DEL-CMAC PROTOCOL DESIGN FOR IMPROVING NETWORK LIFETIME OF MANETS

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***Abstract*— Wireless sensor networks (WSNs) consist of sensor node with sensing and the principal applications of WSNs are energy conservation and maximizing throughput. Cooperative communication, which makes use of terminals to relay the overhearing know-how to attain the diversity gains, has a great capabilities to boost to the transmitting efficiency in wireless networks. To deal with the complicated medium access interactions precipitated by means of relaying and leverage the advantages of such cooperation, an efficient Cooperative Medium access control (CMAC) protocol is needed. On this paper, we propose a novel cross-layer distributed energy-adaptive location-based CMAC protocol, namely DEL-CMAC, for Mobile ad-hoc Networks (MANETs). The design function of DEL-CMAC is to make stronger the efficiency of the MANETs in terms of network lifetime and energy effectivity. A sensible energy consumption model is utilized on this paper, which takes the energy consumption on both transceiver circuitry and transmit amplifier under consideration. A distributed utility-basedhigh-quality relay selection procedure is included, which selects the satisfactory relay situated on area expertise and residual energy. In addition, with the rationale of bettering the spatial reuse, a revolutionary network allocation vector used to handle the various transmitting power and relay terminals. We exhibit that the proposed DEL-CMAC enormously prolongs the network lifetime below various situations even on energy consumption through comprehensive simulation study.**

***Keywords*—Energy Conservation, WSNs, Network lifetime, cooperative communication, medium access control protocol, relay selection.**

1 INTRODUCTION

A Mobile ad-hoc network (MANET) is a self-configured Communication of relay terminals connected by a wireless Hyperlinks. Cell terminals corresponding to telephones, gaming devices, personal digital assistants, (PDAs) and all the electronic gadgets have wireless networking capabilities. By collaborating in MANETs, these terminals could reach the internet when they don't seem to be in the range of Wi-Fi access points or mobile base stations, or keep in touch with every other when no networking infrastructure is available. MANETs can also be utilized within the disaster rescue. The principal drawback with MANETs is the network lifetime, since wireless terminals are battery powered, and energy is a scarce resource.

Cooperative communication (CC) is a favorable technique for conserving the energy consumption in MANETs. The broadcast nature of the Wi-Fi medium (so-known as wireless broadcast skills) is exploited in cooperative fashion. The Wi-Fi transmission between a pair of terminals may also be got and processed at different terminals for efficiency obtain, instead than be viewed as an interference almost always. CC can provide positive aspects in terms of the specified transmitting power due to the spatial diversity done via user cooperation. However, if we take into account the extra processing and receiving energy consumption required for cooperation, CC is just not constantly energy effective compared to direct transmission. There's a tradeoff between the features in transmitting energy and the losses in additional energy consumption overhead.

CC has been researched largely from the understanding theoretic perspective and on the issues of relay resolution. Lately, the work on CC with regard to cross-layer design with the aid of on account that cooperation in both physical layer and MAC layer attracts increasingly concentration. Without because the MAC layer interactions and signaling overhead due to cooperation, the efficiency gain by means of physical layer cooperation won't finish-to-end efficiency. However, important cooperation due to the fact signaling overhead just isn't addressed in a busy-tone-established MAC-layer protocol has been designed to use busy tones to aid avoiding collisions within the cooperative state of affairs on the rate on transmitting energy, spectrum, and implementation complexity. A reactive network CMAC protocol has been proposed by relay node can ahead the information for the source node, while supplying its own knowledge concurrently. However the network lifetime shouldn't be addressed in. A distributed CMAC protocol hasbeen proposed to strengthen the lifetime of wireless sensornetworks, however it is situated on the assumption that every node can connect with the base station within one hop,which is impractical for most applications. A CMAC protocolfor vehicular networks, in particular for gatewaydownloading scenarios. A drawback in is that it may well handiest be utilized inthe state of affairs that the entire autos have an interest in the sameexpertise.

In this paper, we suggest a novel distributed energyadaptivelocation-based CMAC protocol, namely DEL-CMAC, for MANETs. DEL-CMAC is designed founded on theIEEE 802.11 distributed coordination function (DCF), whichis a commonly used usual protocol for most of wireless networks.DEL-CMAC contains a relay-involved handshakingsystem, a cross-layer energy allocation scheme, anallotted utility-founded first-class relay selection strategy, and a progressive network Allocation Vector (NAV) surroundings.From the viewpoint of understanding thought, better diversitygain may also be obtained by way of increasing the number of relay terminals.From a MAC layer factor of view, nonetheless, morerelays lead to the enlarged interference degrees and additionalcontrol frame overheads. We rent single relay terminals this paper to decrease the extra communicationoverhead. DEL-CMAC initiates the cooperation proactively, and makes use of decode and forward (DF) protocol within thephysical layer. We summarize our contributions as follows.

