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MDIA-Master Directed Incentive Based Approach

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Abstract

Mobile Ad-Hoc Network (MANETs) is an autonomous system in which mobile nodes are connected through radio links. These dynamically formed networks provide data communication facility even when mobile network is not in range. However it is a cooperative network based on cooperation of participating nodes, which spend their battery while passing data packets from one node to the other. Since battery life is a critical issue with mobile devices, in case of low battery life mobile nodes participating in a MANET stop forwarding packets. This situation is termed as selfish behaviour of nodes and is a serious problem in MANETs. This work presents an agent based mechanism to detain selfish behaviour of nodes in MANETs. Nodes in MANETs turn selfish due to lack of any direct benefit of participation except for energy consumption.However if participating nodes are facilitated for their participation, it may reduce selfish behaviour to some extent. This paper presents an agent based Master Directed Incentive based Approach (MDIA) that aims to detect emerging selfish behaviour among nodes and detaining the same by motivating the nodes with diminishing energy level. This mechanism reduces transmission load from nodes having critical battery life at the same time providing more incentives so as to keep them participating in communications.

Keywords: MANETs, Routing Protocols, Mobile Agents, Selfish Behaviour.

1. Introduction

Mobile Ad- Hoc Networks (MANETs) are evolving rapidly in the field of wireless networks. These are infrastructure less networks where routers and hosts providing access points are not fixed. In case if a mobile user away from an access point needs to send or receive data packets, this is facilitated by radio transmission and receiving ability of mobile phone with help of other nearby existing nodes creating a dynamic network. In literature MANETs are defined as “an autonomous system of mobile routers (and associated hosts) connected by wireless links – the union of which form an arbitrary graph” [1].

As Nodes in MANETs keep on changing their location it is required to maintain routing paths and tables for every new updation. While maintaining routing paths, energy level of nodes must be considered since it is one of the important characteristics for effective routing. Exhausting battery power affects efficiency of nodes the most. The nodes in MANETs depend on some means of energy or power. The energy resources are limited and can’t be preserved for longer time, as a result participating nodes may stop transmitting and/or receiving for arbitrary time period. This is termed as *selfish behavior* of nodes [2]. Based on their nature, nodes may be classified in following two types:

- **Cooperative Nodes: The nodes** that are active in forwarding data packets along the route.

- **Selfish Nodes**: These nodes become inactive and may deny forwarding a packet to their neibhours for saving energy. Selfish behaviour of network nodes causes inefficient data transmission in MANET.

Since mobile nodes are supported with fixed battery lives and it is difficult to recharge then on the way, nodes obsiously try to save their energy by impeding participation in MANETs. Nodes can't be forced to participate in these dynamic networks however they may be encouraged to participate. Practical solution for encouragement is to associate incentive with participation. In this work an Incentive based scheme is being proposed that aims at improving selfish behaviour of nodes by encouraging them to send packets. This is achieved by providing incentive points to all participating nodes, with extra provision for nodes with diminishing energy levels. Those nodes are assingned less packets for transmission so that they keep on sending packets and don't turn selfish.

Concept of mobile agents is the backbone of this framework. A *mobile agent* (MA) is a process that can transport its state from one environment to another, with its data intact, and is capable of performing appropriately in the new environment while migrating from one host to another in a network, state of the running program is saved, transported to the new host, and restored there allowing the program to continue its exection from the point where it left off earlier. MAS are possessed with features [3] of autonomy, learining ability, cooperativeness and most importantly mobility.

There are several good reasons of using mobile agents in an application as they reduce network load; overcome latency; encapsulate protocols; execute asynchronously (this feature is very much suitable for mobile ad-hoc networks); adapt dynamically and support component-based software development [4].

Rest of the paper is organized as follows: Section 2 presents already existing schemes to detect selfish behavior of nodes in MANET, further it explores mobile agent based routing protocols existing in this domain. Section 3 describe the proposed framework. Section 4 concludes this work and outlines directions for future research.

2. Literature Review

This section explores work of eminent researcher in the field of MANETs and applicability of mobile agents in mobile communications. Extensive literature review highlighted that there are various mitigating schemes available for detecting selfish behavior of nodes. These schemes focus on suspecting reputation of nodes and to promote or encourage them to participate in network by giving incentives to the nodes for enhancing cooperation in network.For better understanding literature has been arranged in two sections, first section includes selfish behavior detection schemes without software agents whereas second section explores usage of mobile agents in MANETs specially for detecting selfish behavior.

