AN IMPROVED PAYMENT MODEL TO ENHANCE COOPERATION IN MANET

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Abstract

Mobile Ad-Hoc network is a peer to peer network in which nodes are equally responsible for forwarding and routing. If a node drops packet of others it is called packet dropping attack or selfish misbehavior. We have several solutions to minimize packet dropping attack such as reputation-based mechanisms and incentive-based mechanisms. In the incentive-based mechanisms a successful forwarding will be counted and senders must be rewarded by virtual money or credits. Existing incentive-based mechanisms have limitation in terms of message size and range. If a sender wants to send a message whose size comes within a small range then, the question arises that why sender has to pay a fixed amount of virtual money while transferring some small message. In order to enhance the flexibility for sender node we have proposed credit management in more flexible manner. In the proposed Enhance Payment Model (EPM) the sender has to pay variable types of credit for sending a message through intermediate nodes and this credit is totally depends upon the size of messages. Our method reduces the overburden of sender node because the intermediate nodes are assigned credits that follow a particular pattern. The nodes following the sender node is allotted a certain credit value α, and the subsequent nodes are given values a fixed amount 2β less than the previous ones. Thus, the first node has value α, second node has α-$\gamma\beta$; third has α-$2\gamma\beta$ and so on. The nth node will have the credit value α-(n-1) $\gamma\beta$. Where γ is any other variable and the value of γ is always belongs between the range $0 \leq \gamma \leq 1$. Simulation results shows that the proposed model reduces the overburden of sender node more than 20%.

Keywords: enhance payment model (EPM), credit, virtual money, incentive-based mechanism, packet dropping attack, peer to peer network

1. Introduction

A Mobile Ad-Hoc Network [1-5] is a form of Ad-Hoc network that can change locations and build up itself anytime and everywhere in dynamic fashion. This type network can utilize any medium such as a Wi-Fi connection, a cellular or satellite transmission.

The main applications of MANET have been used for military and some emergency situations where it is impossible to create a network with any existing infrastructure [20-21]. Because in such type of application all the nodes within that network belongs to a single authority and they have a common goal. Therefore, the aim of this network is to make all nodes co-operative. But some kind of non-cooperation occurs into this network and it may be because of the nature of nodes. These nodes are known as selfish node. Selfish node is economically rational node which wants to preserve or maximize their own welfare and utilize the resources of other nodes.

We have several solutions to minimize packet dropping attack or selfish misbehavior such as reputation based mechanisms and incentive based mechanisms. In the incentive based mechanisms a successful forwarding will be counted and senders must be rewarded by virtual money or credits. In this scheme, to forward a message it will incur some cost to the sender, and a selfish node will need incentive to forward other's message. Here, the costs will be in the form of frequency, bandwidth or energy. Existing incentive based mechanisms have limitation in terms of message size and range. If a sender wants to send a message whose size comes within a small range then, the question arises that why sender should have to pay a fixed amount of virtual money while transferring some small message. In order to enhance the flexibility for sender node we have proposed credit management in more flexible manner. In the proposed Enhance Payment Model (EPM) the sender should pay variable types of credit for sending a message through intermediate nodes and this credit is totally depends upon the size of messages. In this paper we have reduced the overburden of sender node because the intermediate nodes are assigned credits that follow a particular pattern. The nodes following the sender node is allotted a certain credit value α, and the subsequent nodes are given values a fixed amount 2β less than the previous ones. Thus, the first node has value α, second node has $\alpha-\gamma\beta$; third has $\alpha-2\gamma\beta$ and so on. The nth node will have the credit value $\alpha-(n-1)\gamma\beta$. Where γ is any other variable and the value of γ is always belongs between the range $0\leq\gamma\leq1$. Simulation results shows that the proposed model reduces the overburden of sender node more than 20%.

The sections of the paper are organized as follows. Section 2 presents review of literature. Section 3 discusses proposed Enhance Payment Model. Simulations and evaluations are shown in Section 4. Finally, Section 5 concludes the paper.