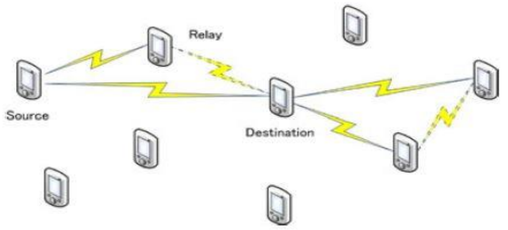


Figure1: Multi hop MANET for cooperative transmission.

On describingthe proposed DEL-CMAC protocol with the excellent relay selection procedure, the cross-layer energy allocation scheme and the NAV setting.

2. MODELS AND PRELIMINARIES

In this part, we present the process on energy models, and the abilities about DCF protocol.

2.1. SYSTEM AND ENERGY MODELS

A multi-hop MANET with randomly deployed cellular terminals is viewed, the place all terminals have the capability to relay. To come up with a reasonable system model, we expect that data connections amongst terminals are randomly generated and the routes are established with the Ad hoc On-demand Distance Vector (AODV), which is a widely used conventional routing protocol for MANETs. There are two types of relay terminals in our network, i.e., routing relay terminals and cooperative relay terminals. In the method AODV builds the route in a proactive manner by the way of opting for the routing relay terminals firstly. When a route is headquartered, DEL-CMAC initiates the cooperation in a hop-by-hop manner. In this paper, the source and destination terminals are observed the terminals at MAC layer, and the relay terminals indicate the cooperative relay terminals. For convenience, we use term source, relay and destination in the remainder of the paper to denote the source terminal, relay terminal and destination terminal respectively. It is cheap to anticipate that the energy is consumed both on transmitting and receiving the information, an identical energy consumption mannequin is used in previous work, e.g. To transmit a packet, the energy cost is $Ct = (P + P')$ And to receive a packet, the energy rate is $Cr = P'$ T. Prefers tothe energy consumption at transmit amplifier (additionally denotes as transmittingenergy on this paper), and p refers to the power consumption at transceiver circuitry. To gain knowledge on energyconsumption on transceiver circuitry, the instances $P'/P = 0.5,1,2$ allotted generally. Low P'/P ratio suggests that the power consumption on transmit amplifier debts for fine percentage of the whole energy consumption. Andsuggests the excessive circuitry energy consumption case.

2.2 DISTRIBUTED COORDINATION FUNCTION (DCF)

The basic operations of the proposed DEL-CMAC are founded on the IEEE 802.11 DCF. In DCF, after a transmitting terminal an idle channel for a length of distributed Inter Frame Space (DIFS), it back off for a time period that chosen from 0 to its Contention Window (CW).After the back off timer expires, the famous RTS-CTS-DATA-ACK system is shown in figure. Any terminal overhearing both the RTS or CTS extracts the information contained in the MAC header, and units its NAV to indicate the time period for the duration of which the channel is busy.

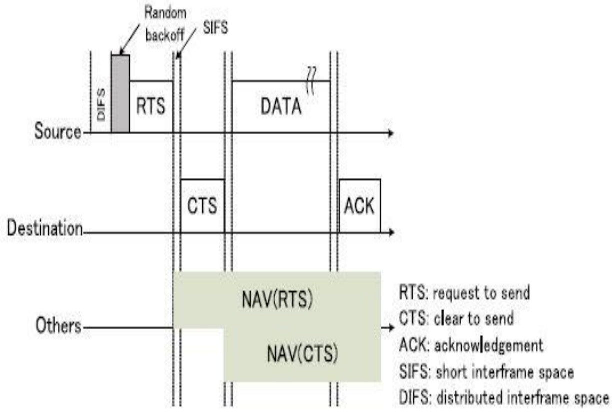


Figure 2: IEEE 802.11 for DCF

3. THE PROPOSED DEL CMAC PROTOCOL

In this part, with the target of prolonging the network lifetime and increasing the energy effectivity, we present a novel CMAC protocol, namely DEL-CMAC, for multi-hop MANETs. When cooperative relaying is concerned, the channel reservation needs to be improved in each house and time with the intention to coordinate transmissions at the relay. To care for the relaying and dynamic transmitting energy, besides the conventional manipulate frames RTS, CTS and ACK, further control frames are required. DEL-CMAC introduces two new control frames. i.e., eager-To-help (ETH) and Interference-Indicator (II). The ETH frame is used for deciding upon the best relay in a distributed manner, which is sent through the winning relay to notify the supply, destination and lost relays. In this paper, the relay is defined as the relay that has the maximum residual energy and requires the minimal transmitting power among the many capable relay candidates. The II body is utilized to reconfirm the interference variety of allocated transmitting energy at the profitable relay, in an effort to enhance the spatial reuse. Amongst the entire frames, RTS, CTS, ETH and ACK are transmitted via fixed energy. And the transmitting energy for the II body and data packet are dynamically allocated. We denote the time durations for the transmission of RTS, CTS, ETH, ACK and II frames by means of TRTS, TCTS, TETH, TACK and TH, respectively.