2.1 Literature survey on Selfish behavior Detection

In general, mechanisms that try to mitigate and stimulate the misbehaved or uncooperative node can be classified into two classes [5]:

a) **Virtual Currency Schemes**
Virtual Currency based scheme motivates the nodes to enhance cooperation in the network by paying them for that. These schemes promote cooperation among nodes by giving them incentives for their service. These nodes if gains help from the network pay back some price e.g. Nuglets, Sprite.

b) **Reputation based Schemes**. Reputation mechanisms are based on the behaviour of a node in the network. Each node has a reputation value that reflects its behaviour. This value is stored and calculated by other nodes watching its behaviour. The mechanism must update and calculate the reputation of nodes timely and carefully so that right decision is taken and optimum path is found at last.

Marti et. al in [6] have analyzed two namely schemes watchdog and parthrater for detecting selfish behavior of nodes in MANETs.

Bruchegger et. al [7] described CONFIDANT model used for detecting selfish node behavior in MANET. This model includes neighborhood watch scheme where node locally look for deviating nodes.Performance of this framework reduces due to increase in number of nodes and with constraints of time.

Kargl et. al. [8] presented detection of selfish nodes by developing Mobile Intrusion Detection System (MobIDS).This architecture includes threshold detection node that trigger an alarm when it detects a certain number of packets being dropped by a node within a certain time frame. Problem with this system is manual implementation for getting good results. Thresholds need to be set manually, which is practically infeasible.

A Secure and Objective Reputation-based Incentive (SORI) scheme was proposed by Khosla [9]. It targets non-forwarding misbehaviour type and uses a Watchdog-like mechanism for monitoring The reputation system keeps count of the packets forwarded both by and for neighbouring.It involves punishment mechanism to control congestion and calculating reputation of nodes.

Michiardi & Molva, [10] presented Collaborative Reputation (CORE) mechanism for enhancing cooperation among nodes in MANETs. It uses reputation mechanism and monitoring technique. In this mechanism as a node enters a network and starts transmitting packet reputation value starts decrementing until it reaches a null value, which corresponds to a neutral behavior meaning that it is niether a misbehaving entity nor a cooperating entity But such typeof schemes may demoralize nodes as compare to award based schemes.

Rebani et. al. [11] proposed a trust model for developing reputation concept. This model provided mechanism for diminishing attacks to the system that can be caused by incorrect packet forwarded by a malicious node. However routing path maintenance has not been paid attention in this work and stil needs to be incorporated.

Mohammed et. al [12] proposed a solution for balancing resource consumption of Intrusion Detection System (IDS) among nodes. In this the network is considered as a set of clusters and leader is elected for every cluster. Here nodes participate in the election process and to address selfish behaviour of other nodes. Incentives are provided in form of reputation to encourage the nodes. However as the size of cluster increases cost of leader election also increases imposing burden on the system.

Saravanan et. al [13] presented a framework to cope up major challenges of distributed MANETs such as security, mobility, scalability, reliability and trustworthy communication. This framework presented simulation for various services metrics. But some areas like scalability and self configuration are still left.

Next Section explores applicability of mobile agents in MANETs.

2.2 Selfish behaviour detection strategies based on Mobile Agents.

Mobile Agent is a program segment which is self controlled. They navigate from node to node not only transmitting data but also doing computation. They are an effective paradigm for distributed applications, and especially attractive in a dynamic network environment such as MANETs. Researchers have sensed appeal of mobile agents and proposed mobile agent based frameworks. Critical review of relevant listerature is provided here.

Marwah et. al [14] have presented Ant-AODV hybrid routing technique that uses Ad Hoc On-Demand Distance Vector (AODV) routing protocol with a distributed topology discovery mechanism using ant-like mobile agents that are able to achieve reduced end-to-end delay compared to conventional ant-based and AODV routing protocols. This protocol is beneficial for MANETs where frequent topological information is required and DSDV is not suitable. However, this mechanism suffers from cost overhead involved in maintaining many routing tables.

Migas et. al. [15] presented Mobile Agents For Routing (MARIAN) framework that investigates the degree of suitability of mobile agents in routing, topology discovery and automatic network reconfiguration of ad-hoc wireless networks.This scheme has ignored security issues and time constraints of packet transmission.

Bindhu [16] has proposed constraint based routing algorithm deploying MAS. It is designed for achieving stability and reducing probability of link failure.

