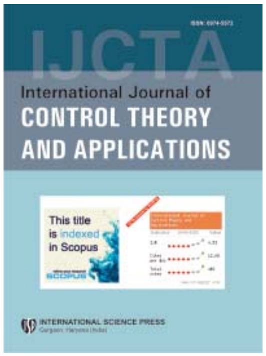

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Optimal Energy Control Algorithm for Improving System Performance in Mobile Ad hoc Networks

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Abstract: Mobile Ad hoc networks (MANETs) is a traditional wireless nodes they form a network without any centralized control. Energy efficiency is considered as an important feature to achieve in the mobile ad hoc network. The nodes of the ad hoc networks are in different range and hence it is considered as a high energy consuming architecture. Energy control is important in mobile ad hoc networks for diminishing the consumption rate of energy, avoiding collisions within the packets. Energy control also helps in improving the spatial throughput of the network for reducing contention among the flow of data. Mobile Ad hoc Networks are energy constraint and takes more energy for the transmission of packet. An Optimal Energy Control Algorithm (OECA) is proposed in this paper for reducing the consumption of energy and to gain a high throughput in the overall structure. In OECA algorithm, an optimal power for transmission is calculated at the receiver. The calculation will be based upon the payload length of the data and the total interference amount. The calculated power is given to the receiver which increases or decreases the energy value by calculating the number of nodes. The adjusted energy rate is again retransmitted to the receiver for adjusting the energy level among the transmitter and the receiver. The energy rate is calculated based upon the interference amount of the network and the chances for collision will be greatly reduced. The simulation result shows that the proposed algorithm performs better in consuming energy when comparing with the existing algorithms.

Keywords: *MANETs, Energy control, Energy efficiency, payload length, Medium Access Control (MAC).*

1. INTRODUCTION

Wireless Communication systems are one of the greatest growing technologies in the field of information, technology and communication. Wireless communication helps in providing exchange of information between the handheld and portable devices anywhere in the world. Nowadays mobile phones and other communication devices becomes an inseparable device in everyday life because of its great usage and its features.

An Ad hoc network is a wireless network and an infra-structure less network. Here the mobile hosts are connected dynamically with the other mobile hosts which are in radio range. An ad hoc network is a set of wireless nodes they practice a network without any centralized control [8]. These networks are not having any base stations (BS). Since they have no infrastructure, the nodes can join freely and leaves from the network. The nodes are in touch with one another with the help of a wireless link. Each node can act as a router for forwarding data packets to the neighboring node. It is not having any centralized administration. Mobile ad hoc network is having the tendency to take over any malfunctioning of the network due to the topology changes. If a link on the ad hoc network is broken, it simply goes for requesting to other routers for establishing a new connection.

Mobile Ad hoc Networks (MANETs) are very much helpful in forwarding data packets in the network. Since the nodes of the MANETs are operated by battery, power consuming is an impact in the Mobile Ad hoc Networks while designing the MAC protocols for such networks [4] . The amount of energy consumed at the time of transmitting, receiving and forwarding are high in Mobile Ad hoc Networks. MANET is not having any centralised control which leads to many drawbacks in energy control designs of such networks.

1.1. Advantages of Energy Control:

When the destination with its receiver is not in the transmission range of multi hop wireless ad hoc networks, the network nodes will transmit packets to other nodes of the network [12]. The range of transmission of every node will be adjusted by collecting energy from each node because energy efficiency is essential for a network to perform better. The various advantages of energy control algorithms are,

1. Energy control leads to reduce the rate of average power consumption.
2. The system throughput will be increased due to the spatial reuse of the spectrum.
3. The total number of neighbours will be reduced with the help of energy control algorithm which leads to reduce the contention of the channel.

Minimal coverage of area that reduces the total number of nodes to reach which can be satisfied by a particular node that gives chance for adjusting the power of transmission. When the energy levels are adjusted, the nodes will not change for further. Some of the nodes are not fit for overhearing the on-going transmission of packets. Because of this problem, RTS/CTS control message transmission is not successful while reserving the channel.

