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Enhancing the lifetime of Network in MANET by Using Sleep Mode MAC Protocol Design

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Abstract

Ultimate aim of authors is to implement a high energy efficient data transmission protocol for Mobile Adhoc Networks (MANET) which prolongs the life time of network in a significant way. MANET devices mainly depend on a limited battery power supply to maintain the network with low power consumption techniques by utilizing the available protocol algorithms with enhanced transmission coverage range of relay nodes. Even though cooperative communication protocol method improves the transmission range of intermediate relay nodes with less power consumption, but it has not been always an effective energy efficient method as compared to direct transmission protocol concept methods. Having been studied power consumption protocol saving methods of [2] and [17], Sleep Mode Cooperative Communication power saving protocol method may be a hopeful solution in MANETs. The existing Cooperative Medium Access Control (CMAC) protocol methods only focus on throughput enhancement while neglecting to investigate the energy efficiency or network lifetime of MANETs. So, authors propose a concept of Sleep Mode Cooperative Medium Access Control protocol algorithm which will be basis on the network lifetime extension as a less traverse aspect in the related work by considering the energy consumption on both transmitter and receiver.

Keywords: sleep mode, power consumption, cooperative communication and energy efficiency.

Summary of Notations used in this paper:

RTS - Request to Send	ACK- Acknowledge
S_s - Source Station	S_d - Destination Station
S_h - Potential Helper	NACK- Negative Acknowledgement
CTS - Clear to Send	DCF- Distributed Coordination Function
ETH - Eager-to-Help	II - Interference-Indicator
HTS- Helper Ready to Send	

1. Introduction:

MANET is a self-configured network of mobile nodes connected by wireless links. Mobile nodes such as mobile phones, personal digital assistants, portable gaming devices, and tablets all have wireless networking possibilities. By involving in MANET's, these nodes may connect to the internet when they are not in the coverage of Wi-Fi hotspot points or base stations or communicate with each other when no communication infrastructure is available. One main issue with continuous involvement in MANETs is the network battery lifetime, because the previously mentioned wireless nodes are powered by battery, and energy is a limited resource. Sleep Mode communication [18] is a promising solution for saving the energy consumption in MANETs. The broadcast behavior of the wireless medium is exploited in cooperative manner. The wireless transmission between any number of nodes can be received and worked at other nodes for quality improvement other than be considered as an noise commonly. Sleep Mode can give improvements in required transmitting power due to the diversity achieved through node cooperation. Anyway, if it will take extra processing and receiving energy loss needed for communication between nodes, cooperative mode is not always power efficient compared with direct communication.

2. Related work

Space or multiple-antenna, diversity techniques are especially delightful [1] as they can be readily combined with other forms of diversity, example time and frequency diversity, and still offer dramatic performance gains when other forms of diversity are unavailable. Authors developed and analyze low-complexity cooperative diversity protocols that combat disappear induced by multi-path propagation in wireless networks. The unexpressed techniques exploit space diversity available through combine terminals relaying signals for one another.

Cooperative communication can achieve spatial variety by utilize dispense virtual antennas of cooperative nodes. The main attribute of cooperative communication is the connection of neighboring nodes in data transmissions. The novel aspect and core idea of authors' proposal is a cross-layer adaptive data transmission algorithm considering both the length of data frame at the MAC layer and immediate wireless channel conditions. Under this algorithm [3], direct transmission mode or proper cooperative transmission mode will be selected for data packets according to both MAC layer and physical layer information.

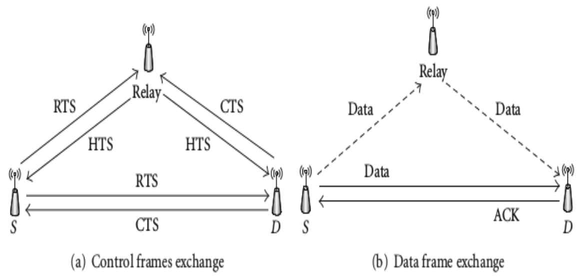


Fig. 1 Data Exchange through Relay Node

When the length of a data surround is less than the RTS , the source will transfer it personally to the destination by the basic entrance scheme of IEEE 802.11 DCF, which brings down the overhead in the network. Otherwise the source will send a RTS setting and wait for a CTS support from the destination. If the source collect a CTS support but does not collect any HTS frame from neighbor nodes in a unquestionable interval, it will transfer the data packet by RTS/CTS straight transmission scheme. If both CTS and HTS frames are collect in succession, the source transfer the data packet on the authority of to the "transfer mode" piggybacked in the HTS surround.

If an ACK is not received after an ACK timeout, the source should perform random back off; otherwise, the source will handle the next data packet in its queue. If the destination receives an RTS frame from the source, it sends CTS surround including the measured channel state information between source and destination and waits for HTS surround from adjoining nodes.

If the destination receives an HTS support before collecting data packet, it will process the received data packet according to the "transfer mode" piggybacked in HTS and then sends an ACK to the source.