Barman & Chaki [17] present Mobile Agent based detection of selfish nodes (MADSN). Here a node may interact with its immediate or indirect neighbors. However this mechanism doesn't discuss scalability and congestion control in MANETs.

Sinha et. al. [18] presented Cluster Oriented Agent based Routing protocol CLAR for MANETs. This work uses Ant colony Optimization technique. In clustering paths are recorded between clusters instead of nodes. It is important to have reliable and stable cluster head for reducing routing overheads and to enhance performance of scheme.

From above literature review it is clear that selfish behavior of nodes is a critical problem in MANETs and is an open research issue. This work presents mobile agent based scheme to minimize the same. Next section elaborates the proposed framework.

3. Proposed Framework

This work proposes an agent based mechanism to detain selfish behavior of nodes in MANETs. This mechanism is termed as Master Directed Incentive based Approach (MDIA) that aims to detect emerging selfish behavior among nodes and detains the same by motivating the nodes with diminishing energy levels. It assumes that every mobile node is embedded with a mobile agent to support MANET formation and collaboration. Since mobile agent is a small software component it may be easily embedded in the existing mobile devices and wouln't required any additional hardware support. Mobile agents embedded inside the nodes may play either the role of master agent or mobile node agent. Whenever a node initiates communication in MANET, it becomes a master node for a while, till the new master node is elected. Its agent takes up the role of master agent. master agent is responsible for following tasks;

- Periodic refreshing of energy table of nodes.
- Periodic analysis of packet_info table of nodes
- Preparing dynamic routing tables and detaining selfish behaviour among critical energy nodes by sending packets in 2:1 ratio.
- Periodically updating incentive table

This framework works in two phases:

1. ***Selection of master_node for the MANET:*** Considering the above mentioned jobs of the master node, it is necessary to have a node with sufficient battery life to be the master. However, it is difficult to stick to a particular value as sufficient battery level since in dynamic environments we can not expect to have nodes meeting our demands. Thus simplest strategy is to elect node with highest remaining battery life as the master node. For this purpose mobility feature of the agents becomes useful and the initiator node's agent travels to all its neibhours and collects status of battery life of all participating nodes in MANET. With this information, the node having longest remaining battery life is elected as master node and is informed about the same. Then it takes over the network for further communications.
2. ***Detecting critical nodes and detaining selfish behavior:*** Once actual master node has been elected in the MANET, it takes control for facilitating communications. For this purpose it maintains energy_table and status_table for all participating nodes as discussed below:

- *Energy Table*: Since battery keeps on decreasing with passage of time, and it is the key criteria for holding master node status, thus master node creates and maintains an energy table to indicate energy status of each participating node. For creating and maintaining this table, master agent can move to all devices and collect required information.This process is repeated periodically and energy level of nodes is analyzed every time, in case a new node having more energy enters in MANET it is elected as new master node in next iteration of energy table updation.
- *Status Table*: This table reflects the record of a node's participation in communication and incentive points earned by a node. Every node maintains a table of all packets received or forwarded by it. Master agent collects this packet transimission information of all nodes by traversing the network periodically. An incentive of 5 points/packet for normal nodes and 10 points/packet for critical nodes is provided to every participating node.These incentive points being the motivation for detaining selfish behavior, here it is assumed that they lead to half number of free sms in the credit of that mobile node.

Next section provide details on working of proposed framework.

4. Working of Proposed Framework

The proposed framework aims towards detecting selfish nodes and detaining their selfish behviour by encouraging them. To illustrate the mechanism let us consider that five nodes n1, n2, n3, n4, n5 forms a MANET. Node n1 wants to send some packets to n5. n1 is initiating the communication so it will become temporary master node (Temp_MN) . Temp_MN then initiates phase 1 as shown in Figure 1 below:

Phase 1: Electing the Master Node

(i) On initiating Phase 1, Temp_MN gathers information of its neibhours, visits them and collects their energy status information in its energy table. Fig. 1 given below shows this.

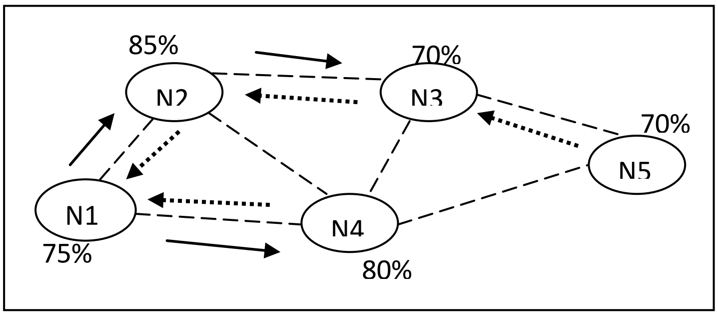

Fig. 1 Collecting Energy Information

(ii) It feeds its own energy information also in the energy table.