The major problem which is addressed at the time of RTS /CTS mechanism is increased number of hidden stations. This is because of dynamic adjustments of energy that are used even after the successful exchanges of RTS/CTS control messages. This leads to a high level of interference in the network [11]. Based upon the link distance and level of interference on the receiver, the power needed for transmission of DATA/ACK packet will be determined. The node that transmits RTS/CTS control messages at the maximum power required. Due to the spatial reuse, there occurs some collision in the network between the RTS/CTS control packets and DATA and the ACK packets. Physical carrier sensing ranges will involve in affecting the network throughput.

1.2. Solutions of Energy Control

The solutions which are said to be addressing the energy control issues in the mobile ad hoc networks can be categorized as follows,

1. **Transmission Power Control (TPC):** Bit error rate, level of transmission and inter radio intrusions that are having a great impact in transmission of power in wireless connections [6]. Energy control will be followed here for improving the throughput of medium access control layer for reducing the interference level. The most highlighted network will be determined with the power of transmission for all the mobile hosts at a glance.
2. **Power Aware Routing (PAR):** The basis for the power aware routing protocol is widely used power cost function such as battery level of the mobile host.
3. **Low Power Mode (LPM):** In IEEE 802.11 MAC protocols, the radios will be enabled only for the usage for saving the power level. For defining the individual active duration of the radios, local area networks use a mobile host for the power saving mode. According to the bit rate power of transmission, the mobile host equaliser will be turned off for helping saving power in the mobile hosts.

2. RELATED WORKS

Vasilis S Gkamas et al, [14] proposed a medium access control protocol which is the slow start power control protocol (SSPC-MAC). This MAC protocol was mainly designed for mobile ad hoc networks and having the enhanced IEEE 802.11 benefits with the help of utilizing the energy control values for RTS/CTS control messages and the transmission of DATA/ACK frames. These will helps in reducing the total consumption of energy and for increasing the throughput of the network and increasing the life time of the link.

Javier Gomez et.al, [13] proposed another quality of service tools for wireless ad hoc networks which is called as Power Controlled Quality of Service mechanism (PCQSM). This mechanism will built quality of service mechanisms for some submissions that liked to trade off enhanced performance for the supportive ideal paths. The power control algorithm is only allowing some selective flows of data for changing their transmission power as a path increase or decrease the relay nodes to their channel. The proposed PCQSM mechanism will be helpful in establishing a differentiated service in the wireless ad hoc networks.

Marvan Al Jameli et.al, [2] proposed an Energy Efficient Cross Layer Network Operation Model (EECLNM) for mobile ad hoc networks. The authors proposed a position based algorithm that is responsible for reducing the end to end delays of the networks for efficiently using the energy of the network.

S. Yuang et.al, [3] proposed an energy efficient medium access control protocol for completely linked wireless ad hoc networks. Energy efficiency is an important metric for the wireless networking protocols mainly for the battery built wireless devices such as smart devices. The proposed algorithm minimizes the consumption of energy by keeping the interfaces of the radio in the sleeping state occasionally by reducing the collisions during the transmissions. This technique helps in getting high throughput and low end to end transmission delay. The proposed MAC protocol is also producing better results in addressing saving of energy in the real time traffics. This leads to a low transmission delay.

Y. Shi et.al, [5] proposed an optimal pricing and load sharing algorithm for cooperative wireless networks. High energy consumption is an important issue of the wireless ad hoc networks. This is because the network nodes are in different range in the ad hoc networks. The above character leads to degradation of performance in the network. Here the optimal pricing mechanism is proposed to motivate or increase the ability of cooperation of the network. Nowadays wireless data traffic is high due to the increased multimedia applications and the data exchanges. Cooperative communication technique is used to improve the cooperation among the nodes of the network.

Based on the uncertainties of the mobile terminals and channel conditions, a new pricing mechanism is proposed to motivate the ability of cooperation between the mobile node terminals. The simulation results show that optimal pricing algorithm reduces the energy consumption by calculating the energy level and channel conditions of the network at each level.

