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OPTIMIZING PERFORMANCE OF MOBILE AD-HOC NETWORK USING COOPERATIVE GAME THEORETIC APPROACH

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Abstract: - During recent years, demand of communication is growing rapidly. Duet to this increment in the demand of communication there are various challenges are faced during communication such as throughput, delay etc. In this field of communication, mobile Ad-Hoc networks (MANET) have been proved a promising technique to achieve better communication quality but due to dynamic nature of mobile nodes in MANET, there is a requirement of new approach to improve the performance of network even if node are dynamic.
In this paper, we use game theoretic approach to support QoS in MANET. According to the proposed model, initially a problem is formulated which generates a non-convex problem for MANET. In order to solve this we use game theory approach. For further improvement in the network, we use cooperative approach of game theory. Simulation study is carried out using MATLAB tool. Experimental study shows the improved performance when compared to other protocols.

Keywords: MANT, Throughput, game theory, cooperative approach.

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1. Introduction

During recent years, demand of communication is increasing rapidly because of this ever increasing demand of communication, mobile devices and wireless networks has become growing interesting areas for researchers[1]. Mobile Ad-Hoc Networks are a special kind of wireless network which comprises collection of various mobile devices or mobile nodes. Figure 1 shows the architecture of MANET. These devices make a temporary network. According to MANET concept, mobile devices nodes communicate each other without using any pre-existing architecture [2]. Intermediate nodes are used to establish communication which acts as routers. Thus, mobile nodes act as both host and routers. The addition and deletion of mobile nodes or devices affects routing path which is a key issue resulting in performance degradation in MANETs. Moreover, nodes have regular unpredicted movement which causes various changes in network topology.
Changing network topology, mobility in mobile nodes arises various challenges for researchers to overcome with. These challenges cause performance degradation of network [3]. To overcome these issues, routing is a hot issue of extensive research. There are various approaches have introduced during last decade which

guarantees efficient network performance by improvising Quality of Service (QoS) of the network. In today's scenario, distributed coordination function approach is utilized in IEEE 802.11 networks [4]. This scheme has gained attraction due to its utilization in routing protocols for performance study of MANET network. As we have discussed before, wireless medium, link failure and mobile node movement is a challenging task in MANET performance improvisation. New protocols are designed and standardize to improve the transmission rate in of wireless communication. For QoS enhancement, 802.11e is the most promising protocol which is an international standard and utilized by various vendors and implemented in MAC [5]. V. Timcenko et al [6] analyzed the performance of Dynamic Source Routing (DSR) [7], AODV (Ad-Hoc On-Demand Distance Vector) routing protocols by considering various mobility models. According to the AODV routing protocol, route is selected based on the hop count. During the route selection, weak quality links are not ignored by this routing protocol.

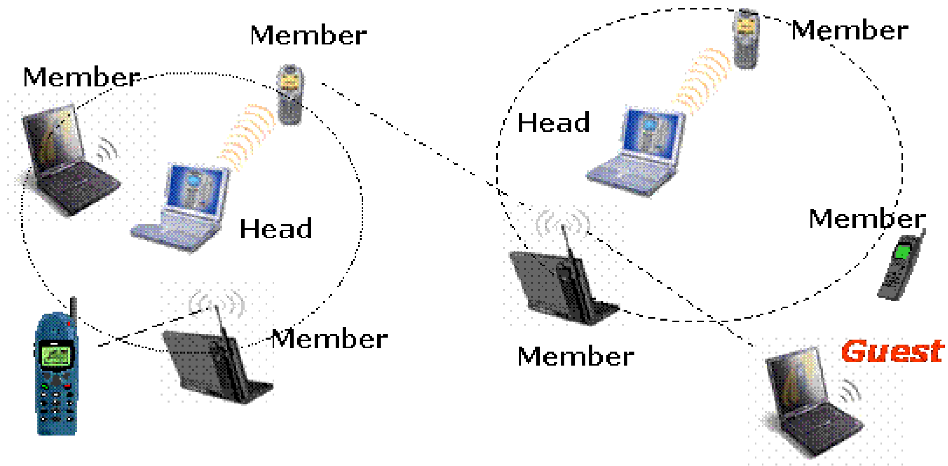

Figure.1. MANET Architecture

For better QoS performance, existing protocols results in unsatisfactory performance. This performance degradation is caused due to computation overhead, routing inefficiency, power consumption etc. To measure the QoS, pre-specified service measurement requirements can be considered, these service measurements are bandwidth utilization, end-to-end delay, packet drop rate and throughput.