(iii) Selects the node with highest energy level, elects it as new master node (New_MN) , informs the same to concerned node and passes energy table to it.

Fig-2 given below indicates formation of energy_table at node N1. N1 then analyzes energy_table and elects N2 having highest remaining energy level, as NEW_MN. N1 informs N2 about its New_MN status and passes energy_table to it for future usage.

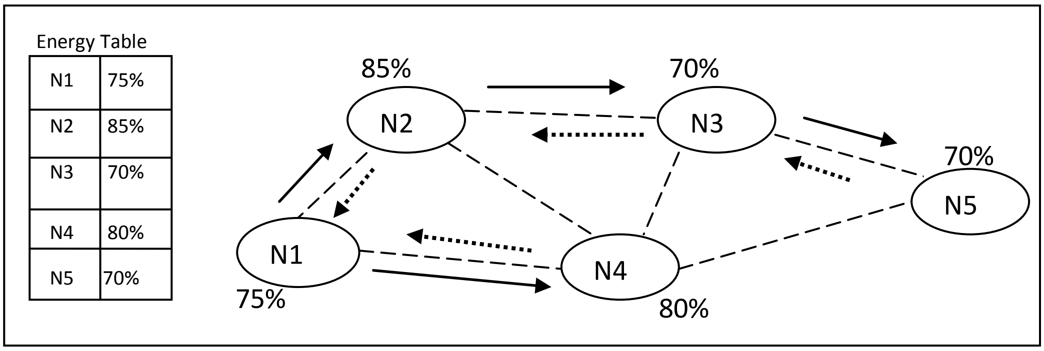

Fig. 2 Energy_Table Maintenance

Phase 2: Detecting and Detaining Selfish behavior of nodes

In phase 2 New_MN i.e N2 prepares status table and maintains energy table of the network. Status table is a comprehensive table indicating participation status of a node, by indicating how many packets a node has forwarded in a unit amount of time. In wireless communication when packets are received and forwarded by a node , it keeps record of the same in a table maintained locally termed here as packet_info table. If a node is receiving a packet in MANET, it is received from some source and has a specified destination, its information is being stored in packet_info table, however if it is not forwarded further then its record is not there with the adjacent neighbours of that node.

To detect selfish behavior emerging in a node, New_MN preodicallly analyzes packet_info tables of all nodes in MANET. Packet_infor table contains information for every packet received or sent by a node. New_MN agent moves to all nodes and copies enteries of packet_info table in its own status table. Fig 3. given below illustrates this concept.

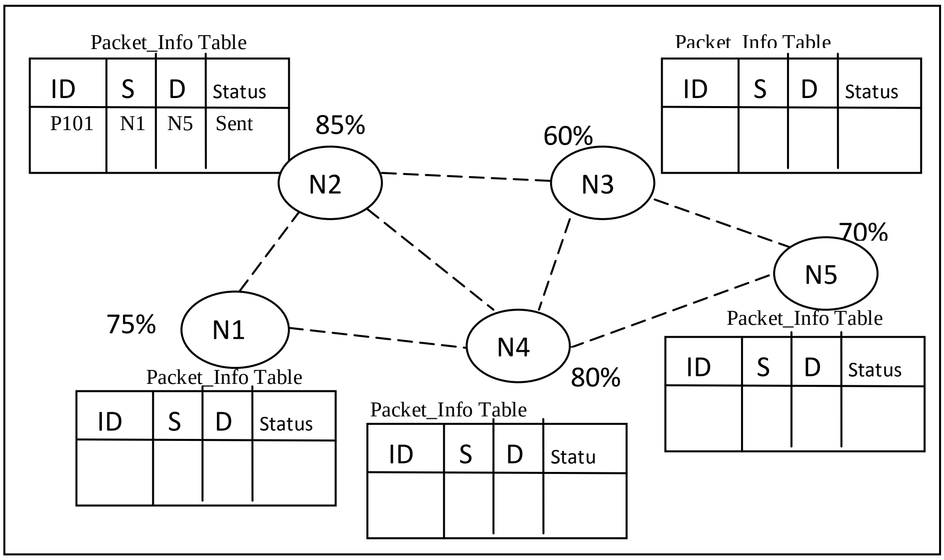

Fig. 3 Packet_Info Table Maintenance at Node Level in MANET

- Preparing Dynamic Routing tables and detaining selfish behaviour by sending packets in 2:1 ratio.