2. Literature Review

SPRITE system was proposed by Zhong et al. [6] which is a simple cheat-proof, credit based system for stimulating coordination among selfish node in Mobile ad-hoc-network. It is incentive based scheme. The SPRITE system consists of Credit Clearance Service (CCS) and a collection of mobile devices. In this system all nodes are accoutered with a network interface that allow node to send and receive messages. According to this system's mechanism, when a node receives a message from the sender node or their successive node, the node kept a receipt of the message and when node get a fast connection to a CCS, it reports to the CCS the messages that it has received/forwarded by uploading its reports. After that the CCS determines the charge and credit for each node, based upon the reported receipt of message. SPRITE system has three types of limitations. Firstly, there is an excessive burden on sender which loses credit for forwarding of its message, secondly there is no provision for punishment scheme for selfish node and lastly, there is also an ambiguity between the nodes as to which one is selfish node.

Stimulating cooperation in self organizing MANET [7] was proposed by Buttyán and Hubaux in 2003 which had main concern on packet forwarding and the system also introduced the issue of catalyzing cooperation in self organized mobile ad hoc network for public applications. This approach has the application of security module. This security module maintains a nuglet counter. When the node sends a packet for the benefit of other nodes, the nuglet counter increases itself to 1 and vice versa. There is a requirement possessed for to maintain a positive counter value so that it can be able to send its own data. This approach ensures that the misbehavior is not beneficial and hence it should occur rarely only. But the availability of hardware module is not guaranteed in general.

Auction based Ad-hoc On-demand distance vector protocol [8] was proposed in 2007 by Demir and Comaniciu. It was another credit based system. This uses digital economy to deal with selfishness in the network i.e. a virtual economy. In this virtual economy system, the source node has to pay some amount of digital currency to intermediate nodes to have its packet forwarded and whereas the intermediate nodes bid and declare the amount of currency that they require from the source if they are able to forward the packet. According to the bid's request the source node is able to make selections among different routes in the network with minimum currencies. The source node sends the payment with the lowest bid. The source node sends the payment with every packets and payment is set in such a way that every node gets a payment.

MODSPRITE [9] system was developed for the purpose of modifying the SPRITE [6] system. This system focuses on many limitations of the SPRITE system. Such as: Detecting the selfish node with the use of neighbor monitoring mechanism, To minimize the overburden of sender node and this system also give some punishment to the selfish node. MODSPRITE system uses a cluster head instead of CCS or any other tamper proof hardware. A cluster head provide services and manages credits and debits into the network and this is done by receiving a receipt from different intermediate nodes. At first, for the sender to forward its message it is necessary that each node has a fixed amount of credit. In case of sending message to the destination node the source will lose some credit and the credit will be earned by intermediate nodes which are responsible for forwarding the message. To earn more credit, a node must forward other's message. There is some limitation of MODSPRITE, while using the payment system such as it does not provide much flexibility to minimize the burden of sender i.e.it provides only a fixed number of decrements of burden to the sender and which is approximately equal to 24%.

David et al. [10] proposed Monetized Ad-hoc Routing System that present fit nodes earn reputation points that can be traded. It uses cryptographic mechanism to find reputation using composite signatures. It is a decentralized reputation tracking and trading system.

Bounouni et al. [11] proposed Adaptive credit-based stimulation scheme capable of detecting smart selfish nodes in mobile ad hoc network. It is a new adaptive credit-based stimulation scheme (NADS). In this scheme, nodes maintain a credit-account for its neighbors. The reward is given to

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nodes on the basis of cooperation level. This method creates lots of overhead in detection and exclusion.

Several game theoretic and models were proposed for the cooperation in MANET. A coalition game model for cooperation in mobile ad hoc networks (MANETs) [12] is proposed to mitigate the negative impact of topology changes on node cooperation using coalition formation. It uses reachability as the base for computing payoff model, but it suffers from extra overhead in calculating the payoff.

A Bayesian-Signaling game model [13] for analyzing the behavior of regular and malicious nodes has been proposed. This model increases the utility of normal nodes and reduces the utility of malicious nodes. This system employs a reputation system for stimulating cooperation between both types of nodes. The regular nodes behavior is examined by calculating belief system using Bayes-rules. This algorithm provides better identification of malicious nodes but suffers from extra overhead in calculating the belief using Bayes-rules.