There are various issues and challenges present for providing better QoS in MANETs. These issues are discussed in this section. Computational complexity and communication cost increases when QoS provisioning is targeted because it consumes more time for implementing the setup and more time for maintaining the QoS support. Network utilization improvement results in complexity reduction by balancing the state information of network. Still there are various challenges are present which are:

Route maintenance: MANETs contain mobile nodes which are highly dynamic in nature which causes rapid changes in network topology which makes difficulty in route maintenance. Routing paths can get affected during the data processing stage hence it motivates to develop an efficient algorithm for route maintenance which impact on network by obtaining minimal overhead and delay issues [9].

Power supply Limitation: mobile node have power constraint which limits the performance of mobile nodes when compared to wired networks. QoS support consumes more power which is caused due to overhead; this power consumption affects the battery status of the network [10].

Centralized Control: according to the structure of ad-hoc network, any mobile node can join and leave the network without any constraints which changes network configurations so there is a need of controlling algorithm which can assess network for node joining and leaving [11].

Channel reliability: reliability of channel during transmission of data bits in MANET is a key component to support QoS. If the channel conditions are induced with some contamination then it causes bit errors due to channel interference, fading effect and noise issues [12].

Interference in channel: MANETs communicate with each other using a common channel for a provided network topology because of this, interference is caused in communication. In peer-to-peer communications, it can be avoided using global synchronization of clock and using different frequency band for transmitter.

To overcome these issues related to MANETs, here in this manuscript we proposed a new approach for QoS improvement.
The remainder of manuscript is organized as: Section II discuss about proposed model for QoS improvement in MANET networks. Results obtained using proposed approach and comparative study is depicted in section IV. Section V gives concluding remarks.

2. System Model

This section describes about the proposed approach for QoS improvement in MANETs. To support QoS, here we propose evolutionary game theoretic approach. Previous section describes about the nature of MANET where mobile nodes are moving continuously. For proposer packet reception or communication, cooperation is required by the nodes. Presence of the non-cooperative nodes increases the risk of communication failure by inducing various faults i.e. link failure, dead nodes etc. which degrade the performance of network in terms of end to end delay, routing protocol, network lifetime, power consumption etc.
Main aim of this work is to design a new approach which can support QoS (Quality of Service) constraints by applying cooperation among highly dynamic nodes. To address this issue of cooperation for QoS provisioning, in this work we propose a cooperative game theoretic approach. According to game theory technique, each mobile node in MANET is considered as a source of traffic. All notes are assumed to carry a bunch of packets to be transmitted. During the transmission, whether packet is transmitted using same node or different node, consumes energy and resources. So to provide better communication, cooperative approach provides better solution by utilizing cooperation strategy.
This approach of cooperative game theory provides configuration of node and their behaviour which can be utilized to develop a better cooperation scheme between nodes. This strategy provides a solution for each node whether to cooperate with other node or not and provides the robustness to various attacks. In this work we utilize game theoretic approach for modelling the nodes and system performance improvisation by considering distributed environment.
In the following section we model the nodes according to IEEE 802.11 architecture using MAC based protocol.

1. Problem formulation

Initialization of Game $(\mathcal{G})$ using IEEE 802.11 : $\mathcal{N}, \mathcal{S}_p, \mathcal{U}_p, \alpha$

Repetition of multi-stage game with unknown end time

$$\mathcal{N}: \text{Non}-\text{cooperative node}$$

$\mathcal{S}_p : Strategy\ of\ game$

$\mathcal{U}_p = utility\ of\ the\ game\ and\ function\ space$

$$Total\ Utility\ (\mathcal{U}_{total}) = \frac{T_p\left[\left(1-C_p\right)s-c\right]}{Time\_Slot}$$

$$TotalUtility_g = \sum_{n=0}^{+\infty} \alpha^n \mathcal{U}_{total}^n\ (w)^n$$

Where c denotes transmission cost, s is successfully transmitted packets, α discontinuation function, T_p represents the probability of transmission, collision probability is given by C_p during random slot.

