Civilizing the Network Lifetime Efficiently in MANETs Through DEL-CMAC Protocol

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Abstract—**MANET (Mobile Ad-Hoc Network) has a dynamic topology. Due to the mobility of nodes in the network of cooperative communication is a technique for archived greater efficiency of transmission. In this paper the Network Lifetime has been improved using Cross layer Distributed Energy Adaptive Location based Cooperative MAC protocols. This DEL-CMAC protocol has been increases the network lifetime and energy efficiency. The performance is achieved by utility based best relay selection strategy selects the best relay used on location information and residual energy. In this proposed work significantly improves the network lifetime even in high circuitry energy consumption in more cases.**

Key words- Network Lifetime, cooperative communication, medium access control protocol, relay selection.

I. Introduction

A Mobile Ad hoc Network (MANET) is a collection of wireless mobile nodes that are able to communicating with each other without the use of any centralized administration or network infrastructure. Mobile nodes are cell phones, portable gaming devices, PDAs (Personal Digital Assistants). The Cooperative Communication (CC) is a technique that allows multiple nodes to transmit the same data. It can save more energy and extend the transmission coverage. Cooperative Communication (CC) [1], [2], [8] technique is used for conserving the energy consumption in MANETs. Cooperative communication uses the nearby nodes for the transmission which is archived greater potential to improving the transmitting efficiency in wireless networks. Traditionally the wireless transmission between a pair of nodes can be received and processed at other nodes for performance gain and considering the interference. CMAC named Cooperative MAC (CMAC) protocol generally considers the practical aspect of CC [3], [5], [6], [7], [8] for the increasing a throughput. This proposed work mainly focuses on the MAC layer which is well-known from the previous protocols by considering the practical energy model and the goals to enhance the energy efficiency and extend the lifetime of the network.

In this paper, Proposed to Distributed Energy adaptive Location-based Cooperative MAC protocols for MANETs. DEL-CMAC protocol has been based on the IEEE 802.11 Distributed Coordination Functions (DCF).In this proposed work the DEL-CMAC comprises the following such as a relay that is involved in a handshaking process, optimal power allocation scheme, a distributed effectiveness-based best relay selection strategy, and an innovative Network Allocation Vector (NAV) setting. The contributions of the proposed work have been summarized as follows.

• The proposed DEL-CMAC protocol mainly focuses an increasing the network lifetime it considering to overheads and interference due to cooperation and energy consumption.

•In a distributed energy-aware location-based best relay selection strategy is proposed in MANETs for comparing with the existing schemes based on channel condition.

• For a desired outage probability requirement, a cross layer optimal transmitting power allocation scheme is designed which conserves the energy while maintaining certain throughput level.

• To deal with the presence of relay terminals and dynamic transmitting power an innovative NAV setting has been provided to avoid the collisions and enhance the spatial reuse.

Extensive simulation results reveals that DEL-CMAC can significantly extend the network lifetime under various scenarios at the cost of relatively high throughput and delay degradation, compared with IEEE standard DCF and throughput-aimed scheme DEL-CMAC. The DEL-CMAC includes the following strategies such as best relay selection strategy [4], the cross-layer power allocation scheme and the NAV Setting.

II. MODELS AND PRELIMINARIES

In this section 2, the employed system and energy models and the background knowledge about DCF and decode and forward protocol are presented.

A. System and Energy Models

There are two types of relay terminals are considered in this network such as routing relay terminals and cooperative relay terminals. In the system model, a route has been built by the AODV in a proactive manner first by selecting the routing relay terminals. When a route is established, DEL-CMAC initiates the cooperation in a hop-by-hop manner by selecting the cooperative relay terminals. In this paper, the source and destination nodes are referred to as the nodes at MAC layer, and the relay terminals indicates the cooperative relay terminals.

B. DCF

The IEEE 802.11 DCF (Distributed Coordination Function) basic operations are similar to the proposed DEL-CMAC.