3. Proposed system

This kind of node's misbehavior can be handled by two different techniques. First technique is to give reward to the node for their best performance according to forwarding other's message and second technique is to give punishment to node for being selfish. There are many pre-existing detection schemes available which are classified into two categories on the basis of OSI layers i.e. MAC layer based detection scheme and Network layer based detection scheme. Network layer based detection scheme are categorized into two types: Reputation based scheme and credit based scheme. Our research paper is working on credit based scheme. Credit based schemes provides incentives to nodes which perform network function correctly and this can be done by giving some kind of credit to nodes i.e. virtual currencies in the form of frequencies, Bandwidths etc. Some of pre-existing credit based schemes are:

- SPRITE
- Stimulating cooperation in self organizing MANET
- Auction based Ad-hoc On-demand distance vector
- MODSPRITE

3.1 Overview of MODSPRITE System

MODSPRITE [9] was the latest system proposed for the purpose of detecting selfish node in mobile- ad-hoc network and it is the modified version of SPRITE [6] system. Fig. 1 gives a small architectural overview of this system. In this system there are many nodes which are communicating with a single node i.e. cluster node which is able to provide credit and debit of charges to nodes when they receive/forward messages to other nodes. The main objective for using cluster head is to minimize the burden of temper proof hardware or Credit Clearance Service (CCS). In MODSPRITE system at the beginning each node has a fixed amount of credit which is the essential requirement for the sender to forward its message to other nodes in the system. Some credit is lost by the sender node when it sends a message to the other node. This credit goes to the intermediate nodes forwards the message. So, if a node wants to earn more credit, then it should do the work of forwarding the messages of other nodes.

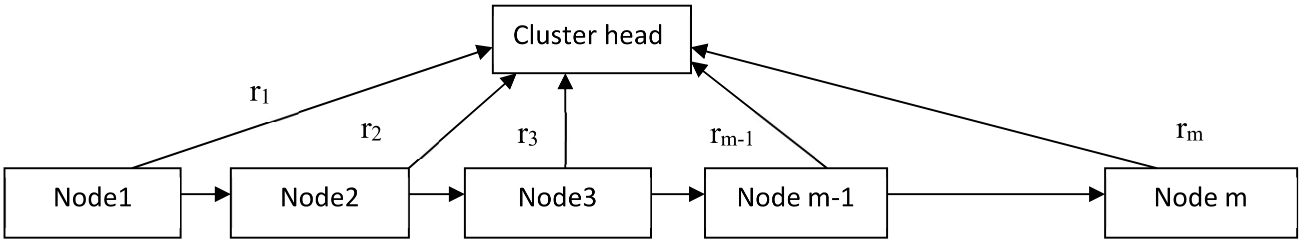

Figure 1: Architecture of MODSPRITE system

All nodes inform the forwarding of data packet to cluster head in the form of small message called receipts which contain the information like forwarding node address, destination address and the number of bytes that are sent. For example, in the figure1, node n1 send r1 receipt, node n2 send r2 receipt and so on. All Nodes communicate with the cluster head after transferring their data and cluster head serves their credit. Only sender loses their credit to forward their message.

MODSPRITE system was mainly focusing to detect the selfish node by the use of neighbor monitoring mechanism. Thus, it minimizes the burden of sender and solves the stage of ambiguity. MODSPRITE also overcome the problems of SPRITE system by reducing the overhead of sender by decreasing the incentive given by sender. It gives punishment to selfish nodes by encouraging co-operative nodes and discourages non co-operative nodes.

3.2 Reducing overburden of sender

In MODSPRITE [9] system to minimize the overburden of sender node the intermediate nodes are allotted credits that follow a particular pattern wherein the nodes following the sender node is given a certain credit value α, and the following nodes are given values a fixed amount β less than the previous ones. So, the first node credit value α, second node credit value has α-β, third node credit value α-2β and so on. The nth node credit value is α-(n-1) β as shown in Fig. 2.

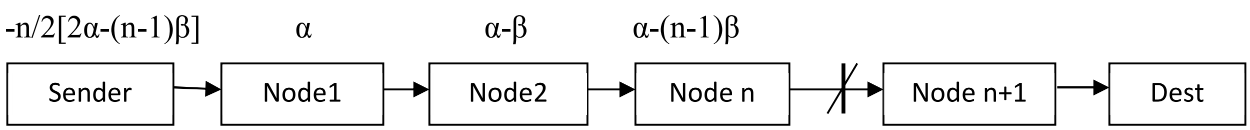

Figure 2: Illustration of payment system in MODSPRITE system

At this point α is measured to be 1 and β is measured to be (α/2n). In this scheme minimum credit to be assigned to send data from source to destination is [1/4 (3n+1)]. As a result, the load on sender becomes [1/4 (3n+1)] as n+1th node drops the packet.