Here we formulate a problem of throughput improvising using QoS support in MANET by using flow contention graph. According to MANET scenario, nodes create interference due to the mobility factor. By considering these assumptions, MANET network can be modelled as undirected graph where vertices shows

stations in network and data flow in the network is denoted by edges between vertices. By using this graph a node graph is constructed which avails all the information between links of the deployed network
Flow contention graph is denoted by $\mathbb{G}$ and number of flows in the network are given as $\mathcal{F}$. Hence the set of communication flow can be denoted as mentioned in equation 1. Flow rate is defined as $x_i, i = 1, \dots, \mathcal{F}$.

$$\mathcal{F} = \{f_1, f_2 \dots, f_{\mathcal{F}}\} \quad (1)$$

One flow may belong to several maximal cliques. These relations of belonging can be described by matrix A as follows:
Relationship between cliques and data flow can be defined as eq. (2)

$$\mathcal{F} = \{f_1, f_2 \dots, f_{\mathcal{F}}\} \quad (2)$$

One flow may belong to several maximal cliques. These relations of belonging can be

$$a_{j,i} = \begin{cases} 1, if\ flow\ i\ belongs\ to\ clique\ j, i \in \mathcal{F} \\ 0\ if\ flow\ i\ belongs\ to\ clique\ j, i \in \mathbb{G} \end{cases} \quad (3)$$

The capacity constraints of the flows can therefore be defined as:

$$\mathbb{M}x \leq \mathbb{C} \quad (4)$$

Where $x = (x_1, \dots, x_N)$ denotes flow rate column vector and clique capacity vector $\mathbb{C} = (c_1, \dots, c_{\mathbb{M}})$.

In this manuscript we propose a new approach for cooperation strategy in MANET by considering game theoretic model to enhance the cooperation between nodes. This approach is used and combined with MANET to provide more robust working to MANET such as packet forwarding scheme, path formulation and controlling the topology.

The way of Mobile Ad hoc systems forces the participation among hubs to have a decent exhibitions, however in such systems where hubs are versatile and with vitality constrained, the collaboration methodologies must be right amid figuring CR particularly with hubs which coordinate all the time yet they can be a selfish hubs automatically because of portability or its restricted and low vitality.

According to the proposed approach, nodes are tracked by other nodes and rate of cooperation is computed based on the OSLR message process which is sent to nodes in the network and by considering different processing of network. Cooperation rate varies for each communication between nodes due to mobility or different network processing, if a cooperation is established between two different node then the cooperation rate will be enhanced by 1 and if the cooperation is established during 2nd iteration also then it will be increased by 2, it is performed until all the packets are transmitted. In non-cooperative mode, cooperation rate value is subtracted from the last added value of cooperation

Step 1. For each node (n) of network perform

Step 2. $C_r(n) \leftarrow 0$ // Computation of cooperation rate

Step 3 $Addvalue\,(cooperation\ rate)\,(n) \leftarrow 0$

Step4. End this operation

Step 5. $Current\ Node\ evaluation \leftarrow 0$

Step 6. For each node(n), compute

Step 7. While $node(n) \cong node(crntNode))$,compute

Step 8. If $(cooperation\ (node(n), (crntNode))$ then

Step 9. Increment last value added i.e. $ValueAddeedLast \leftarrow lastvalue + 1$

Step 10. $C_r(cooperation\ rate)(n) \leftarrow cooperation\ rate(n) + valueaddedlast$

Step 11. Else

Step 12. $CooperationRate(n) \leftarrow CooperationRate(n) - lastaddedvalue$

Step 13. End if// Cooperation computation

Step 14. $CrntNode\ \leftarrow crntNode + 1$

Step 16. End While

Step 17. Selection of cooperation or non-cooperation

Step 18. End For

Data transmission using distributive MAC

Communication States

t^i_{packet} length of current packet

t^i_{unit} duration of handshake using 802.11 network

k_i interval time

t^i_p time interval of current frame

n_i successful transmission

Communication Events

Initiate

$f^n_{packet} = t_{RTS} + t_{CTS} + t_{ACK} + 3 * t_{SIFS} + t^i_{packet} + t_{DIFS}$