3.1 PROTOCOL DESCRIPTION

The Frame exchanging approach of DEL-CMAC just likely to IEEE 802.11 DCF protocol, the RTS/CTS handshake is used to order the channel at first. As we all know, the cooperative transmission shouldn't be imperative within the case that the transmitting energy is small, on account of overhead for coordinating the relaying overtakes the energy saving from diversity gain. Those inefficient circumstances are avoided through introducing attransmitting energythreshold λp. In DEL-CMAC, uponreceiving the RTS body, the destination computes the specified transmitting power for the direct transmission PD.

There are two circumstances relying on the calculated P_s^D .

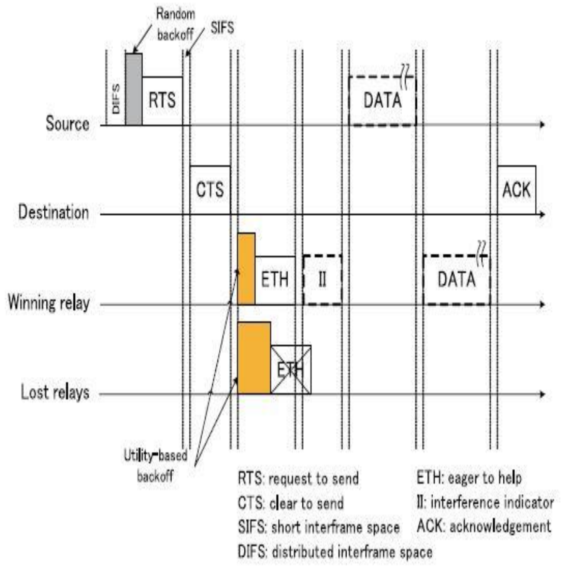


Figure 3: The frame exchanging process of DEL CMAC

Case (i):$P_s^D \leq \lambda$p.The vacation spot sends a CTS frame with flag subject (FLAG_P) equal to zero, which suggeststhat the direct transmission is adequate. As a consequence, when the transmitting power for the direct transmission is sufficiently low, DEL-CMAC is decreased to the DCF protocol and accordingly has backward compatibility with the legacy 802.11 ordinary.

Case (ii) :$P_s^D > \lambda$p. FLAG_P in the CTS frame is set to 1, which shows that the cooperative relaying is preferred. The entire terminals having overheard RTS and CTS, and not intrude with other ongoing transmissions are considered because the relay candidates. The case that a couple of ETH frames collide due to hidden would not exist. After SIFS (short interframe space), the profitable relay broadcasts the II message to reconfirm the interference variety of the allocated transmitting energy at relay, which is used within the NAV environment. After the above control body exchanging, the source and relay cooperatively ship the identical information frames to the destination in two consecutive time intervals utilizing the allocated transmitting energy. In the end, the vacation spot sends an ACK back to the supply if it decode the message effectively.Capable of reduce the strength intake (given in the Eq. (1)),

The capable relay applicants contendfor relaying by way of sending ETH after a application-based back off (utility feature is furnished in Section 4.1).Notice that there may additionally exist the case that relayapplicants hidden with each other (outside thetransmission variety). However, they could still sensethe message sent from each other (within the sensingrange which is about at 1:9 instances of the transmissionrange in the simulator by means of default). The casethat a couple of ETH frames collide due to hiddencould now not exist. After SIFS (quick interframearea), the prevailing relay publicizes the II messageto reconfirm the interference range of the allottedtransmitting strength at relay, which is used in theNAV setting (see Section 4.3). After the above manipulatebody exchanging, the source and relay cooperativelyship the identical statistics frames to thedestination in consecutive time intervals the usage ofthe allocated transmitting strength (see Section 4.2).Finally, the vacation spot sends an ACK back to the supply if it decodes the message successfully.