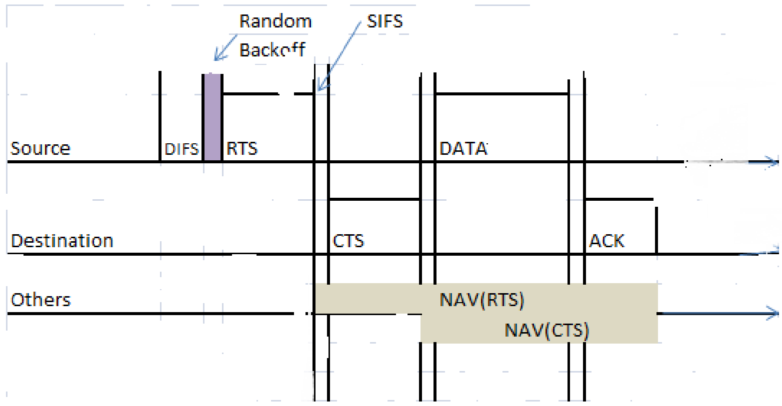


Fig.2 IEEE 802.11 DCF

. If it is the node will decode and forward the data packet to the destination. It [3] can avoid extra overhead, and this technique can improve the throughput by using the MAC and physical layer configuration. It cannot select the optimal relay, this technique not concentrating on the optimal relay selection process and power saving process. As wireless [4] ad hoc networks to establish the reliable communication network between neighboring nodes through relays, cooperative communications as one of the solution which algorithm has spatial diversity from relaying paths via relaying nodes to increase the transmission reliability, enhance the network throughput, as well as reduce the transmission latency. In paper [5] authors proposed an improved cross-layer cooperative MAC protocol by considering the design of a cross-layer medium access control protocol for wireless ad hoc cooperative networks. According to their view, to simplify the signal message exchange process to reduce the protocol overhead specifically they use a helper response pulse signal with shorter length, instead of using a control frame to inform the source and destinations.

3.1 System Model

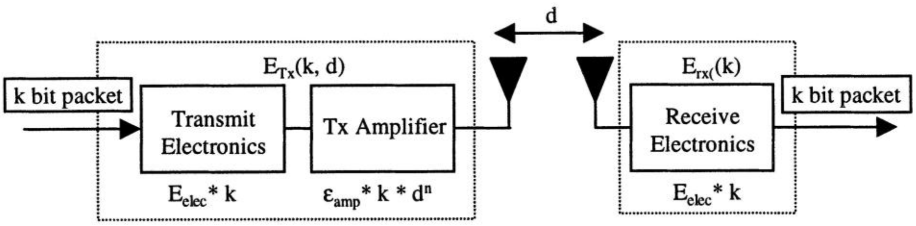


Fig . 3 Radio Energy Channel Model

It can be assumed that any node to establish the communicate to the network [6,7], it uses transceiver circuit which contains electronic circuit and amplifier circuit for both transmitter and receivers as shown in fig. 3. The source station sending its data to the destination using a Cooperative MAC protocol communication with low data transmission rate through a radio channel circuit. When the helper collects the frame from the source, retransfer it to the destination after a SIFS time, and thus stay away from the need to maintain for the medium. After the reception of the frame from the helper, the destination station sends a direct ACK to the source, recognize the reception [18] mainly concentrating on the QoS improvement not on the power efficiency due to electronic amplifier circuit of node. If power consumption also considered at low energy level while cooperative communication possible with *l* bits of data transferred through transmit circuit to receiver circuitry. So, power consumption model of energy channel defined as below, if power losses of free space d^2 and multi path fading d^4 considered for the calculation, then equation is

$$E_{Tx}(l,d) = E_{Tx-elec}(l) + E_{Tx-amp}(l,d)$$

$$= \begin{cases} lE_{elec} + l\varepsilon_{fs}d^2, & d < d_0 \\ lE_{elec} + l\varepsilon_{mp}d^{42}, & d \geq d_0 \end{cases} \qquad (1)$$

To receive the same length of message *l*, energy consumed by receiver is

$$E_{Rx}(l) = E_{Rx-elec}(l) = lE_{elec} \qquad (2)$$

E_{elec} depends on different modulation procedures such as filtering, coding and signal spreading, $\varepsilon_{fs}d^2$ and $\varepsilon_{mp}d^4$ depend on distance to receiver and bit error rate.

Parameters defined as E_{elec}= 50nj/ bit,$\varepsilon_{fs}=10$ pj/bit/m^2 and $\varepsilon_{mp}=0.0013$ pj/bit/m^4 which have got from [12].

It is defined between any random nodes of x ,y as [6,7]

$$L_{xy}(t)=K_{xy}(t)\sqrt{1/D_{xy}} \qquad (3)$$

$$D_{xy}=(4\pi/\lambda)^2 d_0^2 d_{xy} \qquad (4)$$

Where $L_{xy}(t)$ is channel gain, $K_{xy}(t)$ is fading coefficient, whereas D_{xy} is the distance path loss.d_0 is antenna far field and d_{xy} is distance between x, y nodes.

3.2 Energy Cost model for Route :

The energy cost [10] of route m at given time t is expressed as

$$Q(m,t)=\sum Q_i(t) \quad , \qquad i \in m \qquad (5)$$

$Q_i(t)$ is defined as cost of node *i* at time t

$$Q_i(t) = E_i\left[\frac{F_i}{B_i(t)}\right]^a \tag{6}$$

Where E_i is node *i* transmitting power at time t, F_i is fully charged battery power of node *i*,$B_i(t)$ is batter remaining energy of node *i* at time t and '*a*' is a variable factor.

