Balanced Cooperative MAC Protocol for Improving Network Lifetime of MANETS

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Abstract- In order to improve the network performance of Mobile Ad Hoc Networks (MANETs), an Energy-balanced Cooperative Media Access Control (EC-MAC) protocol in MANETs was proposed in this paper. To deal with the complicated medium access interactions induced by relaying and leverage the benefits of such cooperation, an efficient Cooperative Medium Access Control (CMAC) protocol is needed. In this paper, we propose Distributed Energy-adaptive Location-based CMAC protocol, namely DEL-CMAC, for Mobile Ad-hoc networks (MANETs). The design objective of DEL-CMAC is to improve the performance of the MANETs in terms of 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. It provides the best selection algorithm to select the cooperative node with better channel condition, higher transmission rate, best relay and more balanced energy consumption.

I. Introduction

Cooperative communication [1] which takes full advantage of the broadcast nature of the wireless channel and creates spatial diversity is becoming a promising technology for wireless networks. Research verified that cooperation communication can achieve great improvement in the network capacity, delay, robustness, energy consumption and significant reduction in interference as well. The early exploration of the cooperative communication was for the physical layer cooperation [2][3], and now it has been developed to the Media Access Control (MAC) layer [4][5] and the network layer [6][7]. Some researchers also focused on the cross-layer cooperation design [8][9], coupling the functionality of multiple layers, in order to improve the network performance. In this paper, we proposed a new cooperative MAC protocol, Energy-balanced Cooperative MAC (ECMAC), in Mobile Ad Hoc Networks (MANETs). In EC-MAC, the sender takes three factors into consideration, the wireless channel condition, transmission rate and energy fairness factor, and then selects a single cooperative node among all the neighbors...
according to the best partnership selection algorithm. 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) 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 for the increasing a throughput.

II. Related Work
Two similar MAC protocols, relay-enabled DCF (rDCF) [4] and Cooperative MAC (CoopMAC) [5], are both proposed by taking the advantage of the multirate capability of IEEE 802.11. Each node maintains a cooperative table, where the required information of the candidate cooperative nodes is stored. CoopMAC and rDCF both send packets in a high rate two-hop manner instead of low rate one-hop manner, and thus improve the network performance. The Cooperative MAC protocol (CO-MAC) [10] was designed to provide better performance due to the receiver diversity gain than rDCF and the implementation complexity is as low as that of rDCF. The Network Coding enabled Cooperative MAC protocol (NC-MAC) [11] attempted to combine the cooperative communications with the network coding approach. Simulation results showed that this protocol provides greater network throughput by the network coding gain than rDCF. The Opportunistic Cooperative MAC protocol (OC-MAC) [8] was proposed based on the cross-layer information utilization. Opportunistic cooperative [12] strategy was also exploited to use relay only when it can improve the performance of network system. Moreover, the relay node selection considers the channel fading factor. The work [13] also proposed a cooperative MAC protocol based on the opportunistic relaying, where the node with the best channel quality among all the neighbors is selected as the cooperative node. This protocol can significantly improve the network
performance when the quality of the direct transmission path is poor.

III. 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 or Willing-to-help (ETH/WTH) 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.

Protocol Description
The frame exchanging process of DEL-CMAC is shown in Fig. 3. 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. Unlike DCF, in the proposed protocol, the RTS packet carries the residual energy of the source and relay request message with corresponding relay address for supporting cooperative communication. After receiving the RTS, the destination sends CTS back after the period of Short Inter Frame Space (SIFS). All the nodes hearing CTS will update their table about the residual energy of the destination which is carried by CTS packet. If the source does not receive CTS within Trts+Tcts+SIFS, a retransmission process will be initiated. Otherwise, after receiving CTS message from destination, the source waits for Willing to Help (WTH) message from relay.

CMAC Utility 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. 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.

**Single-hop Scenarios:**
We first compare our DEL-CMAC with the IEEE 802.11 DCF in 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. As shown in Fig.4, the distance between source and destination changes from 5 m to 30 m, and angles $\angle SDR$ and $\angle DS R$ keep at arccos(2/3).

**IV. 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.

- **Network Lifetime:** The lifetime is defined as the duration from the network initialization to the time that the first terminal runs out of power.
- **Energy Consumption:** The total energy consumption is the summation of the transmitting (including both transmit amplifier and circuitry) and receiving energy cost at the source, destination and relay.
- **Throughput:** The throughput metric measures how well the network can constantly provide data to the sink. The
throughput is the number of packet arriving at the destination per seconds.

**End to end delay:** This is the ratio of the interval between the first and second packet to total packet delivery. 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 has 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.

**V. Conclusion**

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 DELCMAC 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. As part of our future work, we will investigate our DEL-CMAC for multirelay cooperation for larger scale network size and with high mobility. Also, we foresee a more suitable scenario for multi-relay cooperation in 802.11a/g networks which support a larger set of data rates than 802.11b. This is deeply further discussed and are left as the future work.

**Reference**