Channel Access:

Use current communication window for channel access

If $(ACK\ packet\ received\ succesfully\ )$

$n_i = n_i + 1$

Update the packet state

Update transmission state

After computing the cooperation rate and updating the communication states a cooperation formation is applied which is mentioned in below algorithm 3.

Cooperative approach

1. Select the feasible rate of flow in network and initiate the data communication
2. Local information about network collected by using contention graph
3. Decompose the information in set of cliques of each node
4. Estimate the optimal solution for each clique and set as the global parameter
5. Calculate new flow rate after computing the global parameter
6. Find the new optimal parameter t support QoS

$$O_j(n+1) = \max(\, 0, O(n) + \gamma \left(\sum_{i \in S(j)} x_i - c_j \right)$$

γ denotes the capacity of clique, total flow rate is estimated using $\sum_{i \in S(j)}$ for the previous round

7. Consider mobility parameter and estimate the flow
8. If flow is changed then reinitiate from step 2 else go to 4th step

3. Results and Discussion

In this section we discuss about the simulation results obtained by using proposed approach. Considered simulation parameters are presented in table 1 which includes total number of nodes as 100 deployed in area of 1500x1500 m^2. Each node is considered with different mobility speed such as 5,10,15,20 and 25 m/s in random way point mobility model. Simulation results are achieved depicted in tabular and graphical representation by comparing with state-of-art methods. Qualitative analysis of the proposed protocols is done with the help of Matlab 2013. Tabular results, graphical representation and its discussion are given here.

Simulation Parameters	Range
Number of nodes	100
Length of packet	512
Speed of node	5,10,15,20 and 25 m/s
Simulation time	900 sec
Considered Model	Random Way
Number of transmitted packets	899
Simulation Area	1500x1500 m^2
Range of transmission	250 m

Performance Metrics

In order to evaluate the performance we used some standard performance parameters which are: good put, end-to-end delay performance

- *Goodput:* this is the performance computation of network in terms of delivered data packets to destination. It is a key component of network which shows the efficiency of network

Average End-to-End Delay: Average End-to-End Delay includes all possible delays caused by buffering during route discovery, queuing at the interface queue, re-transmission delays at the MAC, propagation and transfer times.

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- *Normalized Routing Load:* The number of routing packets transmitted per data packet delivered at the destination. Each hop-wise transmission of a routing packet is counted as one transmission. Normalized Routing Load is an important metric, as it measures the efficiency of a routing scheme; the degree to which it will function in congested or low-bandwidth environments.
- *Average Hop Count:* The average hop count is the average distance between any pair of nodes or the mean path length in the network.

Table 2. Throughput performance for speed variations

Protocol	**Speed(m/s)**				
	5	10	15	20	25
PLLR	3725.1	3628.6	3528.4	3508.3	3438.3
CLLR	3758.7	3655.4	3561.6	3513.56	3415
RLLR	3389.5	3207.5	3152.4	3034.1	3006.7
AODV	3369.7	3321.16	3198.4	3129.8	3030.5
Proposed	4342.86	3927.55	36821.97	3623.55	3512.89