The flow charts of the terminals are given in the Appendix B, to be had within the on-line supplemental cloth.The unique protocol operations are provided fromthe attitude of various terminals

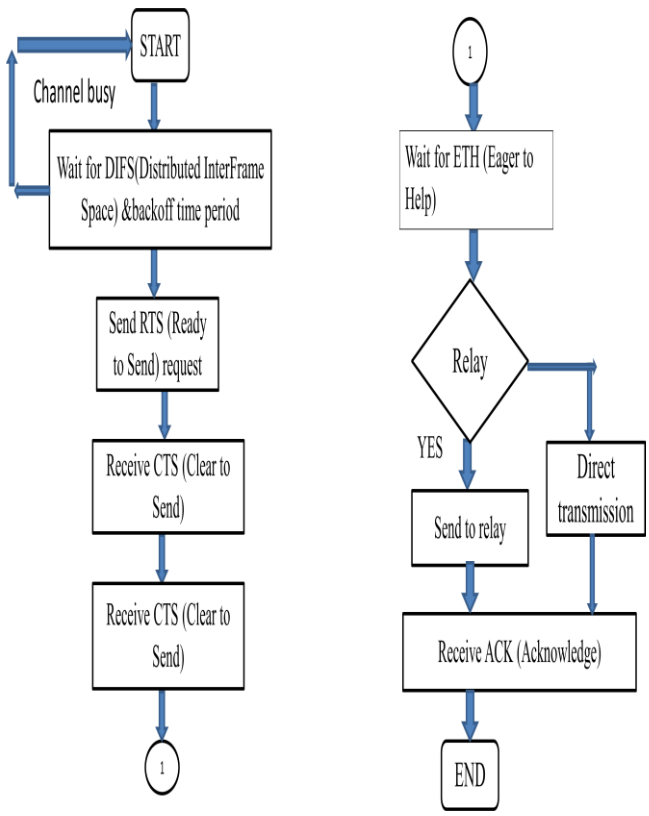


Figure 4: Algorithm for DEL CMAC Protocol

3.1.1 OPERATIONS AT THE SOURCE

When a supply wants to provoke the info transmission with payload size l bytes, it first senses the channel to verify whether itis idle. If the channel is idle for DIFS, the source chooses a random back off timer between zero and cw. When the back off counter reaches zero, the source sends out arts to order the channel. Discover that distinct from DCF, the location information of the source is carried within the RTS, which is used in the premiere energy allocation.

If the source does now not obtain CTS inside Trts +Tcts + SIFS, a retransmission system will probably be performed. In any other case, in the case that flag_P of CTS is zero, the DEL-CMAC is reduced to DCF protocol, and we omit itsoperations within the following. Within the case that flag_P is 1, the source waits for another $T_{backoff}^{max} + T_{ETH}$ +sifs, where $T_{backoff}^{max}$ is the highest backoff time for the relay (given in section four.1). If eth just isn't acquired, which means that that no capable relay exist, the supply sends the info by way of direct transmission with data cost r.

If ACK just isn't received after $\frac{16(L+L_h)}{2R} + T_{ACK}$ +2sifs, where L_h the place is the header length (in bytes), the supply would participate in a random back off equal as dcf. Or else, the transmission approach succeeds and the source handles the subsequent packet in the buffer if any. Realize that the unit for l and L_hIs byte, and the unit for knowledge expense is bits per 2nd, as a consequence the transmission time for one knowledge frame is $8(L + L_h)$/2r.

3.1.2 OPERATIONS AT THE DESTINATION

Upon receiving the RTS, the vacation spot sends a CTS again after SIFS. The CTS contains the region expertise of the vacation spot, the FLAG_P, and the transmitting energy for the direct transmission PDs (within the form of dB m, occupying four bytes), which is used for the feasible relay contention.In the case that FLAG_P is 1, if the vacation spothas no longer heard any ETH inside $T_{backoff}^{max}+T_{ETH}$ + SIFS, it assumes that the direct transmissionshall be carried out and wait for the infopacket from the source.

4. DETAIL AND SUPPLEMENT OF DEL CMAC

In this section, The detail supplement of the proposed DEL-CMAC. In particular, we tackle the premier energy allocation scheme, the utility-founded nice relay decision approach, and the NAV environment in the following sections.