Ying Zhu et.al, [9] proposed an energy efficient cooperative communications for wireless networks. In multimedia applications, achieving quality of service and energy efficiency are some important challenges for achieving in smooth communication between the network nodes. Ad hoc network is a high energy consuming architecture. An ONLINE algorithm with short computational difficulty and positioning overhead is proposed. The increased growth in the multimedia applications needs some new requirements for achieving quality of service and energy efficiency in wireless networks.

3. PROPOSED OPTIMAL ENERGY CONTROL ALGORITHM

3.1. Optimal Energy Control Algorithm Overview

Energy control algorithms are mainly considered in mobile ad hoc networks for increasing the capability of the network and improving throughput. Ad hoc network is a high energy consuming architecture since all the relay nodes are not in the range. So while selecting the relay and also for cooperative communication with relays, the energy can be greatly used. Higher energy consumption leads to degradation in the network.

Energy control is important feature for improving the quality of the multi-hop networks for avoiding collision and increasing the throughput. So there is a need for energy control algorithm. Here the transmission power is measured at the receiver end with the payload and the interference value. Here the power is considered by the transmitter which increases or decreases the power value according to the neighboring nodes. The power adjusted is sent to the receiver and the power value can adjusted between the transmitter and receiver.

3.2. Transmission Energy Control Algorithm

The optimal energy for transmission will be determined with the help of transmission energy control protocol in the mobile ad hoc networks. RTS/CTS control messages helps the network nodes for exchanging the energy levels for transmission for determining the accurate energy level. The interference of the total network shall be determined by the broadcasting power of RTS. In optimal energy control algorithm, two tables are initially created at the receiver for maintaining the transmission power for the communicating nodes of the network. Based on the above Calculation, the optimal power for transmission can be determined.

3.3. Table Creation

The transmitting node of the network maintains two tables initially. The first table formed by the transmitter is called as the Recent Data Table (RDT) which keeps the recent powers of transmission for the communicating network node. The second table is called as the Initial Inspection Table (IIT). When the transmitter finds the record of the receiver from the Recent Data Table, then the transmission can be done by the transmitter to the receiver affording to the energy level of that record. Else the receiver's record is checked in Initial Inspection Table. The Initial Inspection Table is used to check the smallest desirable transmission power for the continuing transmission. The total interference in the network and the normal distance of the getting node to the transmitting node can be shown by the transmitting node by choosing the energy level from the Initial Inspection Table. IIT can be used when the transmitting node cannot find the record of the receiver in the Recent Data Table. Otherwise if the RTS transmission energy level in the RDT terminates. When RDT is not having the record of the receiver, then transmitter transmits RTS that is mentioned in the IIT. The transmission power will be incremented to the next level in IIT if there is no further acknowledgement.

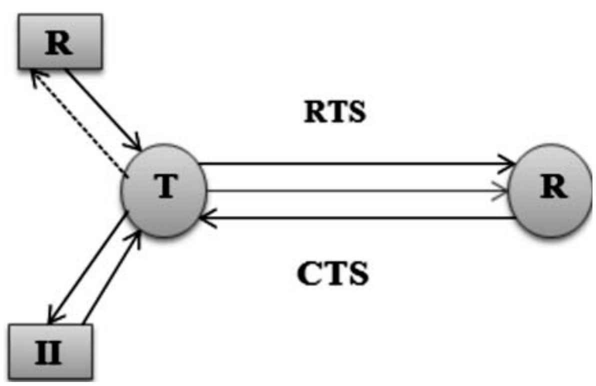

Figure 1: Transmitter and Receiver's Records

The figure 1 shows the Initial Inspection Table and Recent Data Table of the transmitter and receiver. The middle line from transmitter to the receiver indicates the record of the receiver will found in Recent Data Table. The dashed line from the transmitter to the Recent Data Table indicates that the data table contains the record of the receiver and the transmitter drafts the record of the receiver in the Initial Inspection Table. After getting the record from the Initial Inspection Table, the transmitter transmits the Request-To-Send to the receiving node until Clear-To-Send.

