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QoS Improvement in Mobile Ad Hoc Networks Using Cross Layer Optimization

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ABSTRACT: In this paper we have studied the performance improvement in wireless network by using the cross layer approach. In the next generation wireless communications, mobile ad hoc networks (MANETs) have gained great importance. MANETs consist of several mobile nodes that can communicate with one another without any fixed infrastructure. These wireless networks are expected to carry a traffic that contains voice, data, multimedia applications etc. In such situations, the use of conventional layered architecture may not be able to provide the expected Quality of Service (QoS). Due to these limitations, cross layer design has proved to be a promising method to satisfy these network requirements. Cross layer design is an emerging proposal which allows flexible interactions between the layers. In this paper we have done a review about the cross layer mechanism and the energy aware issues in the MAC and network layers. Here we have done the cross layering between MAC and network layers. Simulation results show that cross layering has helped to improve the QoS parameters of the network like throughput, end to end delay and the energy consumption of the nodes.

KEYWORDS: MANETs, cross layer, energy aware issues, QoS parameters.

I. INTRODUCTION

One of the emerging trends in today's commercial communication market is the adoption of wireless technology. In the next generation of wireless communication systems, there will be a great demand for the rapid deployment of independent mobile users. And these network scenarios cannot depend on centralized and organized connectivity. In such applications mobile ad hoc networks (MANETs) play an important role [1]. MANETs can be considered as a collection of wireless mobile nodes that can communicate with one another without any fixed networking infrastructure. Ad hoc wireless networks are highly appealing for many reasons. They have the advantage of rapid deployment and reconfiguration. It is easy to adapt the network to specific applications. They are highly robust due to their distributed nature, and the lack of single point of failure. While ad hoc networks exhibit much promise, they also pose some significant design challenges. The challenges are due to their lack of established infrastructure, dynamic topology, wireless channel characteristics and their decentralized nature.

Despite the challenges posed, the various network requirements need to be met. As a promising solution for efficient networking, we address the issue of crosslayer design of network protocols. Previous approaches interpreted and implemented the network as a hierarchy of layers that are independent and non - cooperating. Thus, they were unable to take advantage of the interactions between the layers. The approaches were optimizing each layer by itself when a joint optimization across the various layers of the network would have resulted in greater performance. The inflexibility of this paradigm results in poor performance of ad hoc wireless networks in general,

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especially when energy is a constraint or the application has high bandwidth need or strict delay constraints. To meet these requirements crosslayer protocol design that supports adaptivity and optimization across layers of the protocol is required.

This paper mainly considers cross layering between MAC and network layers. Section II describes about the need for cross layer architecture. Energy related issues in MAC and network layer is mentioned in section III and the proposed protocol called cross layer AODV (CAODV) is described in section IV. Section V shows the various simulation results and section VI concludes the paper.

II. CROSS LAYER DESIGN

Traffic on wireless networks is becoming increasingly complex with a mix of real-time traffic such as voice, multimedia teleconferencing, and games, and data-traffic such as browsing, messaging and file transfers etc. All these applications require widely varying and very diverse QoS guarantees for different types of traffic. Various mechanisms have been proposed to support these QoS requirements [2]. However, providing a robust QoS support for multimedia applications over wireless networks is a very challenging task due the following reasons

- Wireless channels have high packet loss rate and bit error rate (BER) due to fading and multipath effects. This can lead to adverse effects in various multimedia applications.
- Wireless channels have bandwidth limitation and fluctuations of the available bandwidth, packet loss rate, delay and jitter.
- The mobile devices are power constrained. Maintaining good media quality and minimizing average power consumption are two conflicting requirements.
- Multimedia may traverse different types of networks, e.g., wire-line networks, cellular networks, and wireless local area networks (WLAN). Each of these networks has different characteristics such as reliability, delay, jitter, bandwidth, and medium access control (MAC) mechanisms.
- Different applications have different QoS requirements. Real-time media such as video and audio is delay-sensitive but capable of tolerating a certain degree of errors. Non-real time media such as web data is less delay-sensitive but requires reliable transmission.

Due to the above constraints, a strict modularity and protocol layer independence of the traditional TCP/IP or OSI stack will lead to a sub-optimal performance of applications over IP-based wireless networks. For optimization, we require protocol architectures that require modification of the reference layered stack by allowing direct communication between protocols at non-adjacent layers or sharing state variables across different layers to achieve better performance. The objective of a cross layer design (CLD) is to actively exploit this possible dependence between protocol layers to achieve performance gains.

