Using Hand-shake Transmission Rate Adaptation Scheme in MANET

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Abstract
MANETs are decentralized networks that widely used in different communication domains. They represents mobile ad-hoc networks which are composed of individual network members communicating with each other directly. MANETs are usually suffering from choosing, maintaining and optimizing the appropriate transmission rate to meet the domains applications bandwidth according to the mobility and dynamic topology. Therefore, the status of the transmission channel becomes a problem that may affect the ability of network members.
In this paper, we adopt the cooperative game to propose a new adaptation scheme called hand-shake transmission rate. The proposed scheme allows MANETs nodes to select the correct transmission rates based on the bandwidth demands and supports a decentralized approach where transmission rates between neighboring nodes are used in the transmission rate adjustments. Knowing the neighbor transmission rates helps the individual nodes to calculate the suitable transmission rate. The proposed scheme is scalable since the transmission overheads are only used in the process of exchanging transmission rates between the neighboring nodes. It also supports no single point of failure. Several simulation scenarios of the proposed scheme have been tested using different size of networks.
Key words:
Mobile ad-hoc networks, Transmission rate, Adaptation rate, Packet loss, Quality of Service.

1. Introduction

Mobile Ad-hoc Networks (MANETS) has been growth rapidly in the area like military and civil application in the last decade. They are a group of mobile node or network members that cooperates to achieve a specific tasks or missions. The nature of the network is a slightly different from the others networks; since it is an infrastructure-less and self-organized where the topology keeps changing. Due to that, MANETS may suffer from problems such as low bandwidth, congestion and high overhead and power consumption. On the other hand, mobility of the nodes is an advantage where services and resources can be access anywhere and anytime during the movement.
MANETS suffers from rapidly varied link condition that may leads to packet loss or not utilizing the transmission channel rate. These problems are the main issue that limits networks performance. In these types of networks, nodes or members are expected to maximize network performance to meet bandwidth requirements. Adaptation rate scheme is a popular scheme used to increase bandwidth availability and reliability. The scheme is used to optimize the data rate for the communication links with neighboring nodes in the network. The estimation of transmission rate or bandwidth is an important measure that is needed in quality of service (QoS) of MANETs. Determining the proper data transmission rate that is available between networks members results optimizing end-to-end performance which leads to better overall network performance.
Owing to the manner of network nodes interaction, game theory has been extensively used to solve many research problems in MANETs. This game is categorized as cooperative and non-cooperative games. A cooperative game is a game which played between nodes who have mutual relationship with each other. On the other hand, non-cooperative game is played between nodes that have mutual relationship with each other. In this scheme we assumes that the nodes in the network play a cooperative game to assure the QOS, reliability and increase the performance as much they can to get a fair payoff from this cooperation.
The recent research has been focused in determining a path from source to destination or from sender to receiver without considering network traffic status or network channel transmission rate as a real time system such as in [1],[2], [3], [4] and [5]. To avoid wasting or wrong selection in transmission rate, there is a strong need of a scheme or mechanism which adapts the rate between network members on the real-time network conditions.
In this paper, we propose Hand-shake Rate Adaptation (HRA) scheme to avoid wrong selections in transmission rate. The scheme allows MANET nodes to select the appropriate transmission rates to ensure that bandwidth requirements are met. It adopts a decentralized approach where neighboring nodes are involved in calculating transmission rate. The knowledge of neighbor transmission rates allows an individual node to select the proper rates. The scheme is scalable because the overhead only involves in the process of exchange transmission rates between neighboring nodes. It is also used to avoid central point of failure and reduce the lack of scalability.

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2. Background and Related Work

MANET is a decentralized type of networks where the communication workload is distributed among several nodes and each node contributes in forwarding data to the neighbor nodes. MANET does not operate on the common mobile communication infrastructure such as routers or access points, but rather the data is forwarded dynamically through the nodes based on the defined network connectivity and the routing algorithm. Due to the distributed nature of this kind of networks, there is no single point of failure; also their nodes have a better privacy since the information is passed through many nodes which makes it hard to be tracked.

