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Self Organized Energy Efficient Algorithm for Network Creation and Maintenance in MANETs

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Abstract

Self organized network is on the fly and infra structured less network. Identification of various roles in Wireless Ad-Hoc Networks is in demand due to characteristics like emergent behavior , simplicity of algorithm, low cost and no central administration. Different Strategies for creation and maintenance of this robust and on the fly network are introduced. The major factor that affects the self organized wireless network is Energy of devices. Consumption of energy of devices and non interruptible service in self organized network is major focus of our research. This paper introduces robust algorithm for network creation and maintenance by avoiding network inconsistencies due to various nodes whose roles are not uniquely identified. We have identified various roles like Agent, Leader, Gateways, Bridge and nodes showing willingness to act as leader, Gateway and Bridge. With the identification of various roles network is created and further this network is maintained with our network maintenance algorithm which is explained in detail in this paper. Implementation studies shows energy efficiency and minimum links in network as compared to MST.

Keywords- Self Organization**,** On the fly Network, Emergent Behavior, MANETs

1. Introduction

Wireless ad hoc network is on the fly and non centralized network. Devices can have mobility and power for self organization. Self organized network is emergent in behavior hence every node in that network plays an important and crucial part in communication. Critical sensor Network in Hospitals, Military applications, Disaster management, needs high availability of all the nodes to provide communication effectively. Non availability of nodes at particular situation may incur communication overhead, unnecessary broadcasting, extra consumption of resources. Identification of various roles like Agent and Leader forms cluster effectively. To provide communication among the clusters one more role is identified, Gateway [1]. So gateway is a node which can sense two leaders those want to communicate with each other. When more than one gateway is available on same path the new role is assigned, willingness to act as Gateway, which will keep single Gateway functioning on a path and can take charge of original functioning Gateway in case of its failure. This avoids network inconsistencies raised due to duplicate Gateways [1][2] also unnecessary broadcasting[1].

To avoid Communication overhead, unnecessary broadcasting, extra consumption of resources, we have introduced two more roles to already existing self organized wireless network [4], Willingness to act as Gateway and Willingness to act as Leader. These two roles tries to make unavailability of devices minimum and in turns saves extra overhead to form and maintain network. With these roles we formed a virtual backbone in network which tries to use the resources optimistically. Our Network maintenance algorithm runs periodically with small interaction among nodes which keeps network live all the time.

Remainder of the paper is organized as follows: Section II highlights major contributions in role based self organization strategies, Section III focuses on Network Creation and maintenance Algorithm, Section IV gives implementation details and Results. In Section V conclusion and future scope is written.

2. Literature Survey

Research in wireless network mainly focuses on battery life of devices. Wireless network which is build from various wireless devices need to maintain their battery life as long as possible. Many factors like communication overhead due to failure of devices, message broadcasting for fast recovery after failure of network or devices, non availability of devices for longer communication definitely consume extra battery life. So these battery operated devices tries to maintain their battery life by frequent on off mechanism[1], but in this case self organized network need to run cluster creation algorithm again and again after every on and off operation.

In self organized network as there is no central administration, based on global emergent behavior all devices tries to play different roles. Based on this many approaches are designed and proposed like a multi-point relay (MPR) based approach[8], a connected dominating set (CDS) based approach[7]and a cluster based approach[9]. All approaches suggests roles like Cluster Head which will be Leader for particular cluster formed from various nodes and all nodes from that clusters are called Agents[10]. Leader is responsible for communication of that cluster. Communication among the

cluster is necessary to build entire network, so new role which facilitate the communication between two or more leaders is introduced that is Gateway. Gateway is node which is registered for both the leaders and provide path for communication between two leaders [1]. As wireless network process real time information, unavailability of any particular device at any moment which is responsible for communication may cause communication overhead and unnecessary broadcasting to settle the traffic. So in case of Gateway failure communication between and among clusters is stopped. To avoid this willingness to act as Gateway role is identified [2]. Willingness to act as a gateway is node which is additional gateway present on same path where already Gateway is present and handling the traffic for that particular path. If more than one gateway is present on same path due to duplicate gateway broadcasting will be more and network inconsistency may occur which is avoided by adding willingness to act as gateway role[4][5].