Crosslayer design [3] emphasizes on the network performance optimization by enabling different layers of the communication stack to share state information or to coordinate their actions in order to jointly optimize network performance. A general definition of a cross -layer design is given as any violation or modification of the layered reference architecture. The intent of CLD, is to exploit information from multiple layers to jointly optimize performance of those layers. The breaking of hierarchical layers or the violation of reference architecture includes merging of layers, creation of new interfaces, or providing additional interdependencies between any two layers.

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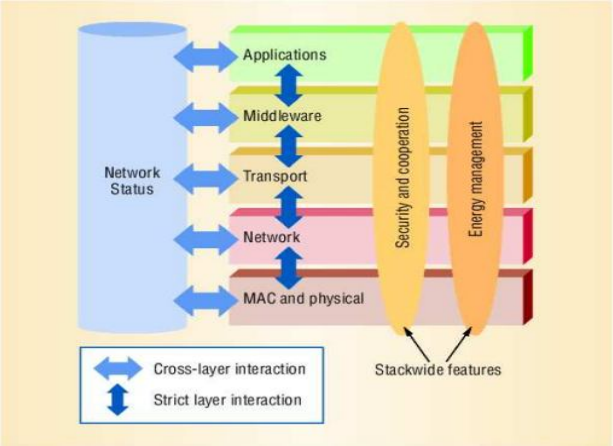

Fig. 1 Mobile man architecture

There are different ways in which cross layering can be done [4]. One of the most common architecture used is the Mobile Man architecture [5]. This reference architecture exploits the advantages of a full cross-layer design while still satisfying the layer-separation principle. Fig.1 shows that some network functions such as energy management, security, and cooperation, are crosslayer by nature. The architecture consists of the core component, Network Status. They function as a repository for information that network protocols throughout the stack collect. Each protocol can access the Network Status to share its data with other protocols. This avoids duplicating efforts to collect internal state information and leads to a more efficient system design. Hence the QoS parameters can be improved using cross layer approach. Hence we can conclude that cross-layer design has been proposed to maintain the functionalities associated to the original layers but to allow coordination, interaction and joint optimization of protocols crossing different layers.

III. ENERGY AWARE ISSUES

A mobile ad hoc network consists of several nodes that forward the information from one node to the other nodes. Many conventional routing protocols like AODV, DSDV, DSR etc. were proposed to route the informations. But the problem with these routing protocols is that, they do not consider energy as a metric or a parameter. Since these nodes are battery powered, when we are using one node continuously the energy of the nodes get exhausted. So, to account for this issue, various energy efficient routing protocols have been proposed.

From various studies, it has been shown that the cross layer designs are much more efficient compared to the conventional layered architecture. Introduction of cross layering will help to improve the QoS parameters of the wireless network like end to end delay, energy efficiency, throughput etc. So, in this paper to improve the energy efficiency of the network we have done cross layering between MAC and network layers.

3.1. Energy aware issues in mac layer

Medium access control (MAC) layer is mainly responsible for scheduling and allocating the wireless channel. MAC protocols provide a means for the nodes to access the wireless medium efficiently and collision free to the best of their ability. Major issues in the MAC layer regarding the energy wastage are collision, idle listening, over-hearing and control packet overhead [6]. Collision occurs when two or more nodes try to transmit the informations at the same time. Collision causes retransmission of packets and thus, the latency and the power consumption of the network will be increased. Idle listening refers to the listening to an idle channel for some possible traffic. When a node is listening to an idle channel, the energy of the node is wasted. In order to conserve energy, most of the energy efficient

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protocols put their network interface in sleep state rather than in idle state. Receiving packets which are meant for other nodes is called over-hearing. All these are some of the main issues of energy wastage in MAC layer.

3.2. Energy aware issues in network layer

The function of network layer is packet forwarding, which includes routing of information from source to the destination. To route the packets from one node to the other, there are many routing protocols proposed like AODV, DSDV, DSR etc. In the conventional AODV routing mechanism, a node broadcasts or floods RREQ message to its neighbors when it needs to communicate with a destination node. If intermediate node does not have sufficient energy, then the node will expire after some time. Therefore, it could not be able to forward the RREP message on the reverse path. Hence, the source node would have to rebroadcast the Route Request (RREQ) message in order to find an optimal path for communicating to the destination node. This may possibly cause congestion in the network which is the major issue we have to consider in the network layer. To address the above problems[7], different energy aware routing mechanisms can be used by considering the residual energy of each node.

IV. CROSS LAYER AODV

In order to reduce the energy aware issues related with MANETs, many solutions have been proposed. It has been showed that, these energy issues with the network layer can be reduced by considering the residual energy of the nodes. Various solutions to these MAC and network layers were considered in the paper [8]. But, various studies have showed that cross layering is one of the emerging techniques that help to improve the performance of the network [9]. So, in this paper we have adopted the cross layer design instead of the conventional layered architecture. We have chosen MAC and the network layers for cross layering, so that the network performance can be improved by the coordination and interaction between these layers.