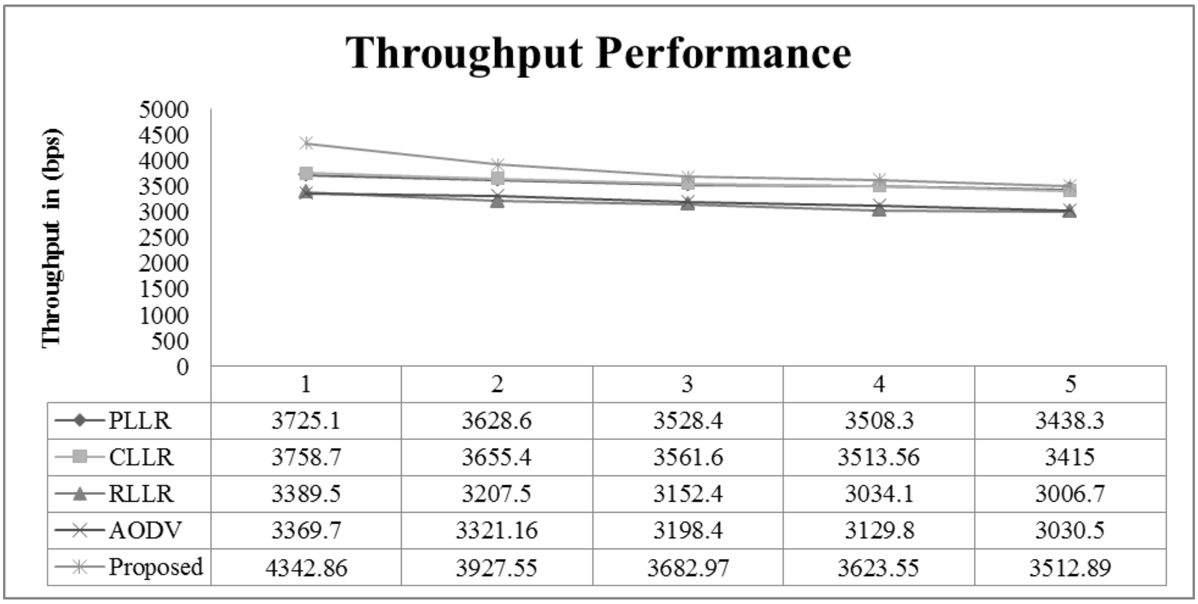

Figure.2. Throughput performance comparaison

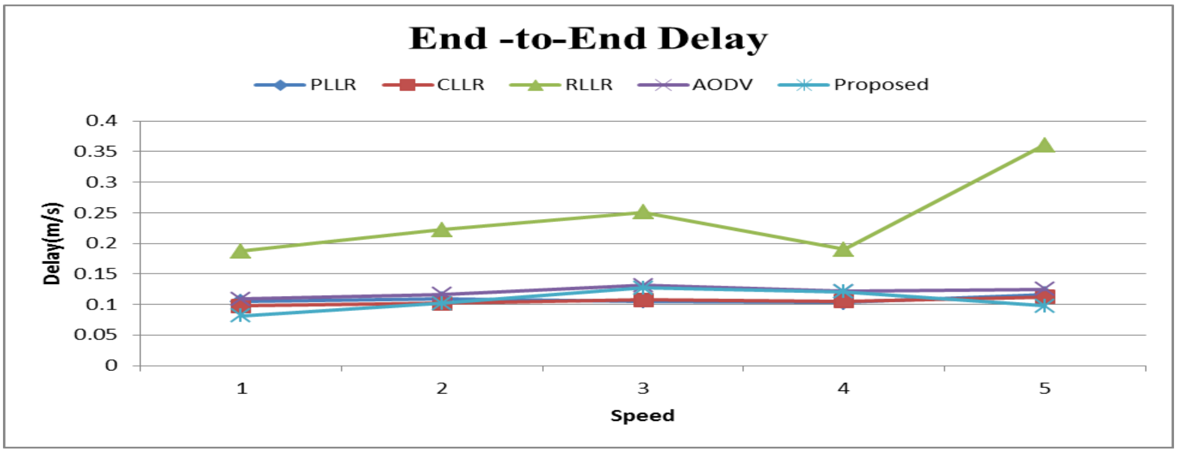

Figure.3. End-to End Delay performance

4. Conclusion

In this work we have analysed the problem of quality of service in mobile Ad-Hoc Networks using a game theoretic approach model. In this work we have adopted contention graph to obtain the information about link and nodes. QoS problem is modelled as a primal problem. In order to enhance the fairness of system, utility function based scheme is used using concave function. Primal problem can be solved by using cooperative game theory approach. In this work we analysed Nash equilibrium state of cooperative game theory. Performance analysis shows that the proposed approach provides better results in terms of throughput and and end to end delay.

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