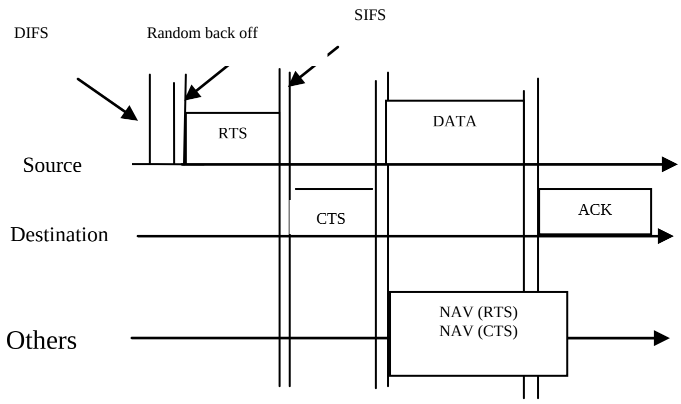

Fig. 1 802.11 DCF Block Diagram

In DCF, after a transmitting terminal senses an idle channel for a duration of Distributed Inter Frame Space (DIFS), it backs off for a time period that is chosen from 0 to its Contention Window (CW). After the back off timer expires, the well-known RTS-CTS-DATA-ACK procedure is carried out as shown in Fig. 1.Any terminal which is taking off either the RTS or the CTS extracts the information contained in the MAC frame header, and sets its NAV setting to a time period that the channel is busy.

C. Decode and Forward

DEL-CMAC utilizes the Decode and Forward (DF) protocol with Maximum Ratio-Combiner (MRC) in the physical layer.

III. THE PROPOSED DEL-CMAC PROTOCOL

Before The proposed DEL-CMAC protocol aims at increasing the network lifetime and the energy efficiency for multi-hop MANETs. To deal with the relaying and dynamic transmitting power, besides the conventional control frames RTS, CTS and ACK, additional control frames are required. DELCMAC introduces two new control frames to facilitate the cooperation, i.e., *Eager-To-Help* (ETH) and *Interference- Indicator* (II). The ETH frame is used for selecting the best relay in a distributed and lightweight manner, which is sent by the winning relay to inform the source, destination and lost relays. In this paper, the best relay is defined as the relay that has the maximum residual energy and requires the minimum transmitting power among the capable relay candidates. In order to enhance the spatial reuse an Interference indicator frame is utilized which reconfirms that the interference range of allocated transmitting power is only at the winning relay. Among all the frames RTS, CTS, ETH and ACK are transmitted by fixed power and the transmitting powers for the Interference Indicator frame and data packet are dynamically allocated. The time durations for the transmission of RTS, CTS, ETH, ACK, II frames are denoted by TRTS, TCTS, TETH, TACK and TII respectively.

A. Protocol Description

The frame exchanging process of DEL-CMAC is shown in Fig. 2. The IEEE 802.11 DCF protocol, the RTS/ CTS handshake is used to reserve the channel at first. In DEL-CMAC, upon receiving the RTS frame, the destination computes the required transmitting power for the direct transmission

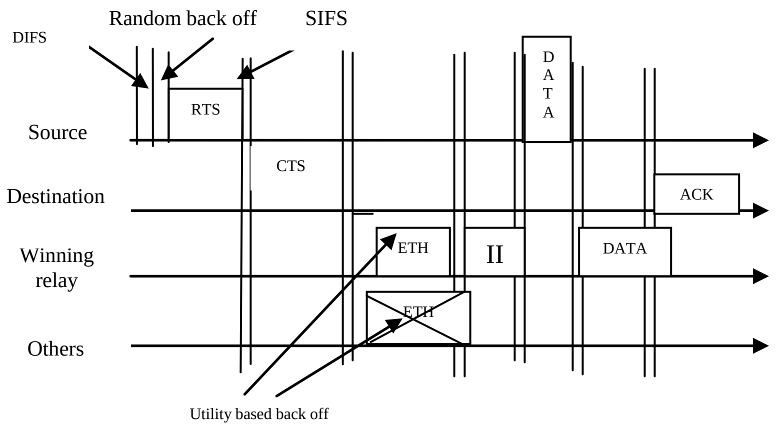

Fig. 2 Frame Exchanging Process of DEL-CMAC Protocol

There are two cases based on the calculated.

. • *Case (i)*: $P_s^D \leq \Lambda p$. The destination sends a CTS frame with the flag field (FLAG P) equal to 0, which implies that the direct transmission is adequate. Thus, when the transmitting power for the direct transmission is sufficiently low, DEL-CMAC is reduced to the DCF protocol and thus has backward compatibility with the legacy 802.11 standard.

• *Case (ii)*: $P_s^D > \Lambda p$. FLAG P in the CTS frame is set to 1, which indicates that the cooperative relaying has been desired. All the terminals having overhead RTS and CTS, and not interfere with other ongoing transmissions are considered as the relay candidates. After the relay candidates check if they are able to reduce the energy consumption they are given in the Eqn1.