4.1 UTILITY AND BASED BEST RELAY SELECTION

Deciding on the exceptional relay distributed and successfully affects the performance of the CMAC protocol vastly. The existing relay choice schemes that incorporated into the CMAC protocols, largely depend on the instantaneous channel condition, which headquartered on the belief that the channel situation is invariant for the period of one transmit session. For MANETS that deployed in heavily constructed-up city environments or heavy traffic environments, this assumption is hard to assurance. This implies that the "satisfactory" chosen relay terminal in step with channel situation during the route development or handshaking period, is probably not the satisfactory one within the genuine data transmission period. Opting for the excellent relay terminal established on theinstantaneous location as a substitute of instantaneous channel is also cheaper for MANETs. In this paper, we recommend a disbursed energy-mindful locationbased excellent relay selection process which is incorporated into the manage frame replacing interval in DEL-CMAC. The region expertise of individual wireless contraptions can also be got by means of GPS or other localization algorithms. The desired area information of source and vacation spot is carried through RTS and CTS frames. Therefore no additional conversation overheads are involved. DEL-CMAC chooses the excellent relay headquartered on a utility-established backoff, which depends on the specified transmitting energy to fulfill unique outage probability and the residual energy of individual terminals. It is carried out in energy-effective fashion, in which the back off of the relay that has the minimal utility price expires first.We define the back off utility function for relay r as

$$BU_r = \pi \min\left(\frac{E}{E_r} . \delta\right) * \frac{P_r^C}{P_S^D/2} \quad (1)$$

Where Er is the current residual power of relay r, computer r is the transmitting energy at relay r in cooperative mode, and PD s is the transmitting power at supply in direct mode (both got by means of the equations in part 4.2). The parameters in Eq. (2) comprise the power consumption threshold d, the consistent unit time t, and the preliminary energy E. Intuitively, the terminal with high residual energy and low transmitting energy (i.e., small BUr value), has a relatively brief backoff time. The terminal whose backoff expires first will probably be selected as the profitable relay. The threshold d is to hinder the maximum backoff time inside a suitable variety. In view that when the residual energy may be very low, E=Er will be particularly tremendous, leading to a very lengthy backoff time that we should preclude. The term$P_r^D/2$ laptop r is strictly higher bounded with PD s =2,i.e., the term laptop r is normally lower than 1.Consequently, BUr is higher bounded with the aid of the maximum back off time $T_{backoff}^{max}$ which is equal to $\tau.\delta$.

We discover that there is a tradeoff between the chance of collision (because of totally shut utility worth) and the time spent within the relay decision method. The value of t cannot be made too tremendous to postpone the time to search out the excellent relay, or too small to elevate the probability of collision. In our simulation, t is ready to 0:1ms. Nonetheless, atmosphere t adequately can handiest depress the collision likelihood however are not able to preclude the collision utterly. Incorporate the collision free relay selection methods into our utility-situated back off scheme is our future work. Unique from the existing fine relay determination schemes, the proposed process utilizes the location know-how and takes the residual energy into issues. Besides, it is entirely allotted and every terminal makes the decision independently. Making use of the proposed relay resolution method, the power consumption fee among the terminals can be balanced, and the complete energy consumption may also be reduced.

4.2 OPTIMAL POWER ALLOCATION

Most reliable energy allocation is critical for a cross-layer CMAC protocol that pursuits at increasing energy efficiency. In this section, we deal with the energy allocation for CC.

Direct transmission in the given outage probability. We begin with deriving the transmitting energy at supply within the direct transmission mode, which is calculated by way of the destination after it receives the RTS. Then, underneath the identical outage chance and finish-to-finish data cost, the choicest transmitting energy at source and relay within the cooperative transmission mode is calculated by using individual relay candidates after the RTS/CTS handshake.

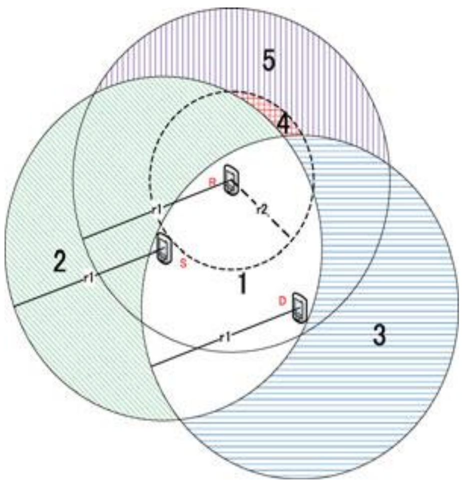


Figure5: An illustration for the NAV Setting RangesFigure

4.2.1 DIRECT TRANSMISSION

In order to meet a desired outage likelihood PO D, the minimum transmitting power in the direct transmission mode isgiven as

$$P_S^D = -(2^R - 1)N_o d_{sd}^{\propto} / \ln (1\text{-}P_D^o) \quad (2)$$

Where R is the transmission fee, is the space between the supply and the vacation spot, is the path loss exponent, Dsd is the channel fading acquire and N0 is variance of the noise element. Because of the gap constraint, we provide the derivation of Eq. (three) in the Appendix C, to be had within the online supplemental mental material.