The market provides different simulation applications to mimic the behavior of MANETs such as NS-2 [7], NS-3 [8] and OPNET [9]. In this paper, we used Network Simulator NS-2 which provides a discrete event simulating for TCP, routing, and multicast protocols over wired and wireless networks. It is an open source simulation tool used for research and development.

Several approaches and mechanisms have been followed recently that manipulate the transmission rate of the decentralized type of network. Johnson and Maltz in [10] present a protocol in ad hoc networks that adapts rapidly to routing changes for frequent host movement, while still requires little or no overhead during the less frequent movement periods. Huang et. al in [11] propose two self-tuning neighbor detection schemes: dynamic timer algorithm and fast neighbor handshake algorithm. These algorithms are used to tune automatically the routing performance of MANETs based on the packet delivery ration and control overhead. Wu and Harms in [12] propose two on-demand methods: Compared with Dynamic Source Routing (DSR) and the Diversity Injection method, to efficiently seek for several node-disjoint paths and present the path selection criteria. The proposed methods are used to provide source nodes with more selections to identify good quality multiple paths. Sun in [13] briefs the essential problems and challenges of ad hoc networking by introducing some of the research background that are related to the concept, features, status, and applications of MANET. Abd Rahman and Zukarnain in [14] uses NS-2 application to simulate three protocols: AOD, DSDV and I-DSDV and the result of the simulations were compared in terms of packet delivery ratio, end to end delay and routing overhead using various number of nodes, speed and delay time. Singh et. al in [15] propose a routing protocol (OPSAODV) to select an optimal path in MANET by finding the route selection process congestion status. Prakash et. Al in [16] propose an approach called load balancing adaptive Internet gateway discovery this approach trey's to solve the congestion and overload in MANETS by using Particle Swarm Optimization to select the optimal path from the available paths and using mathematical function to select the shortest one.

3. The Proposed Model

We consider our model for the system as a coalition repeated game with imperfect information. The game is repeated at each iteration until the nodes accomplished any given task. To design an efficient transmission rate adaptation scheme for mobile ad-hoc networks, first we need to have a good knowledge about network dynamics. Our scheme share transmission rate statistics at different time slots or iterations to makes rate selection decisions at each iteration by using our methodology which will be selecting the average transmission rate for a given time period between different network nodes. The selection of an appropriate transmission rate which consider as a problem in mobile ad-hoc networks can be adjusted based on network dynamics.

We propose our HRA Scheme to address this issue by ensuring that the network nodes compute the average transmission rates during every time slot or iteration based on the transmission rates that has been shared by the neighboring nodes.

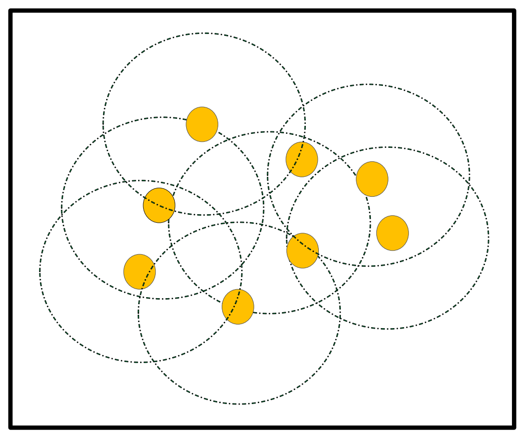

Fig.1 System Model

Fig. 1 shows our system model, without losing of generality, is consisting of 8 nodes. Each node generates its own transmission rate and sends it to neighboring nodes, at the same time it receives neighboring nodes' transmission rates. Then each node computes the average transmission rate that has been received from all other nodes individually for many handshake iterations during a given time slot. So, each node generates the new average transmission rate which will be used in the next time slot.

We assume that all nodes or network members are cooperative members and they obey to the regulation rolls.

Also, we assume that all nodes are moving slowly because fast movement brings a frequent change in the node's neighbors. We consider that all of the nodes start with the same initial transmission rate. During every time slot, nodes transmit their rates to the neighboring nodes while they are moving. Based on the feedback from the neighbors, each node uses the HRA scheme to compute the average transmission rates for the next time slot. Selecting and sharing transmission rates as much as the nodes can during any given time slot assures the network performance by computing the proper average transmission rate from the rates that has been shared.
The strength of the scheme is that the time during each slot can be vary according to the networks dynamics, movements or according to the sensitivity of information that needs to be exchanged among the network members to give a better and more accurate and reliable average transmission rate to be used.