To provide communication support and avoid Leader failure we have introduced new role for Leader backup [4]. This new role willingness to act as Leader will be normal agent of cluster which can take charge of present leader in case of Leader failure[4]. This willingness Leader is decided such that it should have maximum battery life remained and must be visible to almost all nodes within that cluster. Suggesting this new node avoids the requirement of running leader selection or election algorithm in case of failure of leader, in turns avoids unnecessary broadcasting[4].

Further Network segmentation is the situation when two clusters cannot communicate with each other as they cannot communicate directly through their visibility or through gateways.

This situation is tackled by defining a role Bridge [1]. Bridge is a role which is associated with two particular nodes which are registered for two different clusters and can view each other for communication. With the help of bridge two clusters can communicate with each other even though they are facing network segmentation problem [1].

As our focus is to maintain the network and provide uninterrupted service throughout network it is now necessary to provide backup mechanism for Bridge also.

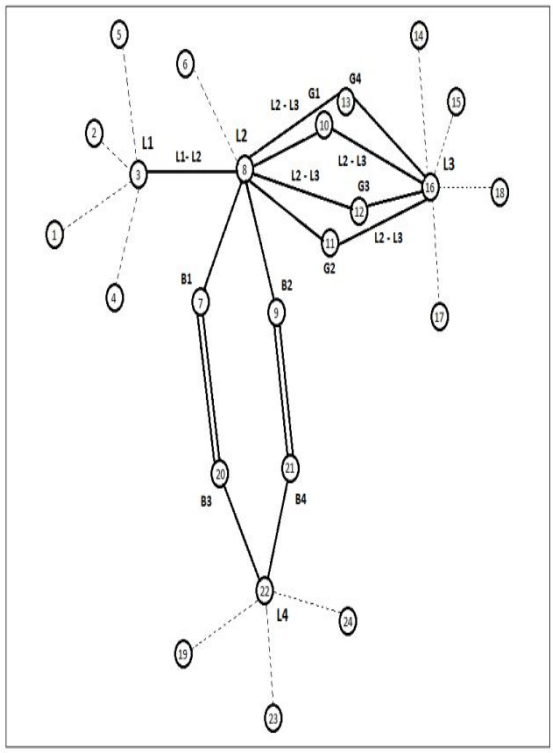

Fig.1 Assignment of roles to form Virtual Backbone

As shown in figure1, failure of Leader, Failure of Gateway and Failure of Bridge needs backup mechanism. Hence we presented new roles willingness to act as Bridge to provide backup to Bridge and Willingness to act as Leader in case of cluster failure [4]. Following section describes- the network creation with two new roles willingness to act as Leader and Willingness to act as Bridge, Criteria for selection of willingness to act as Bridge and Network creation and maintenance algorithm for effective virtual backbone formation.

3. Network Creation and Maintenance (NCAM) Algorithm for Effective Virtual Backbone Formation

This algorithm creates network by identifying various roles like Agent, Leader, Gateway, Bridge, willingness to act as Bridge and willingness to act as Leader [4].

With the arrival of new node network creation algorithm starts. New node will check for Leader to register, else will declare itself as Leader. In case of Leader already present the new node registers itself as a Agent. Thus various clusters with cluster head as Leader and member as Agents are formed with the help of general Leader Election Algorithm. If a node is registered for two different Leaders that node will get role as Gateway. So

Gateway facilitates communication between or among Leaders. To avoid duplicate Gateways on same path and unnecessary broadcasting when more than two gateways present, the duplicate gateway will work as backup node