Energy modeling is a key element in wireless network scenarios. During different simulation scenarios, we may need to analyze the energy of each node in the network. In such situations, including of energy model will help to monitor the energy. So, in this paper to improve the energy awareness of the wireless network, we have shared the parameters of MAC and network layers using cross layer design. Cross layer AODV (CAODV) algorithm is implemented by applying cross layered approach between MAC layer and AODV protocol at the routing layer. In order to achieve this, the information about the energy of each node is analyzed so that during routing, path with the highest residual energy is selected. So, during the route selection, we can choose routes with maximum energy and hence, the network lifetime can be increased.

V. SIMULATION RESULTS

Network simulator (NS2.34) was used for the simulation purpose of the research. Simulation of wired as well as wireless network functions and protocols can be done using NS2. In general, NS2 provides users with a way of specifying such network protocols and simulating their corresponding behavior. The simulation scenarios were performed for 1000 × 550 m^2 rectangular region. The packet size is fixed at 512 bytes. Different scenarios were simulated in NS2 to evaluate the performance of cross layer design compared to the normal wireless network using AODV routing protocol. Table 1. gives the information about various simulation parameters that were used for the simulations. The various simulation scenarios are presented in this section.

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Parameter	Value
MAC Layer Type	IEEE 802.11
Radio Propagation Model	Two ray ground
Queue Length	50
Topography	1000*550 m^2
Initial Energy	3 J
Simulation Time	10 sec
Transmission Power	0.435 W
Reception Power	0.140 W

Table 1. Simulation Parameters

The simulation is conducted with 30 to 70 nodes for comparing the performance of AODV and CAODV. The performance of these protocols is evaluated using the metrics like average throughput, average end to end delay and average energy consumption of the wireless network. Different number no nodes were selected to analyze the performance of CAODV and AODV protocols. Figure 2 shows the network animator (NAM) window for the simulation with 32nodes. Here, node 0 is the source and node 28 is the destination.

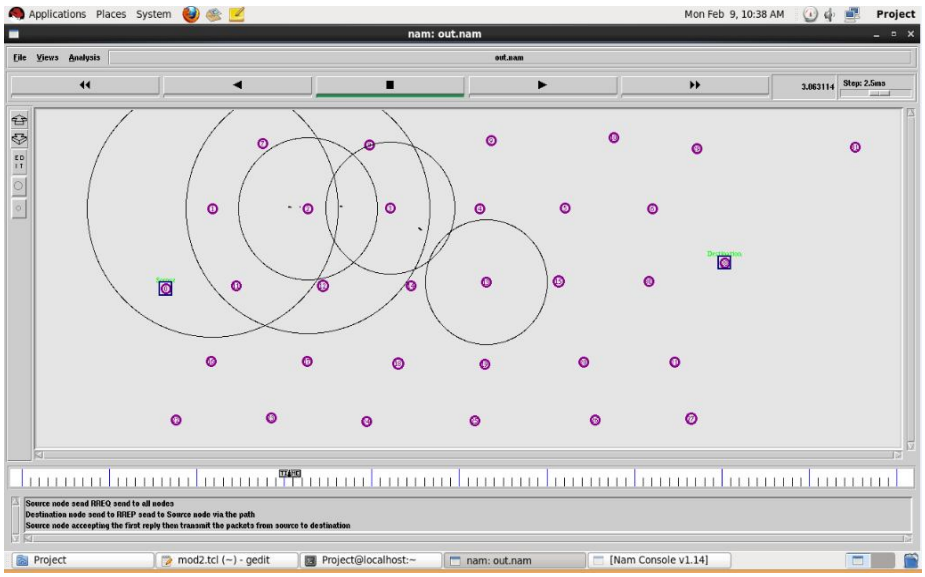

Fig. 2 Network Topology

5.1 Average throughput

Throughput is the average rate of successful delivery of packets in a communication channel. It is the total successful transmissions within the time period from simulation starts and ends. Fig 3 shows the graph between number of nodes and the average throughput of the network. From the graph we can see that crosslayer AODV have better throughput compared to AODV protocol.