3.4. Transmission Power Determination (α)

The transmitter and the receiver collaborate to discover the ideal energy level of transmission (α). The receiver makes use of the needed Signal to Interference Ratio (SIR) and the needed Bit Error Rate (BER) for calculating the ideal transmission power for the transmission. There are two cases are identified in the transmitter.

Case 1: The record of the receiver will be checked by the transmitter in Recent Data Table and directs RTS using the formerly recorded transmission power.

Case 2: The transmitter cannot discover the record of the receiver in the RDT and jumps to send Request-To-Send messages using the smallest power level transmission command of the Initial Inspection Table.

The RTS control messages combines the transmission power along with it for reaching to the transmitter. The next higher transmission power level should be taken for both cases when the Request-To- Send message is timed out. The transmission power level can be transmitted through the RTS and when the Clear-To-Send data packet received the transmission process will be stopped. When the transmitter gets the CTS message from the receiver, it transmits the data frame using the transmission power requested by the receiver.

3.5. Payload Length Calculation Data

The energy level for transmission should be determined for meeting the Bit Error Rate requirements. The transmission power level will be determined from the data payload length of files in the RTS interval field if the data frame is extensive than the RTS. Higher Bit Error Rate is achieved when data setting is received with the same signal to interference value as the RTS. If the data set is longer then burst error arrives and thus signal to interference ratio value will be incremented to 0.5 dB

3.6. Interference Amount Calculation

The interference of the network will increase Bit Error Rate. When the data frame is transferred with the greater transmission power, it will affect more interference to the other nodes of the network. The signal to interference values must be satisfied for the data payload length. When the condition is not fulfilled, the signal to interference values will be incremented. After getting the accurate signal to interference value, the receiver analyses the required transmission power. This power is said to be the optimal transmission power.

The maximum transmission power can be restricted by the maximum transmission power finally. The throughput is neither improved or the energy consumption is reduced if the control frame with a greater transmission power is transmitted. CTS control message is sent to the transmitter at the ideal transmission power and CTS message also includes the expected transmission power.

3.7. Energy Level Adjustment of Neighboring Nodes

The receiver calculates the best transmission power (α) in the data payload calculation. This value is sent through CTS data packet to the transmitter. When the transmitter receives α value, then it will adjust the power of the neighboring nodes according to that. If the number of neighbor increases the power must be decreased and if the number of neighbors decreases the transmission power will be increased. The energy level adjustment algorithm is executed every time when the number of neighbors changes.

The total number of neighbors are taken as N, the power of transmission is P_t, the maximum power for transmission is taken as Pt^{max}. The current number of neighbors is said to be N_C and desired number of neighbors be N_D. The increase or decrease in N_D is mentioned as P_D and transmission power history is P_h. Comparison will be done between the number of neighbors currently with the desired number of neighbors. When the current number of neighbors is smaller than desired the power of transmission will be incremented or decremented using the equation

$$P_D = \in * \log_{10}(L) * Ph \quad (1)$$

where $L = NC/ND$

When the total number of neighbors reduces or increases, the transmission power was modified based on the P_D.

3.8. Energy Control Algorithm

The energy control algorithm is accessible for calculating the optimal transmission power and adjusting the energy level according to the number of neighbors.