According to energy model [11], to transmit a packet at transmitter (E_t) side and receive a packet at receiver (E_r) ,energy cost of a node at a packet duration of time T is determined as $E_t = (Q + Q')*T$ and $E_r = Q'*T$ .Where Q is power consumption at transmit amplifier and Q' is power consumption at transmit circuit or receiver circuit. It has been compared the energy-efficiency of the cooperative and non-cooperative schemes, for cases $Q'/Q = 0.5, 1, 2$.

Improved network quality of service performance technique represented in [1] and it makes effective relaying in signal transmission. And disadvantage is not concentrating on the energy efficient transmission in wireless network.

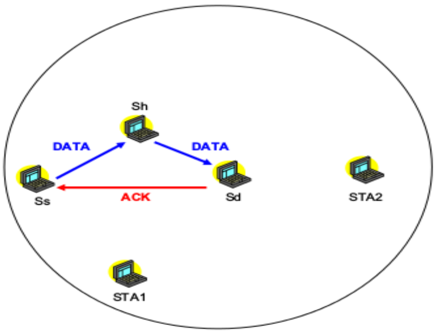


Fig.4 Exchange of data- ACK frames for Cooperative MAC

Wireless networks [18] that provide multi-rate brace give the stations the ability to adapt their transmission rate to the link quality in order to make their transmissions better founded. Thus stations that event poor channel conditions tend to use lower transmission rates and vice versa. The basic functionality of the proposed protocol is illustrated in fig. 4.

In fig. 4, S_s is the source station,S_d is the destination station and S_h is a potential helper. S_h for exchange data with the source and the destination at higher than the rate of the attention link between them.

Data transmission through helper node S_h is possible, if below condition satisfies [8]

$$\frac{1}{R_{sh}}+\frac{1}{R_{hd}} > \frac{1}{R_{sd}} \tag{7}$$

Where R_{sh} is data rate between S_h and Ss, R_{hd} is data rate of S_h and S_d and direct data transmission between S_s,S_d denoted by R_{sd}. To transmit L bytes of data packet from source to destination, transmission time is $8L/R_{sh}$ + $8L/R_{hd}$.

In RTS/CTS mode, cooperative communication condition defined as

$$\frac{8L}{R_{sh}}+\frac{8L}{R_{hd}}+T_P+T_{HTS}+2T_{SIFS} < \frac{8L}{R_{sd}} \tag{8}$$

Where Tp is physical layer overhead. In coop-MAC protocol communication [8], if source S_s determines helper node S_h, then source sends cooperative RTS message and it's time duration expressed as

$$T_{CoRTS} = \frac{8L}{R_{sd}}+T_P+T_{CTS}+4T_{SIFS}+T_{ACK} \tag{9}$$

T_{CoRTS} denoted as cooperative time duration.S_S performs normal operation, if it does not receive HTS or CTS within $2T_{SIFS}$ +T_{CTS} duration period. S_S performs normal operation as it receives CTS from S_d and could not receive HTS from S_h.

S_s transfer the data to S_h, if it receives both data packets of HTS and CTS by setting ACK time out as

$$T_{ACK\,Time\,Out} = \frac{8L}{R_{hd}}+T_P+2T_{SIFS}+T_{ACK} \tag{10}$$

S_s should perform normal operation as 802.11 protocol standards as source does not receive acknowledge within ACK time out duration.

3.2.1 Helper node S_h:

If helper node S_h after verifying received cooperative message T_{CoRTS}, it sends HTS to source node S_s with time duration of $T_{HTS\,Duration}$ expressed as

$$T_{HTS\,Duration} = \frac{8L}{R_{sh}}+\frac{8L}{R_{hd}}+2T_P+4T_{SIFS}+T_{CTS}+T_{ACK} \tag{11}$$

S_h goes to initial stage as it does not receive the CTS message or the data packet within specific time boundaries.

3.2.2 Destination node S_d :Destination should involve in cooperative communication through helper node S_h if the data packet was received within the time boundary of $8L/R_{sh}+T_P+2SIFS$. Destination time duration derived as

$$T_{Dest-CTS} = \frac{8L}{R_{sh}} + \frac{8L}{R_{hd}} + 2T_P + 3T_{SIFS} + T_{ACK} \tag{12}$$

If data packet does not received by within the time limits of destination Clear to Send $T_{Dest-CTS}$,it goes to initial stage.S_d goes to IEEE 802.11 protocol standards and performs direct transmission T_{Direct} of

$$T_{Direct} = \frac{8L}{R_{direct}} + T_P + 2T_{SIFS} + T_{ACK} \tag{13}$$

According to [9], time taken for length of data defined as to transmit *x* octets of data packet through IEEE 802.11a Physical layer by using mode *y*, time duration derived as

$$T_{Data\ Packet}(x,y) = 20\mu s + \left\lceil \frac{30.75 + x}{BpS(y)} \right\rceil * 4\mu s \tag{14}$$

Where BpS(*y*) is Bytes per Symbol information of physical layer with mode *y,*similarly acknowledge (ACK) frame duration is

$$T_{Ack}(y) = 20\mu s + \left\lceil \frac{16.75}{BpS(y)} \right\rceil * 4\mu s \tag{15}$$

For BPSK modulation [9] with 6 Mbps of data rate, BpS is 3.