Those nodes that have less energy level are assigned less Load For example if packets are to be transmitted from node N1 to N5 and energy level of N3 is diminishing in that case N3 can stop transmitting packets towards N5 and can behave in selfish manner as observed from table 1 given below. Now to detain selfish behavior of N3 New_MN creates new routing table dynamically so as to transmit less packets through path containing N3. In that case packets can be transmitted in 2:1 form. It means 1 packets should be transmitted on way n2->n3->n5 and 2 packets are to be transmitted on way n2->n4->n5. Fig 4 provides the energy level of nodes in MANET in next time period.

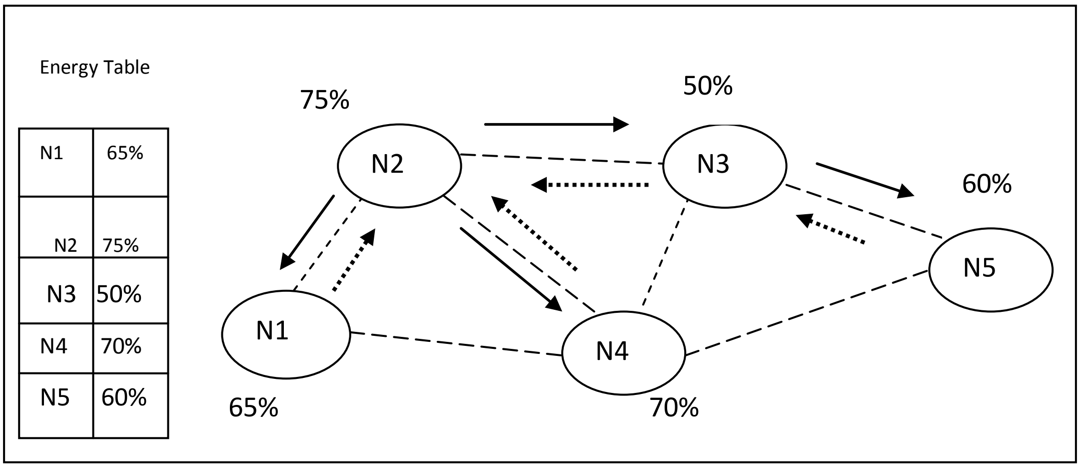

Fig. 4 Updating Energy Table

Status table contains node no., energy level, packet transmitted per second ,state of node and incentive points earned.

Table 1. Status_Table

Node No.	P_ID	Source	Destination	P_status	Energy Level	State	Incentives.
N1	P101	N1	N5	Sent	65%	Normal	
N2	P101	N1	N5	ReceivedN1	75%	Normal	
N2	P101	N1	N5	Forwrded N3	75%	Normal	
N3	P101	N1	N5	Received N2	50%	Critical	
N4	P203	N2	N5	Received N2	70%	Normal	
N4	P203	N2	N5	Forwarded N5	70%	Normal	

N3 is not forwarding packets as its energy level is diminishing

Fig. 5 given below provides the dynamically adapted routes for packet transmission.