4.2.2 COOPERATIVE TRANSMISSION

The most reliable energy allocation for cooperative transmission exists when the transmitting energy at source computer s equals the transmitting energy at relay pc r . And pc s is the strategy to the next equation

$$d_{sd}^{\propto} g(d_{sd}^{\propto} - d_{sd}^{\propto}) - d_{rd}^{\propto} g(d_{sr}^{\propto} + d_{sd}^{\propto}) + (1 - P_c^o)(d_{rd}^{\propto} - d_{sd}^{\propto}) = 0 \quad (3)$$

Where

$$G\ (d) = \exp\ (-2^{2R} - 1) N_o d / P_S^C \quad (4).$$

4.3 SPATIAL REUSE ENHANCEMENT

Because the involvement of relaying and varying transmitting power, the interference ranges in DEL-CMAC are changing for the duration of one transmit session. With the intention to avoid the interferenceand conserve the energy, smooth NAV atmosphere is required. NAV limits the use of physical carrier sensing, as a result conserves the power consumption. The terminals listening on the wireless medium read the period discipline in the MAC frame header, and set their NAV on how long they have to defer from gaining access to the medium. Taking IEEE 802.11 DCF for example, the NAV is about making use of RTS/CTS frames (see Fig. 2). No medium access is approved throughout the blocked NAV durations.

Comparing with the easy NAV setting in DCF, the surroundings in DEL-CMAC needs to be greatly modified. The presence of relays will amplify the interference degrees and the dynamic transmitting power makes the interference stages range for the duration of one transmit session. The NAV atmosphere induces energy waste and collisions. In particular, environment the NAV duration too quick will wake up the terminal too quickly, which results in energy waste due to medium sensing. On the other hand, setting it too lengthy will curb the spatial effectivity, which outcome to the performance degradation in terms of throughput and extend. Therefore, amazing NAV setting is imperative and imperative. Sadly, many of the prior works does now not handle the NAV atmosphere issue in CC to not mention the one with varying transmitting energy. On this paper, we divide the transmission degreesfor the supply, vacation spot and relay to 5 unique regions. In view that different transmitting energyresult in one of a kind transmission levels, there exist two levels for the relay. Four, the stable circle denotes the transmission range for fixed transmitting energy (with radius r1), and the dashed circle denotes thetransmission range for the allocated transmitting power (with radius r2). In the following, we deal with the targeted NAV environment for our DEL-CMAC from the standpoint of unique regions through Fig. 5.

5 PERFORMANCE EVALUATION

In this section evaluation of DEL-CMAC protocol through simulations with IEEE 802.11 DCF and CoopMAC. The analysis metrics on this paper are the transmitting power, total energy consumption, networklifetime, aggregated throughput and common delay. The transmitting energy denotes the power consumed attransmit amplifier (without the energyconsumed at transmit circuitry).The proposed work is simulated utilizing community simulator NS-2.38 and the efficiency is analyzed established on prolong, throughput and network lifetime. At the start wireless verbal exchange is situated between the nodes within the network. The nam output trace in figure: 3. represents the cooperative transmission between the source terminal and the destination terminal.

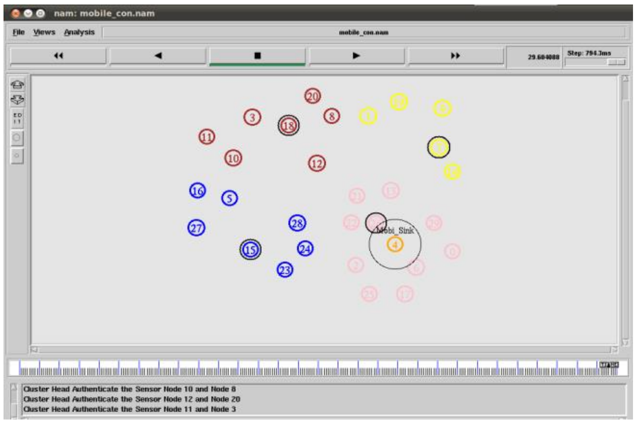


Figure 6: NAM window for DEL CMAC protocol

5.1 SINGLE-HOP SCENARIOS

We first compare our DEL-CMAC with the IEEE 802.11 DCFin a single-hop scenario that only consists of three terminals (one source, one destination and one relay), to show the differences between cooperative and non-cooperative communication on energy consumption.