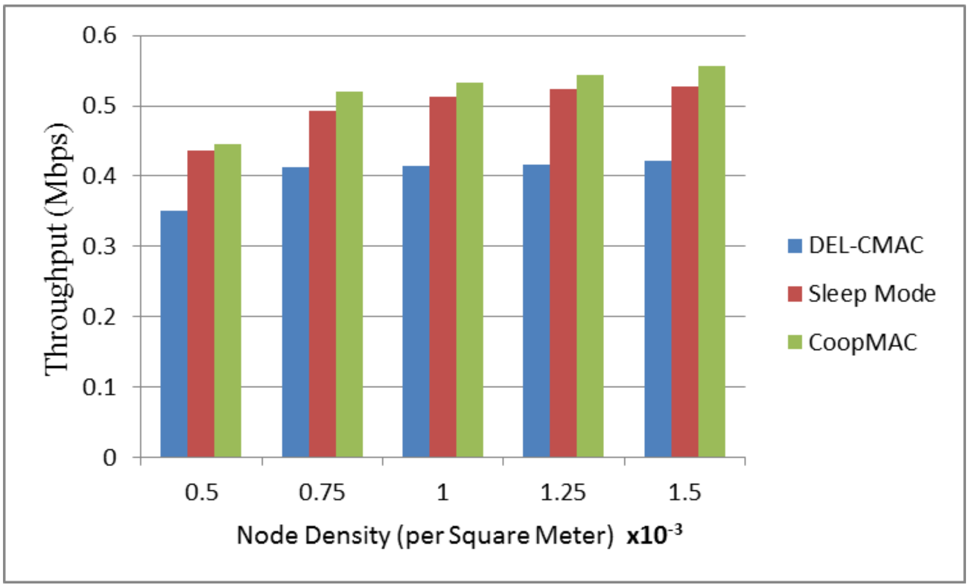
From the equations of Eq (1) to Eq (6), any mobile node utilized energy in MANET summarized as consumed energy (C) expended of transmit a packet (Tr),Receive a packet(Recev) and overhear the neighbor nodes [19]. The energy consumed by a particular node (nx) is calculated as follows:

$$E(nx)_C = E(nx)_{Tr} + E(nx)_{Recev} + (N) * E(nx)_{Overhearing} \tag{16}$$

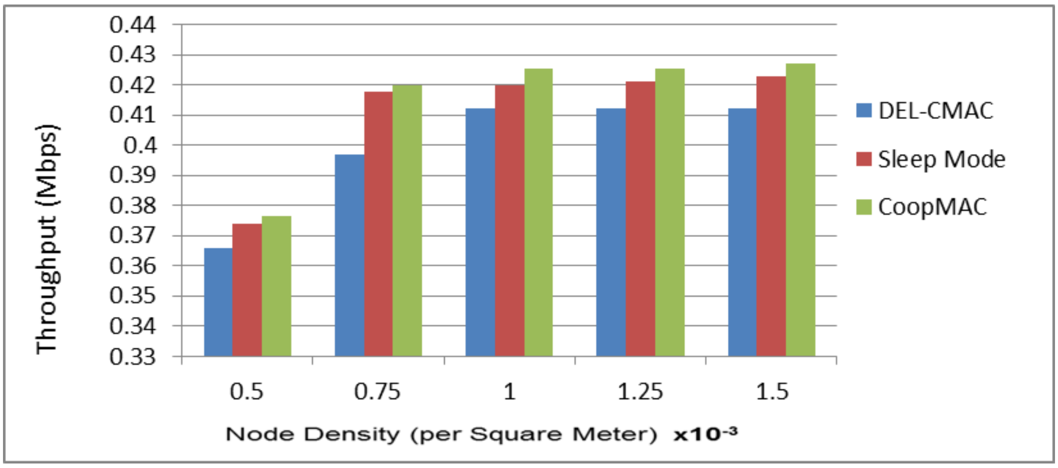
$$E(nx)_{Remainingenergy} = E(nx)_{Initialenergy} - E(nx)_C \tag{17}$$

$$E(nx)_{Remainingenergy\ ratio} = (E(nx)_{Remainingenergy} / E(nx)_{Initialenergy}) * 100 \tag{18}$$

where N is number of neighboring nodes of nx. The energy value of a mobile node is calculated at regular intervals to determine the remaining energy and in turn calculate the remaining energy ratio. If the remaining energy ratio for a node is greater than equal to 50 the node energy level is assigned with a value of 1 else 2. Once the mobile node energy level gets reduced to 2, it will broad cast an Energy Level message



(a) Static Environment



(b) Mobile Environment

Fig . 5 Throughput Vs Node Density

The shortened length of the HRP signal helps to reduce the protocol overhead, and thus better the path throughput. The HRP signal with shorter length is transmitted more reliably over erroneous channels leading to higher cooperative opportunity. In this protocol algorithm [5] , only one HRP signal is used at randomly picked up mini-slot to inform the source even if there is more than one optimal helper. This design allows the protocol to switch from the unsuccessful cooperative mode to the direct transmission.