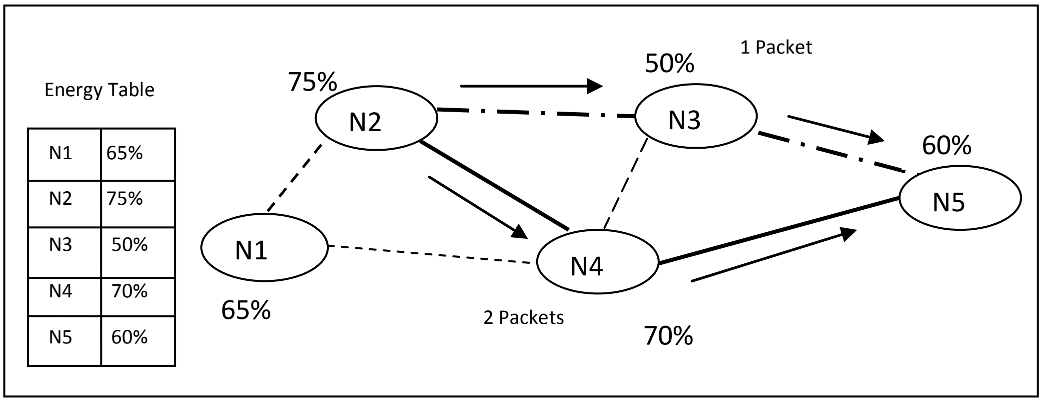

Fig. 5 Adapting Dynamic Routes for Load Adjustment

Routing table ginen below presents various routing paths in MANET along with active and critical path. An active path is the one currently being used. A critical path is the one containing critical nodes. A critical node is the node having energy less than or below a fixed threshold, in this case threshold value is 50%. Node start turning selfish on reaching critical energy level, however they may be motivated for participation to some extent, say till energy level reaches 35%. For motivating critical nodes they are assigned less load and more incentive points as compared to normal nodes. Incentive points are calculated as follows:

Incentive points= I_value* number of packets transmitted

Where $$\begin{Bmatrix} I\_value = 5 \forall nodes \in status = normal \\ I\_value = 10 \forall nodes \in status = critical \end{Bmatrix} \quad (1)$$

Table 2 given below illustrates Routing table maintained by New_MN so as to send packets in 2:1 ratio

Table 2: Routing Table

Routing Paths	Active Paths	Critical Path
N1→N2→N3→N5		
N1→N4→N5		
N1→N2→N4→N5		
N2→N3→N5	N2→N3→N5	N2→N3→N4
N2→N4→N5	N2→N4→N5	
N2→N4→N3→N5		
N3→N5		
N3→N4→N5		
N4→N3→N5		
N4→N5		

Let us assume nodes N1 to N5 forward number of packets as shown in Table 3 below:

Table 3: Packet Sent Info Table

Node No.	No. of Packets	Sent Status
N2	6	6
N3	2	2
N4	4	4

Table 4. given below indicates the status table containing incentive values calculated using eq (i) based on number of packets forwarded and state of the node.

Table 4: Updated Status_Table

Node No.	**P_ID**	**Source**	**Destination**	**P_status**	**Energy Level**	**State**	**Incentives.**
N1	P101	N1	N5	Sent	65%	Normal	**30**
N2	P101	N1	N5	ReceivedN1	75%	Normal	**30**
N2	P101	N1	N5	Forwrded N3	75%	Normal	**30**
N3	P101	N1	N5	Forward N5	50%	Critical	**20**
N4	P203	N2	N5	Forward N5	70%	Normal	**20**

Next section provides the algorithms for various agents involved in the proposed mechanism.

5. Algorithms

Figure 6(a) & 6(b) given below provide the algorithms for Temp_MN() and New_MN() respectively.

```
Temp_MN()
Input: NODEi ;
Output: NEW_MN;
Action: Activate, Sleep;
{ for (j=1,n)
do
 {get (NODEi);
get (energy_level (node_i));
put (energy_level (node_i)→energy_table;
} }
set max=energy_level_i ;k=i;
for (j=i+1, n)
{if (energy_level_j>max);
  set max= energy_level_j ;
k=j; }
 set New_MN= Node_K;
send Node_K (New_MN_ status);
send New_MN ← energy_table;
}
```

Figure 6(a) Algorithm for Temp_MN()

```
New_MN( )
Input: New_MN_status; Energy_table;
Output: Critical path (node_i);
Action: Activate, Sleep;
{ On (input)
  { Create status_table;
     update energy_table;
       set threshold_energy=50%;
    for (i=1,n)
    {  if (energy_level(node_i)<threshold_energy)
      { Set state(node_i)= critical;
         for critical(node_i) ∈ path_i set status_path_i=  critical ;
              incentive(node_i)= 10* total_packets_sent;
    }
    else { Set state (node_i)=normal;
              incentive=5*total_packets;}
}
Update status table; }}
```

Figure 6(b) Algorithm for New_MN()

6. CONCLUSION

Selfish behavior of nodes is a critical problem in MANETs. When nodes have dimishing energy levels they start turning selfish and stop participating in communications. This work presented an agent based mechanism for detecting and detaining selfish behavior of nodes in MANETs. This mechanism is based on the strategy of providing incentives to nodes for their participation and amount of incentive is being increased for nodes having critical energy level so as to motivate them. Embedding nodes with mobile agents also reduces energy consumed in MANET status maintaince tasks, since master agent travels itself and collects desired data on its own. Thus this mechanism contributes towards optimal utilization of energy available with nodes and also detains their selfish behavior. However, some variations of MANETs have been left as part of future work.

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