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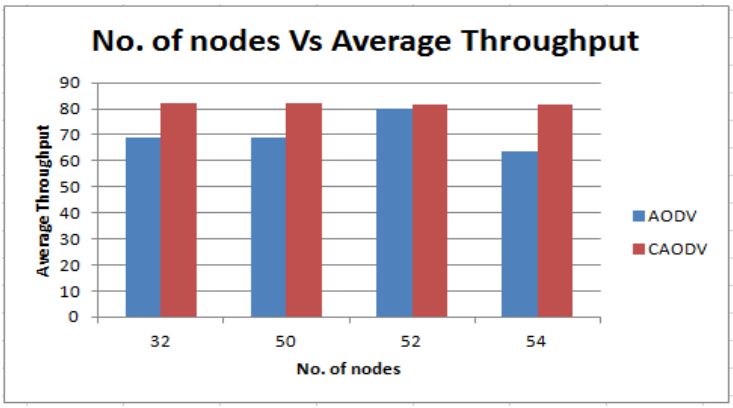

Fig. 3 Comparison of no. of nodes Vs average throughput

5.2 Average end to end delay

The average end-to-end delay of data packets is the interval between the data packet generation time and the time when the last bit arrives at the destination. Fig 4 shows the performance of AODV and CAODV in terms of average end to end delay. Here, we can see that by performing the cross layer approach between the layers, the average end to end delay of the network has been reduced significantly compared to the conventional AODV routing protocol.

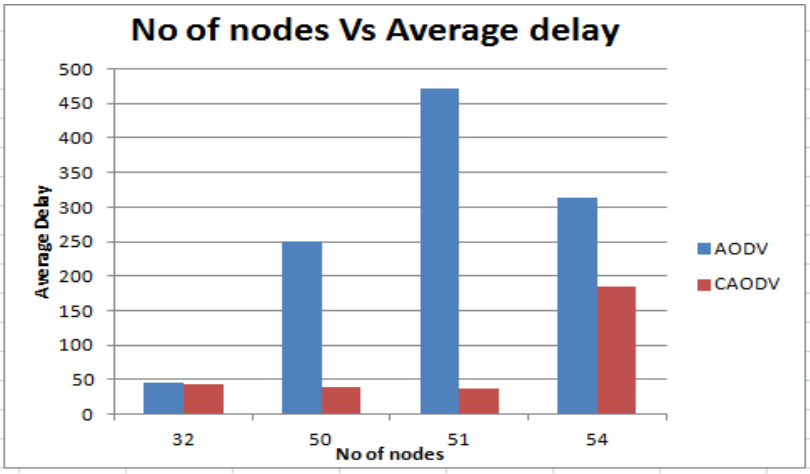

Fig. 4 Comparison of no. of nodes Vs average delay

5.3 Average energy of the nodes

The mobile node battery power consumption is mainly due to transmission and reception of data packets. Whenever a node remains active, it consumes power. Nodes involved in the routing of packets losses some energy after each transmit and receive. So when we can continuously using one node o transmit the data packets, the energy of the nodes may get depleted. To avoid this problem, we have considered the energy of each node during the routing process. Fig 5 depicts the average energy consumption of the nodes using CAODV and AODV routing protocols. Here, we can see that the average energy consumption of the network has been improved by using cross layer approach

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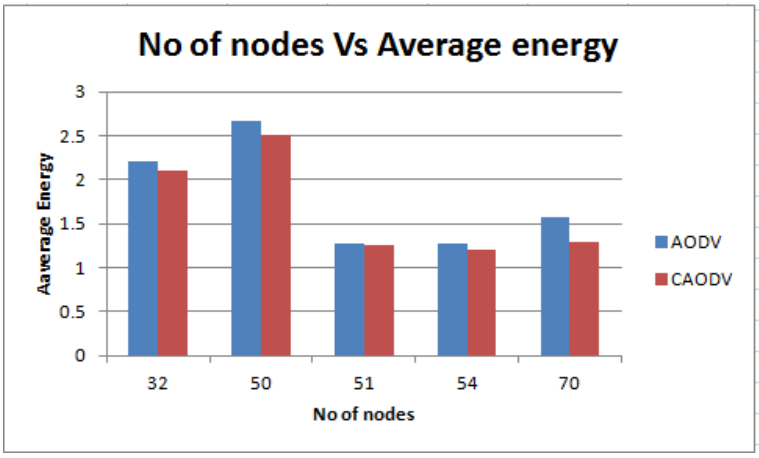

Fig. 5 Comparison of no. of nodes Vs average energy consumption

VI. CONCLUSION

In this paper we have studied how the cross layer optimization can help to improve the network parameters of the wireless network. These works have showed that cross layering has become one of the emerging proposal which helps to improve the network parameters by the joint interactions between different layers. Here, cross layering is done between MAC and network layers and we have discussed various energy aware issues related with these layers. Simulation results showed that cross layer design has better performance than the conventional routing mechanism using the AODV protocol in terms of average throughput, end to end delay and the average energy consumption by the nodes.

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