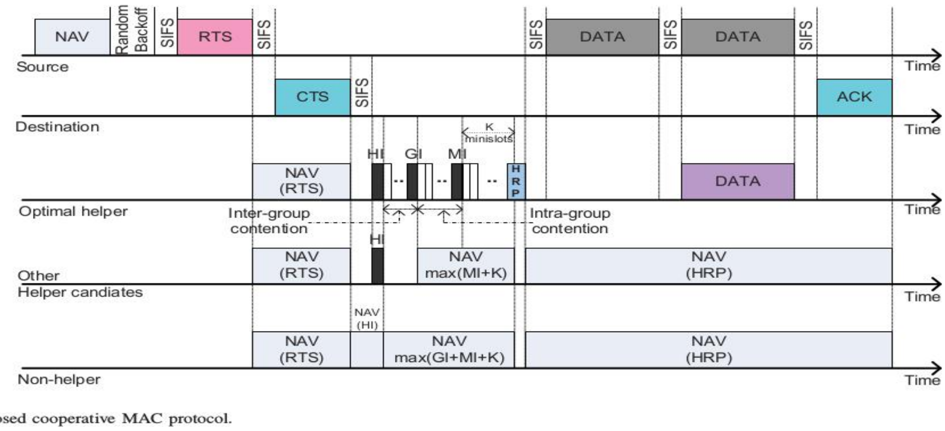


Fig. 6 Proposed sleep MAC Protocol

This technique solely concentrates on QoS parameters like overhead and out turn. Spacial diversity has been extensively studied within the context of Multiple- Input-Multiple-Output (MIMO) systems to combat the results of multipath weakening. However, in wireless networks, particularly device networks, it would not be possible to put in over one antenna on the wireless terminal owing to area limitations or the desired simplicity in implementation. to unravel such issues, cooperative diversity has been introduced. The analytical and numerical results reveal that for tiny distance separation between the supply and destination, transmission mechanism is additional energy economical than relaying.

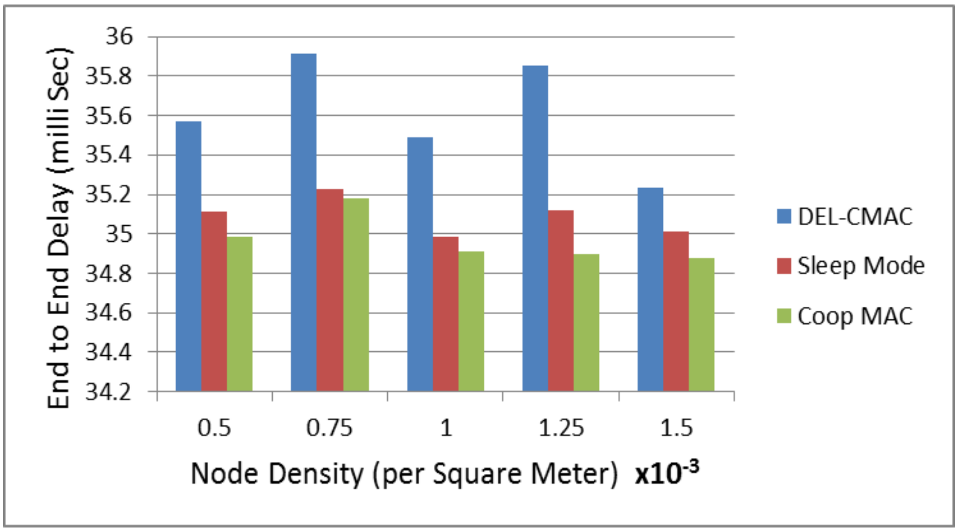


Fig. 7 Delay performance versus Node Density in Mobile Environment

The results additionally reveal that equal power allocation performs moreover as best power allocation for a few situations. If source transmits a symbol to the destination, and owing to the printed nature of the wireless medium the relay will hear this signal. If the destination receives the packet properly, then it sends back ACK and therefore the relay simply should be in idle condition. On the opposite hand, if the destination cannot decipher the received packet properly, then it sends back a NACK during this cooperative mode, if the relay is ready to receive the packet properly, then it forwards it to the destination.

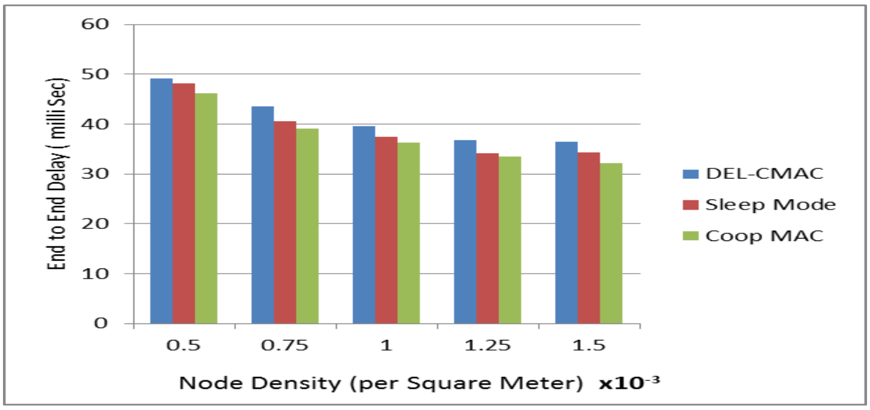


Fig. 8 Delay performance versus Node Density in Static Environment

The supply node transmits its packets to the destination and therefore the relays try and decipher this packet. If the destination doesn't decipher the packet properly, it sends a NACK which will be detected by the relays. If direct communication happened to be in unfaithful situation, cooperative communication may be a one of the solution for maintaining of network for a long time. It provides another best resolution to enhance the saving by exploitation the ability allocation technique. According to paper [5] principally appropriate for wireless device network with totally different fastened power levels, more improvement is required with this idea for mobile adhoc network.