4. Hand-shake Rate Adaptation (HRA) Scheme

In this section we describe the design and implementation of our scheme. HRA scheme is deployed on all the mobile ad-hoc network members. This model does not require any centralized or controller to coordinate the transmission rates exchange or to calculate the average transmission rate. Also the scheme is repeated for each given time slot, while time slots can be modified according to the network requirements and topologies to assure achieving the best suitable transmission rate among all network members.

- After deploying the scheme in all network members, each node or member collects a list shared transmission rates by each individual neighbor node by itself.

$$\sum_{i=1}^{n} r_i(t)$$

Where,
r_i is the transmission rates that has been collected for a node from all other neighbors. The rate is shared multi-times during the time slot to compute the average rate in next step.
$i \ to \ n$ represents the range of neighboring nodes.
t is the variable time slot for the duration of collecting the transmission rate.

- Then each node calculates the individual average transmission rate for each neighbor node from the rate that has been exchanged during the given time slot. The average rate is used for data transmission each node according to the average sum.

$$Average \sum_{i=1}^{n} r_i(t)$$

- After exchanging date using the selected transmission rate between nodes, nodes will test the accuracy of that rate according to the packet loss percentage. If the percentage in less than μ then its ok, else choose a shorter time period for computing the average transmission rate. This may occurs because the network topology keeps.
  For sharing or passing transmission rate between node or network members, we use the term r_{ij} and r_{ji} for all network members where i is the incoming transmission rates from a given node and j is the receiving node from node i. Therefore, we have the average transmission rates between two nodes for a given node i received by j.

$$Average \sum_{i=1}^{n} r_{ij}(t)$$

The algorithm for transmission rates collecting from neighboring node for a given time slot is describe below. Note that the time slot t can be changed as we need according to the network topologies and requirements.

1. *Send data using the calculated average transmission rate*
2. *Test Accuracy and Feed back*
3. *If packet loss* $\geq \mu$
   a. *then ok*
4. *Else*
   a. *Test* $Averge \sum_{i=1}^{n} r_{ij} \ (t)$ *with shorter time period*

End If

where μ is the acceptant packet loss from this given network.

Usually as we know when μ approaches to zero, it means better quality of service. However, sometimes it may happen that we may not get what we need even if we try to reduce μ by shortening the time slot of exchanging transmission rates. It can be caused by misleading information between nodes which is not considered in our case since we assume that all network members are cooperative nodes.

5. Simulation and results

In this section we use NS-2 network simulator to test our proposed HRA scheme. We use three simulated networks that consist of: 40, 80, and 120 of nodes. Simulating different sizes coalition, is used to test the effect of having more nodes in the network performance. Furthermore, we will show the impact of our scheme while the coalition size increases. The system delay and accuracy will be shown and compared by using different coalition sizes. There would also a comparison between the packet loss with and without using our method by updating the average transmission rate and not updating as well. In addition, we show the strength of our method by varying the time slots for calculating the average transmission rate to reduce the amount of packet resending. Overhead also will be shown that can be caused by using and not using our method.

- Simulation Setup
  The simulation setup scenarios will consist of three sizes for the coalition, first scenario will contain 40 mobile modes, the second scenario will contain 80 mobile nodes and the last one will contain 120 mobile nodes. For all scenarios each mobile node will run the HRA scheme algorithm independently and compute the average transmission rates for all neighbors and share it with them this will leads to find the optimal average transmission rate.

TABLE I: Parameters for Simulation

Parameter	Level
Area	3500 × 2300
Speed	10 m/s
Radio range	750m
MAC	802.11
Simulation time	120 s
Number of mobile nodes	40, 80, 120
Network interface type	Wireless
Channel type	Wireless channel

6. Evaluation Results

Figure 2. shows the performance impact for our HRA scheme while the number of nodes increases inside the coalition. It's clearly shown that the overall system performance is increasing while we have more nodes inside the network, also this shows the power of using cooperative game theory methodology, that's because all nodes are trying to maximize its own payoff by sharing the average transmission rate with maximum number of neighbors.