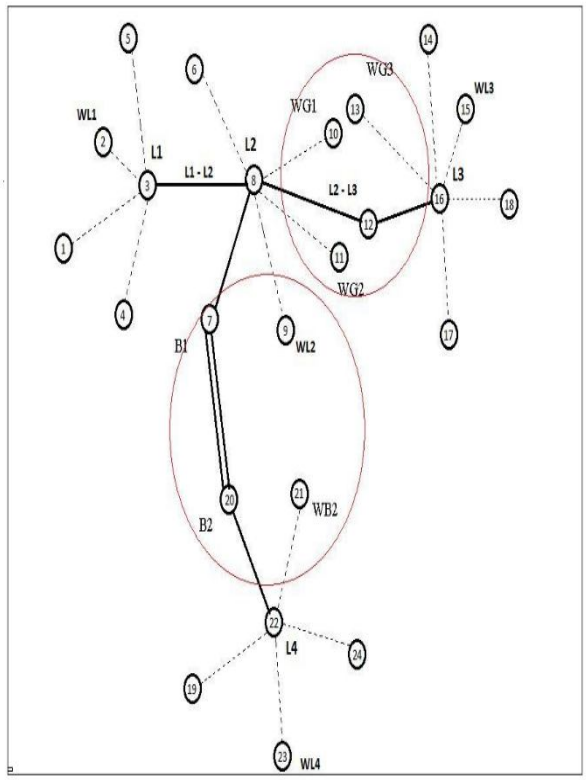

Fig. 2. Role assignment by Network Creation and Maintenance (NCAM) Algorithm

in case of failure and is known as willingness to act as Gateway. As wireless network is distributed network we need to consider network segmentation problem which can disturb communication. Network segmentation problem generally arises due to mobility of wireless devices or nodes. In this case two clusters are not able to communicate directly or through Gateway. In such situation if there are particular nodes which are visible to each other and can facilitate communication between or among clusters are known as Bridge. So bridge role is formed from two distinct node from two different clusters which are visible to each other. Here network is created with all mentioned role and to provide uninterrupted service we have proposed Network maintenance algorithm.

The need for network maintenance algorithm is raised because of mobility of node in wireless network, on the fly nature and emergent behavior of self organized nodes. If Leader fails, communication for that cluster will stop automatically or traditional election algorithm works for new leader selection. We have provided the backup node which can take charge of failed Leader immediately to avoid overhead due to Leader election algorithm. This back up node will be from same cluster and with same configuration as that of failed Leader and can take charge of failed leader, called as willingness to act as Leader. This new role willingness to act as Leader maintains all the table information that Leader held like number of nodes attached, membership, energy levels so that willingness to act as leader will work as agent in case of normal situation and takes charge of leader in case of failure of Leader. Now this situation is analyzed in case of Bridge also. We proposed a new role willingness to act as Bridge to provide backup to Bridge. This willingness to act as bridge exhibit the properties like Bridge. Bridge is responsible for communication between two or more clusters which are separated by network segmentation. In case of failure of node which is participated to form bridge causes bridge crash and disturbs the communication. In such situation the willingness to act as Bridge will take charge of this failed Bridge. Thus our Network Creation and maintenance algorithm identifies different roles and to maintain created network new roles are added and backup is provided. Backup nodes are selected on the basis of high energy availability high Δ. The whole algorithm is as follows:

With the arrival of new node at t=0, Network creation Algorithm and maintenance of Network works as follows:

Algorithm1: Network Creation

```
If Node Exist ≠ 0
 If NodeLeaderNo =0   then
            Role ←Leader
ElseIf    Role =Leader
LeaderElection()
ElseIfNodeLeaderNo = 1
            Role ← Agent
    If    Role ← Agent&&NodeAgentNo= 1
            Role = WL
  Else
NodeLeaderNo>1
            Role ← gateway
If Role= Gateway  &&NodeGatewayNo>1 then
            Role = WG
If
Agent1 € Leader1 && Agent2 € Leader2 &&Agent1 ↔
Agent2
Role ← Bridge{Agent1 & Agent2}
ElseIf
NodeBridgeNo=1
             Role=WB{Agent1#,Agent2#}
  Else
            Roe ←Any
EndIf
```

Algorithm 2: Network Maintenance

```
At (t=0)
RoleAssignment( )  //Algorithm1
At ( t =T || Leader!Available ||Gateway !available || Bridge !Available)
    t=T=15
If Leader ! Available
          If (Numberof WL >1)
σ  WLhighΔ   //select WL with High energy
          Else   Leader ← WL
 Else
LeaderElection()
    If   Gateway ! Available
          If (NumberofWG >1)
σ WGhighΔ//select Wg with High energy
          Else Gateway←WG
    If     (Leader1 ↔ Leader2)  //Checking Visibility
           Add to VirtualBackbone
If      Bridge ! Available
          If (Numberof WB >1)
σ  WBhighΔ   //select WB with High energy
          Else B ←WB
    t=t+15
    END
```

Same algorithm is implemented using NS2.34 and results are noted down. Simulation study has shown that our results with Algorithm1 and Algorithm2 give solution which is mapping to MST.