4. Proposed system:

According to view of authors, the target of prolonging the network life and increasing the energy potency of network, a protocol has been developed to get a completely unique CMAC protocol, particularly DEL-CMAC, for multi-hop MANETs as additionally address the difficulty of effective coordination over multiple synchronic cooperative connections with renascent transmission power. A distributed energy-location-based best relay choice strategy is incorporated in this algorithm design methodology.

To contend with the relaying and dynamic transmission power, besides the standard management frames RTS, CTS and ACK, further management frames square measure needed. Sleep Mode introduces two new management frames to facilitate the cooperation, those are Eager-To-Help (ETH) and Interference-Indicator (II). The ETH frame is employed for choosing the simplest relay in a very distributed and light-weight manner, with minimum back off relay that has the one of the best helping node as satisfying of MANET condition. At any given time, any node position can be determined by geographic routing algorithms [13].

4.1 Operations at the Source :

In this model all nodes exception of source and destination, remaining intermediate nodes considered as are in sleep mode. To make any node as sleep mode, if node is utilized by the network, sleep mode flag reset as 0 otherwise 1.source node and destination nodes will be excluded from this concept. As remaining nodes involve in communication, if not immediately got sleep mode to saving of energy. If node is ready to transmit the data, it sends RTS signal to test the status of channel. If channel is ideal, it does the operation. If it does not receive the CTS within specific time duration of $T_{MB}+ T_{RTS}+ T_{CTS}+$ SIFS,again process will be continued, where T_{MB} is maximum back of time for sleep mode relay .If source get the ACK without sleep mode relay, it directly performs the communication with destination. If both CTS and ETH signals can be received by source within specific back of time interval, it considers neighboring node as cooperative sleep mode node and performs the operation through it.

4.2 Operation at the destination:

After receiving RTS, destination sends out CTS in accordance with IEEE 802.11 DCF concept by including SIFS.Destination performs direct transmission as derived of Eq. (13), if it does not receive any ETH message from sleep mode relay without satisfying of Eq. (12) and within range of $T_{MB}+ T_{RTS}+ T_{CTS}+$ SIFS.

5. Performance Evaluation :

Authors evaluated sleep mode relay concept as compares to the existing methods of basic IEEE 802.11 DCF and Cooperative methods which improves the network lifetime and causing to decrease of energy consumption for both transceiver circuits for all nodes which participate in communication. The proposed algorithm protocol simulated in ns 2.34.The attackers mainly focusing on node energy level, and reduce energy level of intermediate nodes [15].So, this proposed algorithm method energy trust management system deals with network layer.

5.1 Operation at Sleep Relay:

After receiving RTS,CTS data packets from source and destination nodes, sleep mode relay checks the satisfying of Eq. (7) and possibility of reducing the total energy consumption by following relation, if it is not interrupted with any other communication

$$[(2P_c^D - P_{sr}^C - P_s^C - 2Q') \times (L + L_h)/2R)] - (P_{sr}^C + Q') \times T_H - (Q + 3Q') \times T_{ETH} > 0 \quad (19)$$

The term $[(2P_c^D - P_{sr}^C - P_s^C - 2Q') \times (L + L_h)/2R)]$ represents sleep mode transmitting energy saved consumption Interference Indicator energy consumption $(P_{sr}^C + Q') \times T_H$, Eager to Help data packet power consumption $(Q + 3Q') \times T_{ETH}$ are considered to be as part of control overhead power consumptions.

Authors defined the Backoff Utility function for sleep mode relay *sr* as

$$BUsr = \tau\, min\left(\frac{E}{Esr}, \delta\right) \times \frac{P_{sr}^C}{P_c^D/2} \quad (20)$$

Where P_{sr}^C is the transmitting power at sleep mode relay *sr* in cooperative mode, E_{sr} is the current residual energy of sleep mode relay *sr* and P_c^D is the transmitting power at source s in direct mode. The parameters in Eq. (20) include the energy consumption threshold δ, the constant unit time τ(τ = 0.1msec), and the initial energy E.For any sleep mode relay with less back relay considered as winning relay.

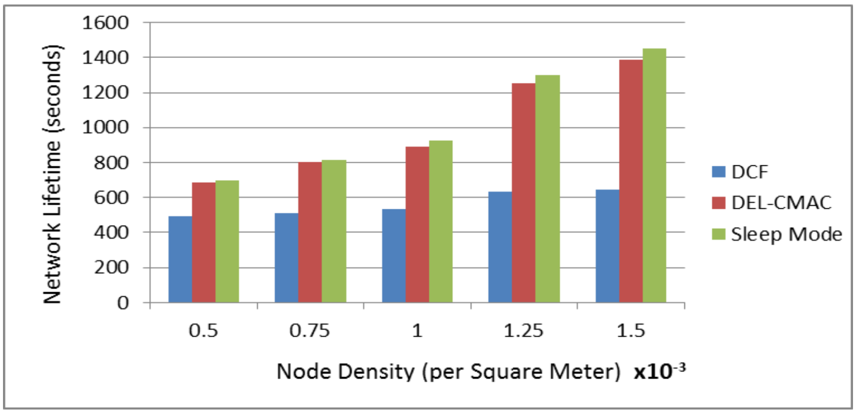


Fig. 9 Network Lifetime versus Node Density in Static Environment

For large value of E_{sr}, the ratio of E/E_{sr} is minimum which is applicable to implent the protocol algorithm. As in Eq. (20) collision probability can be decreased and but not completely avoid it.It is shipped by the winning relay to tell the supply, destination and lost relays.