After SIFS, the winning relay broadcasts the II message that reconfirm the interference range of the allocated transmitting power at relay is used in the NAV setting. After the above control frame exchanging, the source and relay cooperatively send the same data frames to the destination in two consecutive time intervals using the allocated transmitting power. Finally, if message is decoded successfully the destination sends an ACK back to the source. The detailed protocol operations are provided from the perspective of different terminals. They are as follows:

B. Operation at the Source

i) When a source wants to initiate the data transmission with payload length *L* bytes, it first senses the channel, whether it is idle or not. If the channel is idle for DIFS, the source chooses a random back off timer between 0 and CW. When the back off counter reaches zero, the source sends out a RTS to reserve the channel.

ii) If the source does not receive CTS within *TRTS* + *TCTS* + *SIFS*, a retransmission process will be performed. Otherwise, in the case that FLAG _P of CTS is set to 0 and the DEL-CMAC is reduced to DCF protocol.

iii) If both CTS and ETH are received, after waiting for *TII +S IFS*, the source initiates a cooperative transmission with data rate 2*R* using the optimal transmitting power P_s^C which is piggybacked in the ETH.

iv) If the acknowledgement is not received the source handles the next packet for transmission.

C. Operation at the Destination

i) Upon receiving the RTS, the destination sends CTS back after SIFS which contains the location information of the destination, the FLAG_P, and the transmitting power for the direct transmission P_s^D which can be used for the possible relay contention.

ii) In the case when FLAG_P is 1, if the destination has not heard any ETH within TmaxBackoff +TCTS +TETH+S IFS, it assumes that the direct transmission will be performed and waits for the data packet from the source or it sends back an ACK. Otherwise, it just lets the source timeout and retransmit.

D. Operation at the Relay

i) Any terminal that receives both RTS and CTS with FLAG_ P equals 1 and does not interfere with other transmissions in its vicinity can be regarded as a relay candidate. Upon receiving the CTS, each relay candidate checks whether it is able to reduce the total energy consumption by the following equation,

$$(2P_s^D\text{-}P_s^C\text{-}P_r^C\text{-}2P') \times (L + L_{\square\_})/2R\text{-}(P_r^C+P') \times T_{11} - (P + 3P') \times T_{ETH} > 0 \quad (1)$$

P_s^C and P_r^C refers to the transmitting power in the cooperative transmission mode for source and relay, $P_s^D$and P refers to the transmitting power in the direct transmission mode for source and the fixed transmitting power respectively. The Term *(*$2P_s^D\text{-}P_s^C\text{-}P_r^C\text{-}2P'$*)* $\times (L + L_{h\_})$*/2R* denotes the energy consumption in transmitting the data by CC, the terms of $(P_r^C+P') \times T_{11}\text{-}(P+3P') \times T_{ETH}$ additional energy consumption on control overhead. By Eqn. (1), the relay checks whether CC can reduces the total energy consumption both on transmitting and receiving, compared to direct transmission.

ii) Intuitively, when the back off at a better relay expires earlier the best relay will be send out an ETH first. The lost relays give up contention when sensing the ETH. The ETH contains the optimal transmitting power P_s^C for the source.

iii) After SIFS, the winning relay will broadcasts the II message using powerP_r^C. This II message is used to reconfirms the interference range of the relay with the objectives to enhance the spatial reuse. Then, the winning relay will waits for the data packet from the source to arrive.

IV. Detail and Suplimment of DEL-CMAC

The supplement of the proposed DEL-CMAC specifically addresses the optimal power allocation scheme, the utility-based best relay selection strategy, and the NAV (network allocation vector) setting in the following subsections.

A. Utiliuty Based Best Relay Selection

In this the best relay selection efficiently affects the performance of the CMAC protocol significantly. The existing relay selection schemes that incorporated into the CMAC protocols, largely depend on the instantaneous channel condition, which based on the assumption that the channel condition is invariant during one transmit session. For MANETS that deployed in heavily built-up urban environments or heavy traffic environments, this assumption is hard to guarantee. This implies that the "best" selected relay terminal according to channel condition during the route construction or handshaking period may not be the best one in the actual data transmission period. Selecting the best relay terminal based on the instantaneous location instead of instantaneous channel condition may be more reasonable for MANETs.

In this paper, a distributed energy-aware location-based best relay selection strategy which is incorporated into the control frame exchanging period in DEL-CMAC has been proposed. This can be explained that the location information of individual wireless devices can be obtained through GPS or other localization algorithms. The required location information of source and destination is carried by RTS and CTS frames. Thus no additional communication overheads are involved. In this proposed work based on a utility-based back off DEL-CMAC chooses the best relay, which depends on the required transmitting power to meet certain outage probability and the residual energy of individual terminals. Define the Back off Utility function for relay r as

$$BU_r = \tau min\,(\frac{E}{Er}\,\delta) \times \frac{P_r^C}{P_s^D/2}\,,\delta) \times \frac{P_r^C}{P_s^D/2} \quad (2)$$

Where E_r is the current residual energy of relay r, P_r^C is the transmitting power at relay r in cooperative mode, and P_s^D is the transmitting power at source s in direct mode. Using this proposed relay selection strategy, the energy consumption rate among the terminals can be balanced, and the total energy consumption can be primarily reduced.