4. Simulation and Experimental Results

NS-2.34 is widely used network simulator for wireless network [6]. Simulation starts at time t=0. We have made assumptions regarding energy, transmission power and Environment.

The initial configuration of agents is as follows:

• The initial energy of every node is 2 J;

• The maximum transmission range is 10 m.

We are checking our results at the time t=200 seconds. To calculate total energy consumption we have considered summation of energy of all nodes at time t=0 and at time t=200s. Comparative analysis is done for MST, SOS [1] and our Network creation and maintenance algorithm (NCAM).Graph Plotted shows residual energy with NCAM and residual energy with basic self organization algorithm against time. Energy consumed by NCAM algorithm shows minimum energy consumption than basic self organization algorithm.

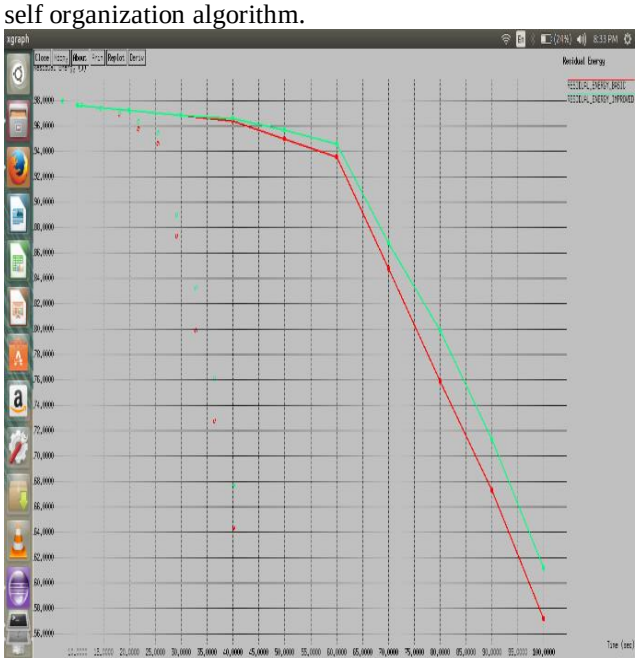

Fig. 3 Residual energy with NCAM and basic self organization

Table 1 Shows Comparative study of our Network Creation and Maintenance Algorithm (NCAM) with MST and SOS [1].

Experimental results have shown that our algorithm gives solution which is mapping to MST. As we are providing backup mechanism for Leader, Gateway and Bridge this automatically avoids the problem of retaining duplicate links for communication.

Table 1: Comparison of NCAM with MST

Environment			**No of Communication Links**			**Performance with %**		
Transmission Range	**No. Of Agents**	**Dimensions**	**MST**	**SOS**	**NCAM**	**Links Deactivated**	**Links Difference**	**% Improvement**
15Mts	50	100x100	49	56	49	0	0	100%
15Mts	60	100x100	59	68	59	0	0	100%
15Mts	70	100x100	69	88	69	0	0	100%
15Mts	80	100x100	79	96	79	0	0	100%
15Mts	100	100x100	99	125	99	0	0	100%

5. Conclusion

Network Creation and Maintenance algorithm is improved algorithm for better utilization of recourses. Battery life of devices is improved by restricting broadcasting and avoiding network inconsistencies. To provide uninterruptible communication and for backup purpose two new roles are identified. Our algorithm is sustaining in case of cluster fail also. Results have proven that our Network Creation and Maintenance algorithm gives solution which is mapping to MST. Further study regarding maintaining the algorithm for scalable wireless network is going on.

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