3.3 Limitation of MODSPRITE system

There is some limitation of MODSPRITE, while using the payment system such as it does not provide much flexibility to minimize the burden of sender i.e.it provides only a fixed number of decrements of burden to the sender and which is approximately equal to 24%.

3.4 Proposed modification

Suppose the sender node has different messages of different sizes and it want to send that message to a known destination via intermediate nodes. According to Enhance Payment Model (EPM) the sender should pay variable types of credit for sending a message through intermediate nodes and this credit is totally depends upon the size of messages. Thus, it enhances flexibility for minimizing the Overburden of Sender.

In MODSPRITE system it only reduces a fixed amount of burden for the sender node i.e. 24%. In order to enhance the flexibility for sender node we have proposed credit management in more flexible manner. For example, if sender wants to send a message whose size comes within a small range. So, the question arises that why the sender has to pay a fixed amount of virtual money while transferring some small message.

To lower the overload of sender node, allocation of credit is done to the intermediate nodes that follow a specific pattern wherein the nodes following the sender node is assigned a fixed credit value α, and the subsequent nodes are given values a fixed value γβ less than the previous ones. Thus, the first node has value α, second node has α-γβ; third has α-2γβ and so on. The nth node will have the credit value α-(n-1)γβ as shown in Fig. 3. Where γ is any other variable and the value of γ is always between the range $0 \leq \gamma \leq 1$. Applying this pattern to the different intermediate nodes we can minimize the overburden of sender more than 20%.

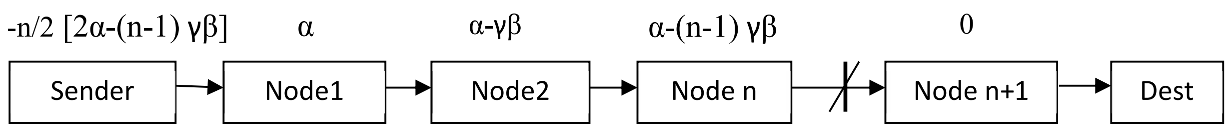

Figure 3: Illustration of Enhance payment Model in SPRITE system

At this point, α is measured to be 1 and β is measured to be (α/2n). In this model minimum credit to be assigned to send data from source to destination is [(1/4) [4n - γ(n+1)]. Thus, the load on sender becomes [(1/4) [4n - γ(n+1)] as node n+1th node drops the packet.

3.5 Formal Specification of Message

In this work we have used the public-key cryptosystems (RSA) for secure data transmission. For sending a payload we have used the SPRITE [6] specification. say node a_0 send (m, p, $s\Delta_0$, s) to destination d_0 via next hop a_1 where m is payload, p is path and $s\Delta_0$ is sequence number. At the destination the received message is decoded and verified in the same way as discussed in SPRITE [6]. Say if the received message is (m, p, sΔ, s) then it is verified on the basis of path *p* and sequence number sΔ. The received message is accepted on the basis of sender's signature.

4. Simulation and Evaluation

In order to investigate the validity of the proposed models, the proposed network is simulated using GloMoSim simulator [14, 15]. We have defined a Certification Authority (CA) responsible for assignment of Digital ID. On receiving message nodes keep a receipt of the message. Our work assumes that nodes have the entire path information of the destination node which is calculated using the secure Dynamic source Routing (DSR) Protocol [16]. Our work uses the protocol stack of GloMoSim. The fundamental protocol for this work is DSR, the implementation considers the plain DSR (PDSR) which is the original DSR and the modified DSR, named MOD-DSR. The architecture of the proposed model is shown in Fig. 4 and the layer wise structure of GloMoSim for each node is shown in Table 1.