5.2 Direct Transmission : It is derived by considering the factors of fading effect,probability of occurance of noise and path loss parameters as

$$P_C^D = -\frac{AZ}{Y} \tag{21}$$

Where $A=2^R - 1$,R is transmission rate, $Z= Md^€$ € is path loss exponent ,d source and destination distance,M is noise component,Y = ln(1- X), X is outage probability.

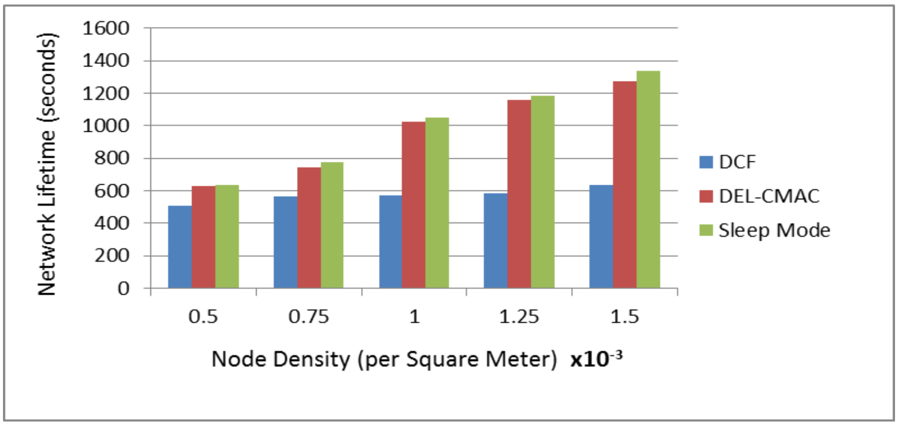


Fig. 10 Network Lifetime versus Node Density in Mobile Environment

5.3 Sleep Mode Cooperation :

$$P_S^O = \left[\frac{d_x^€ P(d_x^€ + d_z^€) - d_z^€ P(d_x^€ + d_y^€)}{(d_y^€ - d_z^€)}\right] + 1 \tag{22}$$

Where $$P(d) = e^{\left(\frac{(1-2^{2R})Md}{P_S^C}\right)} \tag{23}$$

distance between source – destination $d_x^€$,source to sleep relay $d_y^€$,relay to destination $d_z^€$.

In this paper, the simplest relay is outlined because the relay that has the most residual energy and needs the minimum transmission power among the capable relay candidates. The II frame is employed to reassert the interference vary of allotted transmission power at the winning relay, so as to reinforce the spacial apply. Among

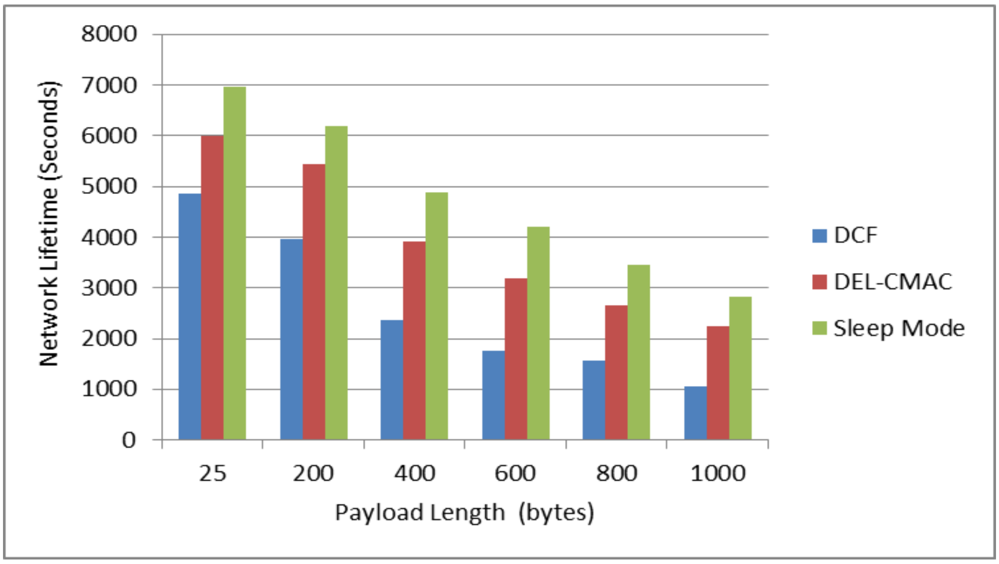
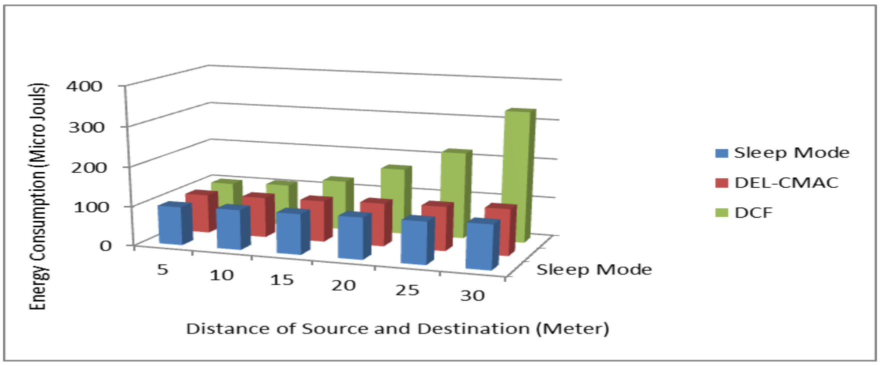