B. Optimal power allocation

Optimal power allocation is indispensable for a cross-layer CMAC protocol that aims at increasing energy efficiency. In this subsection, the power allocation for CC and direct transmission under the given outage probability is addressed. This is started with deriving the transmitting power at source in the direct transmission mode, which is calculated by the destination after it receives the RTS. Then, under the same outage probability and end-to-end data rate, the optimal transmitting power at source and relay in the cooperative transmission mode is calculated by individual relay candidates after the RTS/CTS handshake.

V. PERFORMANCE EVALUATIONS

In this section, simulation evaluations are made for DEL-CMAC comparing with IEEE 802.11 DCF. Since the purpose of this scheme is to prolong the network lifetime and increasing the energy efficiency, the evaluation metrics in this paper are the transmitting power, total energy consumption, network lifetime, aggregated throughput and average delay.

The total energy consumption is the summation of the transmitting and receiving energy cost at the source, destination and relay. The lifetime is defined as the duration from the network initialization to the time that the first terminal runs out of power. The initial energy of all relay path loss model is adopted. constant data rate with 0.5,1,2 mbps is used in DEL-CMAC and DCF he fixed transmitting power used for control frames is set to 10 DBm and, the fixed transmitting power used for data frame in Coop MAC is set to 15 DBm due to the high data rate (the transmitting power for the data frames in DEL-CMAC and DCF is dynamically allocated).

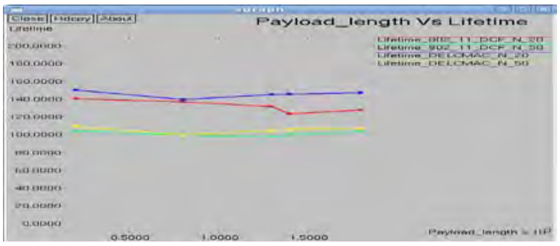

Fig 3 Payload length versus Lifetime

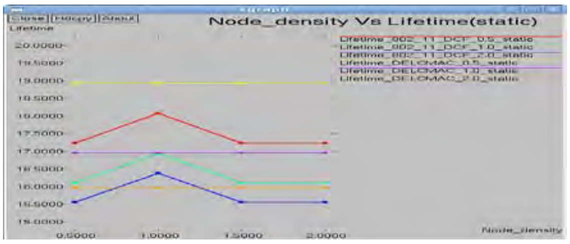

Fig 4 Node density versus Lifetime

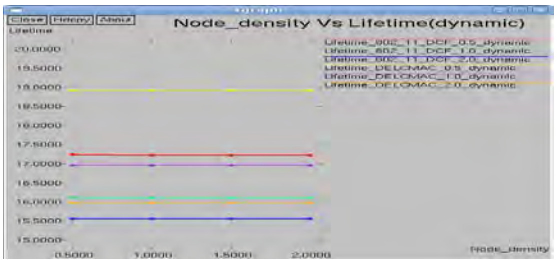

Fig 5 Node density versus Lifetime (Dynamic)

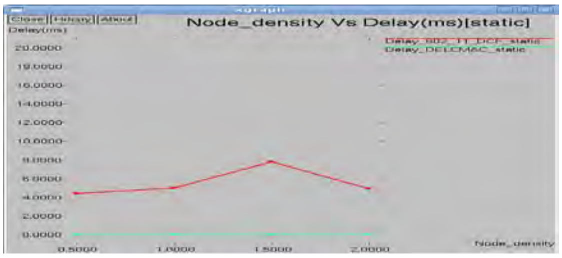

Fig 6 Node density versus Delay (Static)

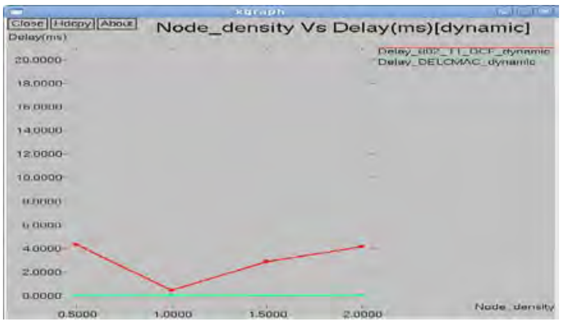

Fig 7 Node density versus Delay (Dynamic)

