set Ai may be empty.

2.2. Fuzzy Clustering

Fuzzy Clustering also called soft clustering. In fuzzy clustering, we make a fuzzy partition of the data set. Fuzzy clustering uses membership function in partition data set.

\[ \sum_{i=1}^{n} u_{ij} = 1, \forall j = 1, \ldots, n \]

This function is called membership function and its value between 0 and 1

Clustering advantages -Clustering has many advantages. Some of these are:

- By the Clustering reduces the size of routing tables which are stored at the individual nodes by localizing them and soft clustering.
- Clustering can conserve communication bandwidth since it limits the scope of inter cluster interactions to Cluster Heads (CHs) and avoids redundant exchange of messages among nodes.
- The Cluster Head can increase the battery life of the individual nodes and the network lifetime as well by implementing optimized management strategies.
- Clustering reduces the topology maintenance overhead. Nodes would care only for connecting with their CHs.
- A Cluster Head can perform data aggregation in its cluster and decrease the number of unnecessary packets.
- A Cluster Head can reduce the rate of energy consumption by scheduling activities in the cluster.
3. WORKING STEPS OF STABLE ELECTION PROTOCOL FOR CLUSTERING

It is a clustering protocol to create clusters of nodes and it is a heterogeneity aware protocol. This process involves selecting cluster head on the basis of their battery and computation power. The whole mesh network is composed into clusters and those clusters are connected to other clusters by using the cluster head. [3]

Steps to create cluster and cluster Head -

Step 1- Select number of nodes randomly in wireless mesh network and make clusters of those nodes on the basis of cut off frequency of the nodes.

Step 2 - In a cluster cut off frequency selected by the user. The frequency is divided into three levels, Higher, Middle and Lower levels.

Step 3- Select the cluster head on the basis of battery power. Selection of cluster head in energy efficient techniques generally depends on the initial energy, residual energy, and the average energy of the network or energy consumption rate or a combination of these.

Step 4 - After selection of cluster head, for the communication between two cluster heads or other nodes. Established the connection between new cluster head to other nearest cluster heads in wireless mesh network.

4. THE STABLE ELECTION PROTOCOL

In a wireless mesh network, the data are sent in the form of digital signals between one cluster head to another cluster head. To send any types of signal some energy is required. The distance from one cluster head to another is d. Energy consumption formula for sending an r bit message to a distance s is

\[ E_{\text{TX}}(r, s) = E_{\text{TX-elect}}(r) + E_{\text{TX-amp}}(r, s) \]

\[ E_{\text{TX}}(r, s) = E_{\text{elec}} \times r + E_{\text{amp}} \times r \times s^2 \]

In a wireless mesh network, if the cluster head receives data that also require some energy. The distance from one cluster head to another is s. The energy consumption formula for receiving a r bit message to a distance is d.

\[ E_{\text{RX}}(r) = E_{\text{RX-elec}}(r) \]

\[ E_{\text{RX}}(r) = E_{\text{elec}} \times r \]

To calculate consumption of energy, following parameters are defined. The average energy used by a node in a cycle includes energy from cluster head plus energy from leaf nodes, as given below

\[ E_{\text{avg}} = pE_{\text{head}} + (1 - p)E_{\text{leaf}} \]

The number of nodes is given, then creates a cluster and calculates the energy of all nodes for selection of cluster head on the basis of energy level of nodes. The expected number of nodes in a cluster with every node has the same probability p to become a cluster head, given by:

\[ M = \frac{1}{p} \]

Subsequently, the stable probability of a node to become a cluster head is derived from a function of P\text{Rate}. Assume that all the nodes have data to send in each cycle P\text{Rate}, the stable cluster head election probability (p) becomes

\[ p = \frac{E_{\text{amp}} \times E_{\text{data}} \times 1^2}{\sqrt{N(3E_{\text{elec}} \times E_{\text{inter}} + 2E_{\text{amp}} \times E_{\text{data}})}} \]

With the help of these equations, we can create a mesh network having various cluster heads selected on the basis of node energy.

5. DISCUSSION AND RESULT

We use Stemplot to track all the data in from of 1’s and 0’s that is called sub carrier indexing because all the data is sent in digital form. By Placing data in empty vector and thus creating different size of sub carriers. Here we show the Random bits graph between Bit Index and Binary Values. Fig 1 shows the all signal sources:

![Fig 1: Signal Processing Symbol Index](image)

A stemplot in statistics is a device for presenting quantitative data in a graphical format, similar to a histogram, to assist in visualizing the shape of a distribution. A basic stemplot contains two columns separated by a vertical line. The left column contains the stems and the right column contains the leaves. Here we Plot first 10 symbols in a stem plot out of all signals of symbols. It is a Random Symbols graph between the Symbol Index and Integer Values.
FIG 2: Shown Binary Value Of Bit Index

The data are displayed as a collection of points, each having the value of one variable determining the position on the horizontal axis and the value of the other variable determining the position on the vertical axis. This kind of plot is also called a scatter chart, scatter diagram or scatter graph. Here we show received signals and check the peak to average power ratio (PAPR) for each symbol and select cluster head on the basis of power.

FIG 3: Scatter Plot Diagram For Choosing The Cluster Heads

6. CONCLUSION AND FUTURE WORK

In a wireless mesh network we used a stable election protocol for clustering and to select a cluster head, which reduced overhead and also saved the battery power. Only the cluster heads are responsible for establishing connections and communicate with other cluster heads. In the future, the link heterogeneity of networks will be considered. Also the impact of location and size of the cluster to cluster heads election algorithm will be our further research.

7. REFERENCES