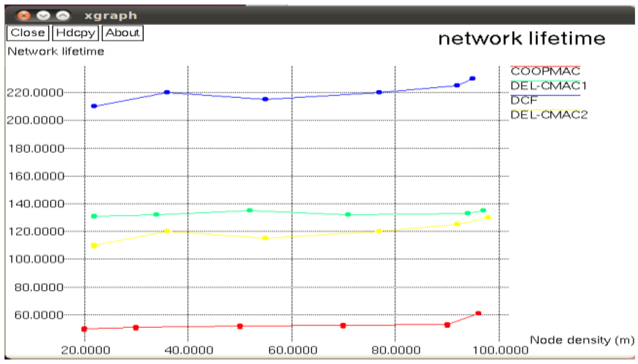


Figure7: Network lifetime vs node density in single hop

It shows the variance of the transmitting power to satisfy different outage probability requirements, when the distance between source and destination is 20 m. The ratio of the energy consumption on transceiver circuitry to transmit amplifier, i.e., P'/P, at 0.5, 1, 2 are investigated. We plot the power consumption at special distances for one of a kind P'/P ratios. Observe that due to the transmitting power threshold investigate and the energy consumption examine by Eq. (1), inefficient instances for cooperative transmission are dominated out in DEL-CMAC.

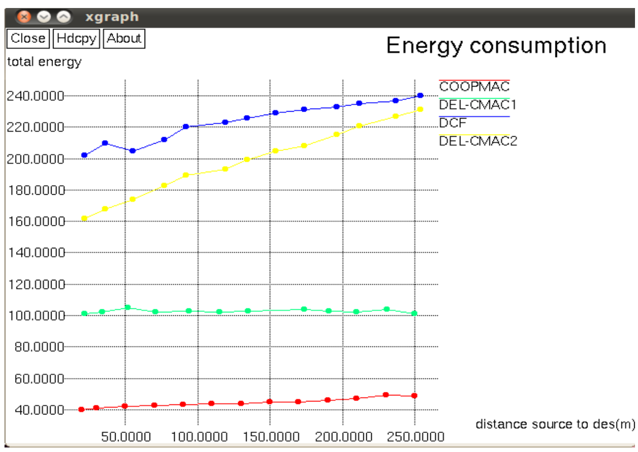


Figure 8: Total energy vs distance from the source

The energy consumption of DCF, however, is dramatically elevated as the gap raises (around 7 meters for case P'/P= 0:5 & 11 meters for case P'/P= 2). At the same time the energy cost by DEL-CMAC stays in the equal stage even for farther distances. The Energy consumption of DEL-CMAC is drastically beneath DCF for medium to lengthy distances, on account that the circuit energy consumption at both sender and receiver.

5.2 MULTI-HOP MULTI-CONNECTION SCENARIOS

The subsequent, we illustrate the performance of DEL-CMAC in a realistic multi-hop multi-connection situation together with IEEE 802.11 DCF and Coop MAC. This state of affairs takes the interference and collision induced with the aid of exceptional connections into consideration. As proven in Fig. 9, terminals are randomly placed in a rectangular area of 200×200m^2. The dashed traces indicate that the entire terminals belong to the identical subnet. The 5 strong traces point out that 5 consistent Bit expense (CBR) connections, where sources (nodes 1, 11, 21, 31, 41) transmit UDP-situated visitors at 1 packet per one hundred milliseconds to the locations (nodes 20, 30, 40, 50) by way of multi-hop. The info payload size is ready to 1,024 bytes (except stated in any other case. We range the number of terminals within the area from 20 to 60 at the same time keeping the number of CBR to 5.

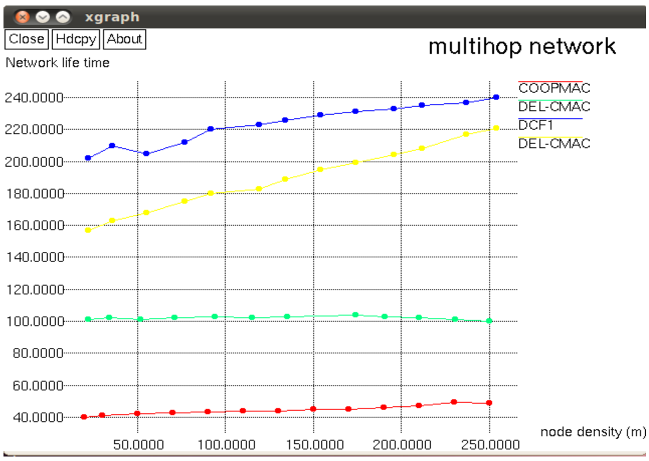
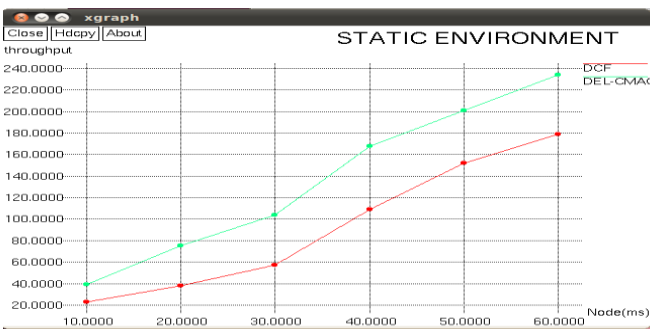


Figure 9: Network Lifetime vs node density in multi hop.