Algorithm 1:

1. Create RDT and IIT tables initially for each node as describes in section 3.3.
2. If transmitter find receiver's data in the RDT
   2.1. Transmitter sends RTS packet to the Receiver
   Else
   2.2. Transmitter checks Receiver's record in the IIT
   2.3. Transmitter sends the corresponding RTS packet to Receiver
   End if
3. Transmits RTS with Transmission power according to the transmitter entry in IIT and include the transmission power in RTS
4. If RTS timed out
   4.1. If Transmission $t = 0$,
   4.1.1. Select the next higher transmission level in IIT
   Else
   4.1.2. Increment the value of transmission t
   4.1.3. Go to step 3
   End if
   Else
   4.2. Send the data using the transmission power indicated by the receiver in CTS and record in IIT
   End if
5. Increase Signal to Interference Ratio to ($INT_n = INT + 0.5$)
6. If INT_n data payload
   6.1. $INT = (INT + (INT_n * 0.5))$
   Else
   6.2. $INT = (INT + ((INT_n + 1) * 0.5))$
   End if
7. At Receiver, data payload length and Interference amount is calculated to determine the optimal transmission power.

8. Receiver sends the calculated power to the Transmitter along with the CTS.
9. When TX receives the transmission power it checks its number of neighbors.
10. If number of neighbors = K, Same transmission power η is distributed among the neighbors.
    Else
    If Number of neighbors = < K
    Transmission power is increased to η*i* among the neighbors.
    Else
    If Number of neighbors > K
    Transmission power is decreased to η*d* among the neighbors.
    End if
    End if
    End if.
11. Then, the new transmission power is retransmitted to the RX along with RTS.

4. IMPLEMENTATION

4.1. Simulation Model and Parameters

The Optimal Energy Control algorithm is simulated through the Network Simulator 2 (NS2) environment. In the simulation environment, the channel capacity of mobile hosts is set to the value 2 Mbps. In our simulation, 100 mobile nodes move in a 1500 meter x 300 meter rectangular region for 50 seconds simulation time. Initial locations and movements of the nodes are obtained using the random waypoint (RWP) model of NS2.The nodes are placed in a uniformly distributed fashion. Initially for considering the parameter transmission rate, the number of nodes is set to be as 50. The energy levels of the nodes are assigned and the transmission range of the node was varied from 230 meters to 500 meters. The capacity of the channel for the mobile host will be set to be as 2 Mbps. The MAC protocol of IEEE 802.11 is used as the wireless LAN for the Distributed Coordination Function (DCF). The Constant Bit Rate (CBR) is used as the simulated traffic. The table below is showing the various simulation parameters for the NS2 simulation. The simulation settings and parameters are summarized in the following table.

Table 1
Simulation Settings

Number of nodes	*50*
Area Size	1000 x 1000
MAC	802.11
Radio range	230m
Simulation time	50sec
Traffic rate	Constant Bit Rate
Packet size	512
Model of mobility	Random way point
Speed	5ms
Routing protocol	AODV

4.2. Performance Metrics

The performance of the proposed Optimal Energy Control Algorithm (OECA) will be compared with the Energy Efficient Localized Topology Control Algorithm (EELTCA). We evaluate the performance of the algorithm according to the following metrics.

1. **Average end-to-end Delay :** End-to-End delay is calculated as the difference of time between the starting to the ending of data packets to reach the destination.

   Delay = Starting time-ending time.

2. **Throughput:** Throughput is defined as the ratio between the numbers of data packets successfully transmitted to the total number of transmissions.

$$\text{Throughput} = \frac{\text{Successfully transmitted packets}}{\text{Total number of transmissions}}$$

3. **Average Energy Consumption:** Energy consumption is defined as the average energy consumed by the network nodes for sending and the receiving of data packets.

5. RESULTS AND DISCUSSIONS

5.1. Based on Number of Nodes

For finding the effect of network contention and the collision in the network, the number of nodes should be increased. The numbers of nodes are initially starts with 50 nodes and then they are increased as 50, 100… The graph will be plotted between the number of nodes and the other performance metrics like delay, throughput and the average energy consumption. The proposed Optimal Energy Control Algorithm (OECA) is compared with the existing Energy Efficient Localized Topology Control Algorithm (EELTCA).