TABLE 1 LAYER WISE STRUCTURE OF GLOMOSIM

Node1	
Layer	**Protocol**
Physical	Free space
Data Link	802.11
Network	DSR
Transport	TCP
Application	FTP

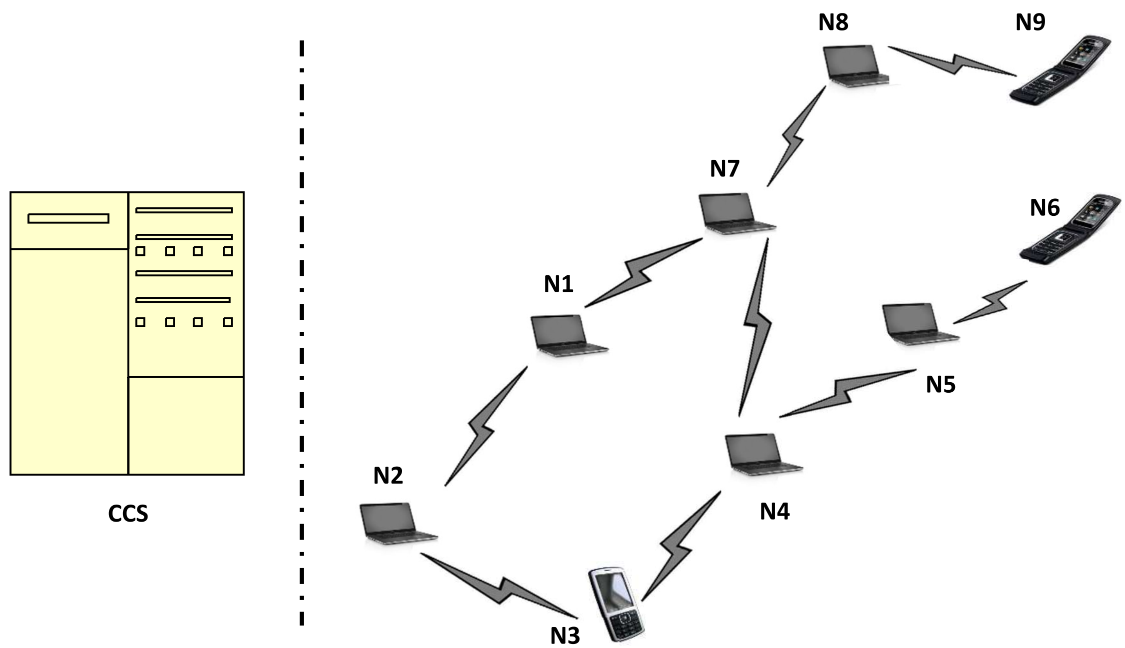

Fig. 4. Architecture of the proposed model

4.1. Simulation environment

For simulation in wireless ad hoc network we have used the GloMoSim, a scalable network simulator [14, 15]. Table 2 shows the parameters and configurations of nodes used in the simulation.

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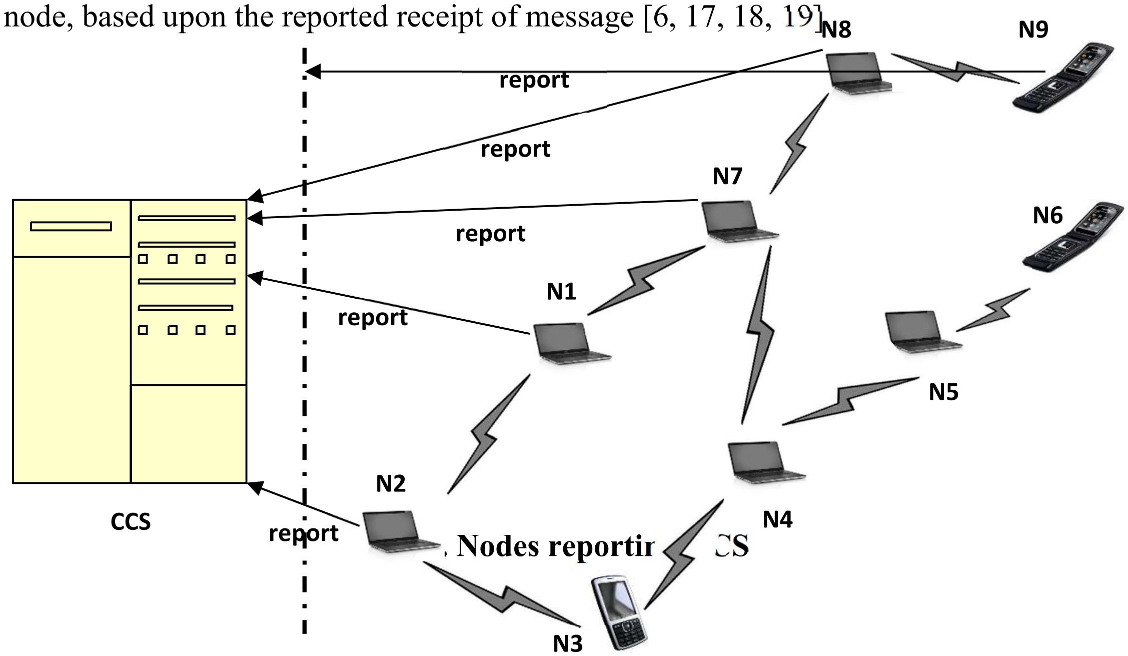
TABLE 2 SIMULATION PARAMETERS