Information payload size for DEL-CMAC is furnished in Fig.12. We discover that after the node density is low and payload size is small, the transmitting energy saved by means of cooperative transmission is broadly canceled out by the overhead entailed via the cooperative relaying, e.g., only 1:26 instances lifetime enhancement for 20 terminals and 128 bytes payload. Nevertheless, as the node density and payload dimension elevate, the lifetime gain that our DEL-CMAC can acquire becomes larger, e.g.2:87 instances enhancement for 30 terminals and 1,024 bytes payload.



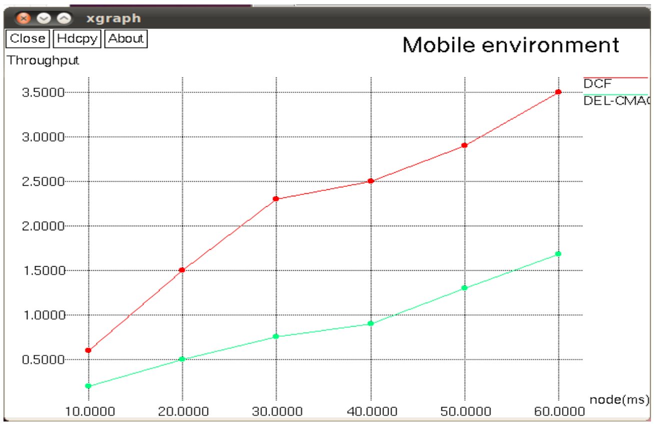


Figure 10:Throughput vs nodes in Static& mobile environment

The aggregated throughput and traditional prolong for the three schemes both in static and mobile environments. The Cooperative MAC outperforms the two others in both throughput and extend due to the utilization of a couple of knowledge charges. And the efficiency of Cooperative MAC decreases greatly within the mobile state of affairs, on that account that the desk-centered proactive relay choice may not adapt to moving networks. For DEL-CMAC, the throughput of the network decreases by at most 7.89 percentage in static environment and, 4.04 percentage in cellular atmosphere, in comparison with DCF. And the extend increases with the aid of at most 5.61 and 3.93 percentage in static and cell.

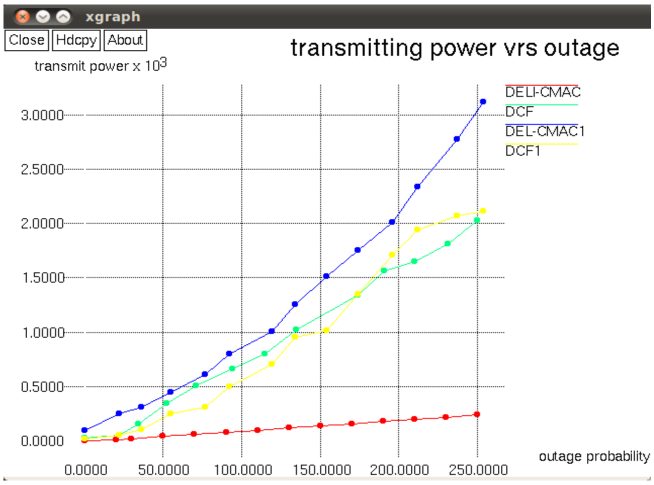


Figure 11:Transmitting power vs outage probability

6. CONCLUSION

On this paper, now we have proposed a novel disbursed energyadaptive location-headquartered cooperative MAC protocol for MANETs. By using introducing DEL-CMAC, both energy skills and place abilities may also be exploited hence the networklifetime is expanded enormously. We have now also proposed a mighty relay determination method to choose the exceptional relay terminal and a go-layer most useful energy allocation scheme to set the transmitting power. In addition, we have more suitable the spatial reuse to minimize the interference among one of a kind connections by way of using novel NAV settings. Now we have established that DEL-CMAC can greatly extend the network lifetime comparing with the IEEE 802.Eleven DCF and Cooperative MAC, at quite low throughput and delay degradation cost.

As a future work, we can investigate our DEL-CMAC for greater scale network dimension and with excessive mobility. We will also don't forget to improve an amazing go-layer cooperative variety-aware routing algorithm at the side of our DEL-CMAC to conserve energy at the same time minimizing the throughput and extend degradation.

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