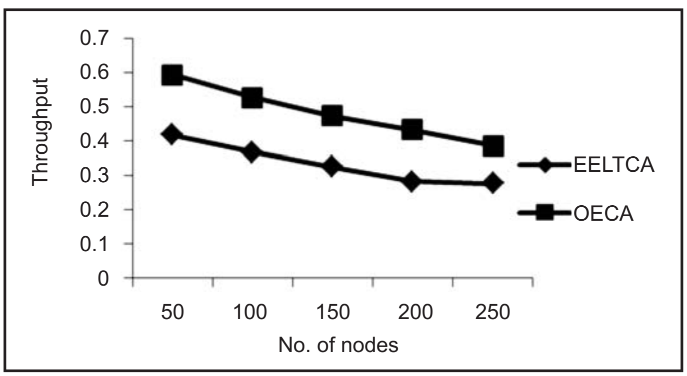

Figure 2: Number of nodes Vs Throughput

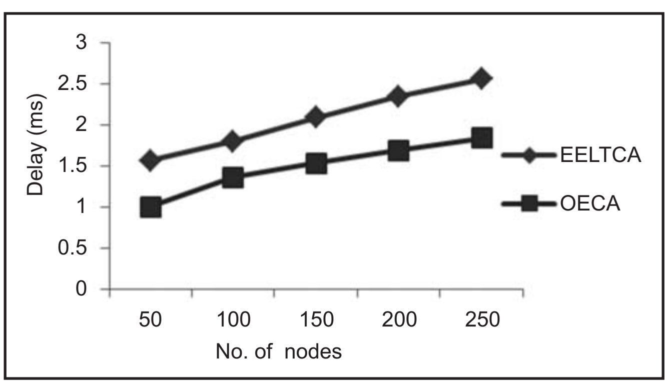

Figure 3: Number of nodes Vs Delay

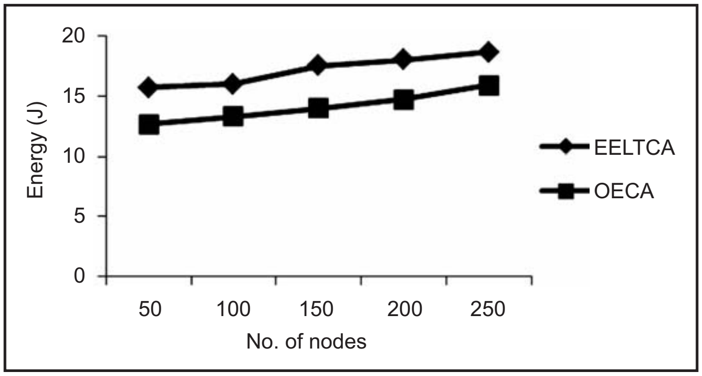

Figure 4: Number of nodes Vs Energy

6. CONCLUSION

Mobile ad hoc network is said to be a high energy consuming architecture because the network nodes are in out of range. The Optimal energy Control Algorithm is proposed to consume less energy of the network and to provide higher throughput. Initially the network nodes create two tables namely initial inspection table (IIT) and Recent Data Table (RDT). When the transmitter finds the record of the receiver from the Recent Data Table, then the transmission can be done by the transmitter to the receiver according to the energy level of that record. Otherwise the receiver's record is checked in Initial Inspection Table. The Initial Inspection Table is used to check the minimum needed transmission power for the on-going transmission. The total interference in the network and the average distance of the receiving node to the transmitting node can be shown by the transmitting node by choosing the energy level from the Initial Inspection Table. IIT can be used when the transmitting node cannot find the record of the receiver in the Recent Data Table. Otherwise if the RTS transmission energy level in the RDT terminates. When RDT is not having the record of the receiver, then transmitter transmits RTS that is mentioned in the IIT. The transmission power will be incremented to the next level in IIT if there is no further acknowledgement. The simulation results show that the proposed algorithm consumes less energy and provide high throughput when comparing with the existing algorithm.

The future scope concentrates on applying a security algorithm along with the proposed system for making the more effective. In the optimal energy control algorithm creating another one table for the receiver for knowing the collisions arises in the networks helps in reducing the end-to-end delay of the network and will reduce energy consumption. These are taken as the future scope from the thesis.

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