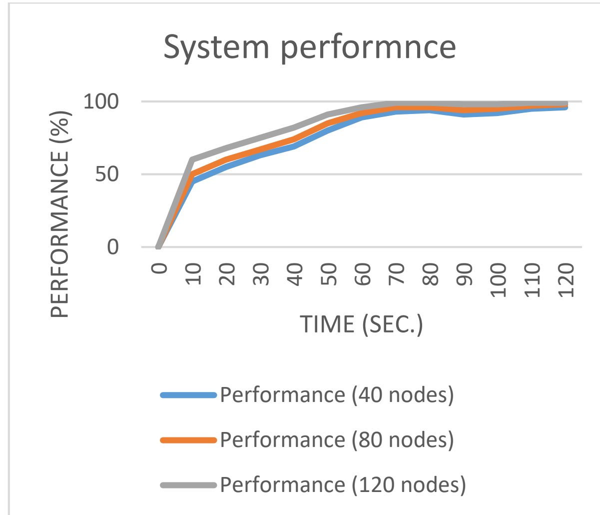

Fig. 2 System Performance

Figure 3. shows the network or system delay with respect to the time for the three different coalition sizes.
In this figure we will show the delay for the three coalition sizes (40, 80, 120). From the results we can see that the system delay reduces while we keep increasing the number of nodes in the network, the delay values of the system improves tremendously, this happens because our system relies on the average transmission rates assigned by the neighbors, therefore, more neighbors that a node have the better performance and less delay will occurs for overall the system.

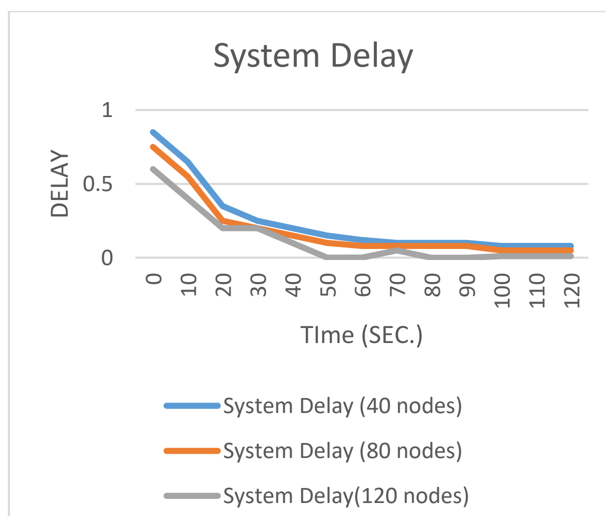

Fig. 3 System Delay

Figure 4. Shows a comparison of pack loss with and without using the HRA scheme. Without loss of generality for this figure we will apply here the 80 nodes coalition size. The

updated average transmission rate is used based on the agreed transmission rate that will be used between neighboring nodes. When the HRA scheme is used, the percentage of packet loss is considerably reduced. In this figure we can see some spikes in packet loss percentage that's because of the changing in network topology.