Parameters	Values
SIMULATION-TIME	16M
TERRAIN-DIMENSIONS	(1000, 1000)
NUMBER-OF-NODES	121
NODE-PLACEMENT	RANDOM
MOBILITY	RANDOM-
PROPAGATION-PATHLOSS	FREE-
MOBILITY-WP-PAUSE	30S
MOBILITY-WP-MIN-SPEED	0
MOBILITY-WP-MAX-SPEED	10
MOBILITY-POSITION-	0.5
PROMISCUOUS-MODE	YES
ROUTING-PROTOCOL	DSR

4.2. Credit Clearance Service

In this system all nodes are accoutered with a network interface that allow node to send and receive messages. According to this system's mechanism, when a node receives a message from the sender node or their successive node, the node kept a receipt of the message and when node get a fast connection to a CCS [6], it reports to the CCS the messages that it has received/forwarded by uploading its reports as shown in Fig. 5. After that the CCS determines the charge and credit for each node, based upon the reported receipt of message [6, 17, 18, 19].



. Nodes reportir CS

4.3. Working of the proposed model

The traffic is generated using FTP, for generating FTP traffic in GloMoSim [14, 15] the command is

FTP 0 1 10 0S

Here, node0 send 10 items to node1 at the beginning of the simulation.

The mobility and node input file in GloMoSim with parameters is as follows

```
MOBILITY.IN
# mobility trace format:
# node-address simclock destination(x y z)
# All lines for a node must be sorted in time increasing order.
10 100S (200.0, 150.0, 0.2)
10 200S (200.0, 150.0, 0.2)
10 500S (250.0, 250.0, 0.1)
10 800S (200.0, 280.0, 0.5)
10 900S (300.0, 310.0, 1.0)

NODES.INPUT
# NODE-PLACEMENT-FILE
# Format: nodeAddr 0 (x, y, z)
# The second parameter is for the consistency
# with the mobility trace format.
#
0  0 (20.2,  0.9, 0.11)
1  0 (20.3, 30.8, 0.01)
```

We have minimized the overhead sender node, because the allocation of credit is done to the intermediate nodes that follow a specific pattern. The nodes following the sender node is assigned a fixed credit value α, and the subsequent nodes are given values a fixed value γβ less than the previous ones. Accordingly, the first node has value α, second node has α-γβ, third has α-2γβ and so on. The nth node will have the credit value α-(n-1)γβ. Where, γ is any other variable and the value of γ is always between the range $0 \le \gamma \le 1$. The 'C' language function for calculating burden on sender and the burden data generated by the function is shown in Fig. 6 and 7 respectively. In this model minimum credit to be assigned to send data from source to destination is [(1/4) [4n - γ(n+1)]. Figure 8 shows the burden of sender in EPM and MODSPRITE.

```
void eps(int n){
float i;
float tc,gm=0.0, tc1;
printf("\t\t\t\t   EPM  | MODSPRITE\n");
printf("\t\t\t\t -------| ---------\n");
for(i=1;i<=n;i+=0.5){
tc=0.25*(4*i-gm*(i+1));
tc1=0.25*(3*i+1);
printf("\t\t\t\t%7.4f | %7.4f\n",tc,tc1);
gm=gm+0.1;
}}
```