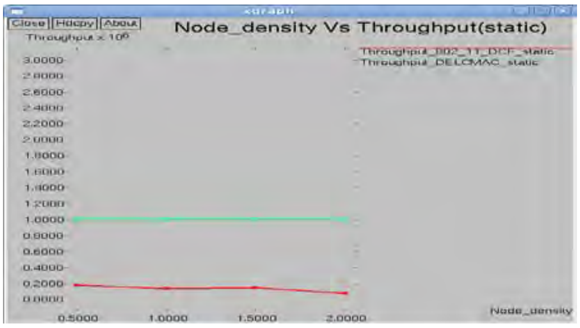

Fig 8 Node density versus Throuhgput (Dynamic)

In Fig. 4 and Fig. 5 graph is plotted between node density versus lifetime. The network lifetime is increased by using DEL-CMAC when compared with 802.11 DCF in both static and dynamic environment. In this graph the number of nodes is indicated by node density where the node density is multiplied with 10^3.For DEL-CMAC, the throughput of the network increases by at most 80% in static environment and, 4.04% in mobile environment, compared to DCF. And the delay decreases by at most 6% and 3.93% in static and mobile environments, respectively. These results are expected since the additional control frame overhead is required to coordinate the cooperative transmission. However, as the node density and payload size raise, the lifetime gain that our DEL-CMAC can number of terminals increases. In Fig. 6 and Fig. 7 static and dynamic environments by using 802.11 DCF protocol delay is maximized. This reduces the network lifetime. This can be overcome by using DEL-CMAC protocol which in turn minimized the delay during transmission.

In fig 8 and fig 9 it is shown that the throughput is increased by using DEL-CMAC protocol when compared to 802.11 DCF protocol. The reason can be explained from the following two aspects. First, if the node density is low, some terminals have to play the role as the source and cooperative relay alternately. Second, the higher the node density is, the higher the probability that relay candidates are located in the ideal positions for the existing source-destination pairs high node density leads to a transmitting power reduction for both source and relay by our optimal power allocation scheme.

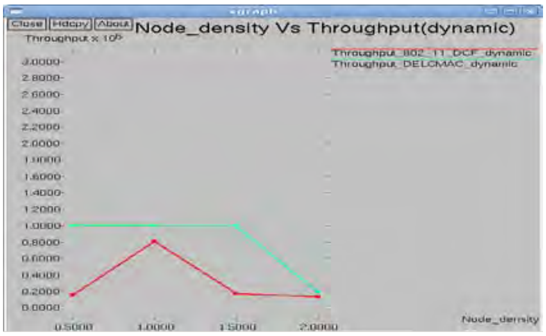

Fig 7 Node density versus Throughput (Dynamic)

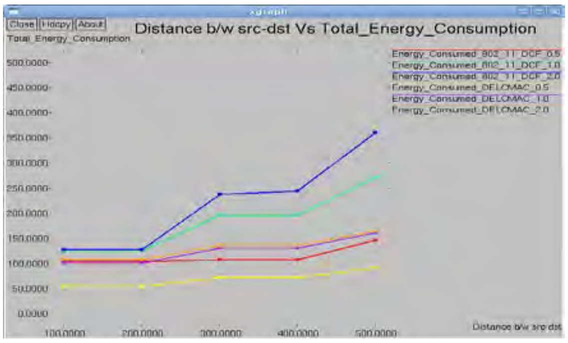

Fig. 10 distance between source and destination versus total energy consumption

In this fig. 10 graph is plotted between the distance between source and destination versus total energy consumption. The DEL-CMAC protocol used, the power is less consumed from source to destination which increases the lifetime of the network.

VI. CONCLUSIONS

In this proposed work the usage of the cross layer distributed energy adaptive location-based cooperative MAC (DEL-CMAC) protocol for MANETs has been demonstrated. Thus by introducing DEL-CMAC the network lifetime and energy efficiency has been increased instantaneously. In addition energy consumption is less when compared with existing IEEE 802.11 DCF protocol. An effective relay selection strategy to choose the best relay terminal and a cross-layer optimal power allocation scheme has been set for the transmitting power in conserving the energy has been a proposed. Thus the proposed DEL-CMAC protocol can significantly prolongs the network lifetime comparing with the IEEE 802.11 DCF at relatively high throughput and low delay degradation. This proposed work has some disadvantages due to the mobility nature of terminals. This proposed work overcomes the hidden terminals problems with considerable low probability. This is deeply further discussed and is left as the future work.

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