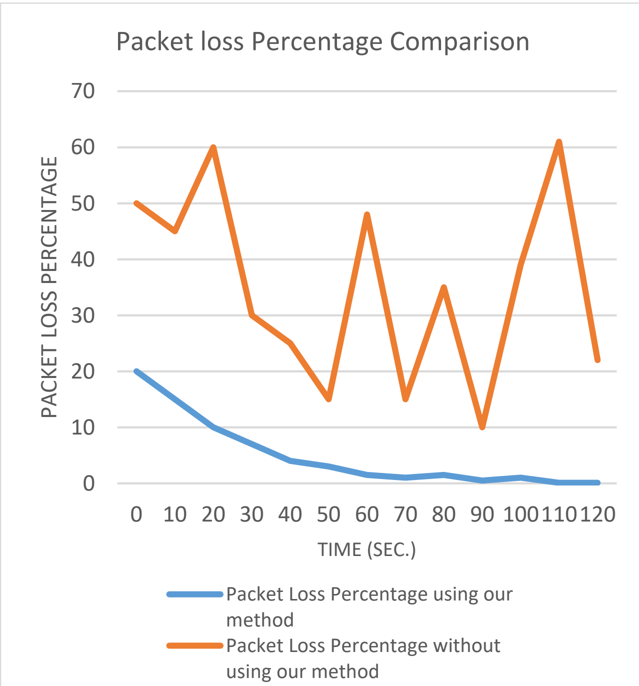

Fig. 4 Comparison of Pack Loss with and Without Using the HRA scheme

Figure 5. shows Packet loss percentage according to the flexibility of choosing the time slots for selecting the suitable transmission rates. Time of selecting transmission rate can be vary it the packet loss percentage is greater than what we need, this give our scheme better performance according to the network circumstances.in this figure show percentage loss with three different time slots for choosing the transmission rate every (20, 10 and 5) seconds With 80 nodes coalition size , shortening the time slots can be used in some points during the overall time especially if the network topology keeps changing rapidly, but that may cause some system overhead which is shown in figure 6 with respect to the number of neighboring nodes.

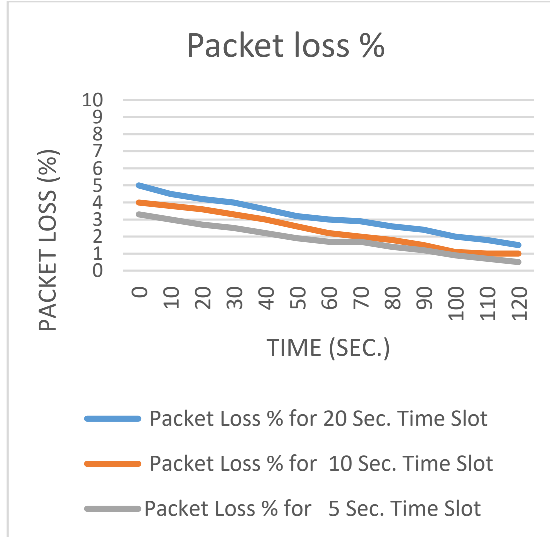

Fig. 5 Packet Loss Percentage with Different Time Slots

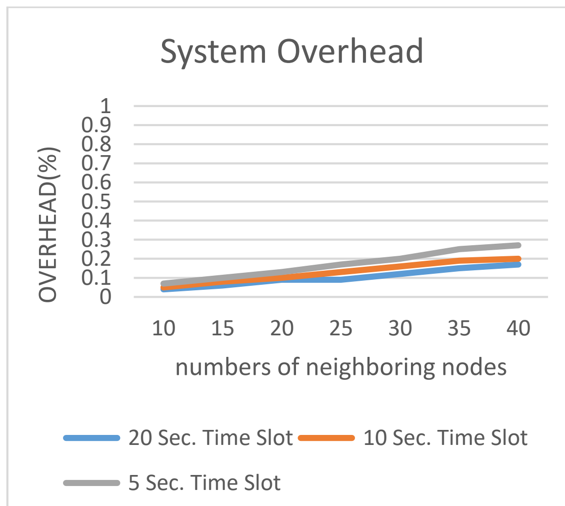

Fig. 6 System Overhead Percentage with Different Numbers of Neighboring Nodes

7. Conclusion and Future work

MANETs are decentralized networks that widely used in the area like military and civil application in the last decade. They represents mobile ad-hoc networks which are composed of individual network members communicating with each other directly. MANETs are usually suffering from choosing, maintaining and optimizing the appropriate transmission rate to meet the domains applications bandwidth according to the mobility and dynamic topology. Therefore, the status of the transmission channel becomes a problem that may affect the ability of network members.

this paper, propose a new mechanism that uses HRA scheme that allows MANETs nodes to select the correct transmission rates based on the bandwidth demands. We use NS-2 simulator to show that HRA scheme and coalitional game can help in increasing over all mobile ad hoc networks' performance. The simulation also show the HRA scheme reduces packet loss with different coalition sizes and reduces the entire network delay. As a future work, we are planning to simulate the proposed mechanism and scale it up to thousands of nodes, also use it on cases of different attacking types.

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