Fig. 6. 'C' language function for calculating burden on sender

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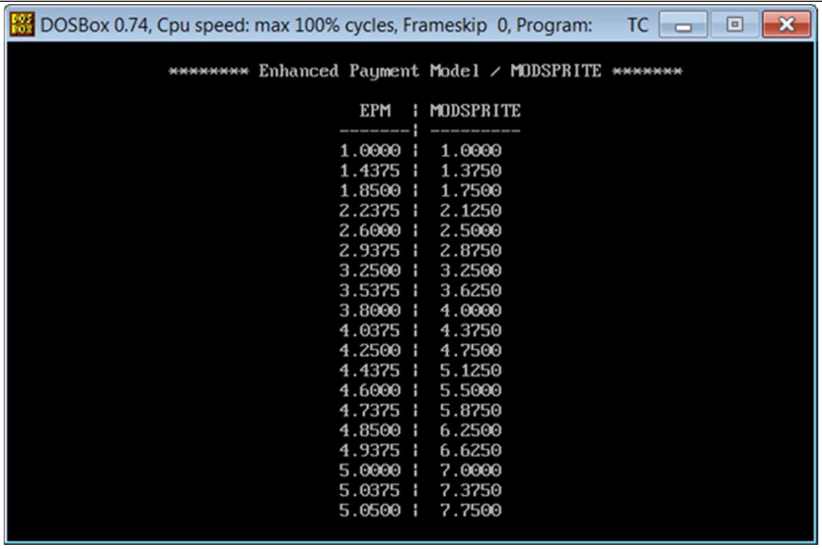

Fig. 7. Burden data generated for intermediate nodes

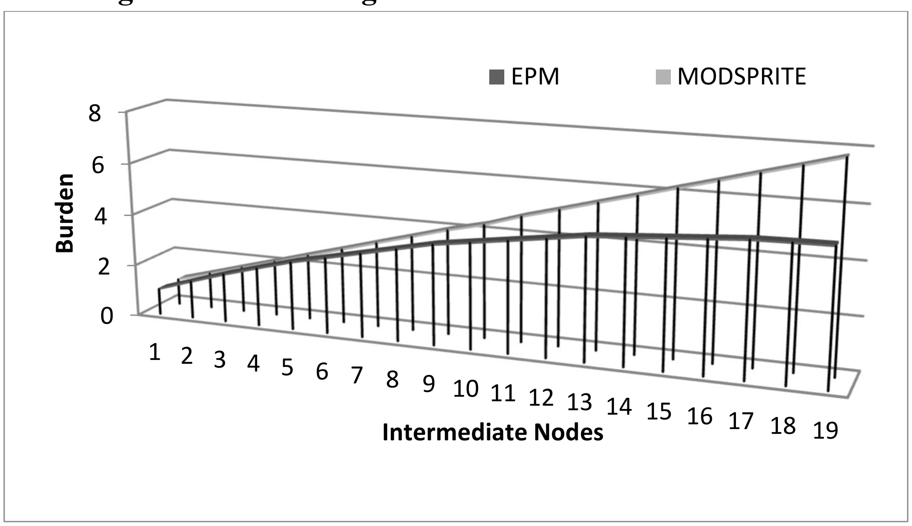

Fig. 8. Burden of Sender in EPM and MODSPRITE

Simulation results show that the proposed model reduces the overburden of sender node more than 20%.

5. Conclusion

To enhance the flexibility for sender node we have proposed credit management in more flexible manner. The proposed Enhance Payment Model (EPM) the sender has to pay variable types of credit for sending a message through intermediate nodes. The credit is totally depending upon the size of messages. Our method reduces the overburden of sender node because the intermediate nodes are assigned credits that follow a particular pattern. The nodes following the sender node is allotted a certain credit value α, and the subsequent nodes are given values a fixed amount 2β less than the previous ones. Thus, the first node has value α, second node has α-γβ; third has α-2γβ and so on. The nth node will have the credit value α-(n-1) γβ. Where γ is any other variable and the value of γ is always belongs between the range $0 \leq \gamma \leq 1$. Applying this pattern to the different intermediate nodes we can minimize the overburden of sender more than 20%.

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