Fig. 11 Network Lifetime versus Payload Length

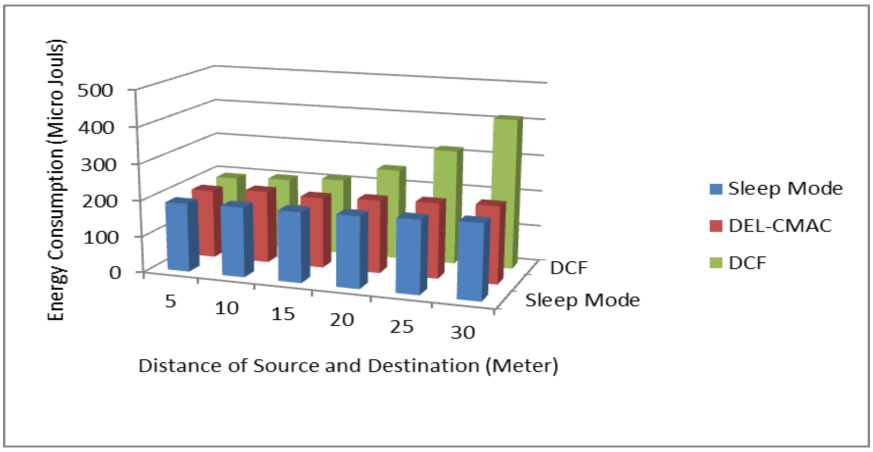
all the frames, RTS, CTS, ETH and ACK square measure transmitted by mounted power and also the transmission power for the II frame and acknowledge packet is dynamically allotted. we have a tendency to denote the time durations for the transmission of RTS, CTS , ETH, ACK and II frames by T_{RTS} , T_{CTS} , T_{ETH} , T_{ACK} and T_{II} , severally.

Initial energy of any node can be taken as 1 Joul. In fig. 12, power consumption at different conditions (Q' / Q = 0.5,1.0,2.0) i.e, ratio of transceiver circuit to transmit amplifier plotted. It has been observed that longer distance between source and destination has more power consumption than shorter range. Fig. 11 provides the relation between network life time to the pay load length. It has been observed that life time of network and pay load are having relation of inverse proportion.

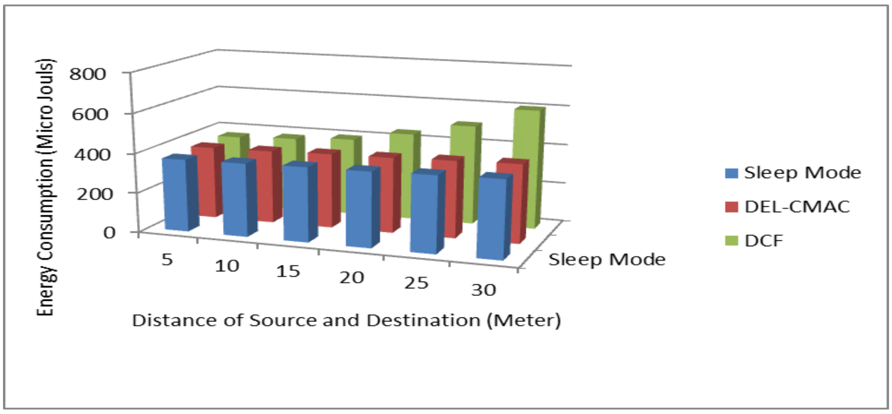
It has been observed from (fig.9 & fig.10), network lifetime of sleep mode concept has been represented in a significant way as static to mobile environment. As node density increases, intermediate sleep mode relay will eventually starts to behaves as a source. Network lifetime of Manet depends upon shorter distance between source and destination, availability of sleep relays within the contension window.



(a) Energy Consumption for $Q'/Q = 0.5$



(b) Energy Consumption for $Q'/Q = 1.0$



(c) Energy Consumption for $Q'/Q = 2.0$

Fig. 12 Energy Consumption of source and destination distance for different scenarios.

Manet other parameters of throughput [fig. 5] and delay performances have been part of enhancing the lifetime of network nodes by utilizing of residual energy of sleep relays for communication. Throughput and delay performances [fig. 7 & fig. 8] considerably better than DEL-CMAC algorithm method. Authors have been noticed that CoopMAC protocol method got better performance at different parameters of throughput and delay due to lack of power consumption and lifetime of network. In both cases, sleep mode relay concept method delivered the better results than present routing algorithms. After having been discussed the results of different network parameters, Sleep mode relay method performs better solution than older techniques.

6. Conclusion:

In this paper, authors implemented a new concept of sleep mode relay protocol method which significantly enhances the network lifetime as decreasing of energy consumption at transceiver and amplifier circuits. After analyzing the simulation results given by this method, authors observed a significant better results in the constitute network parameters of improved throughput performance and reduced end to end delay. Static environment condition performance has been considerably better than that of mobile scenario due to the control overhead performance. In future to extend this work, authors would like to concentrate on high mobility environment with the desired network parameter considerations.

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