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QoS Enabled Cross-Layer Multicast Routing over Mobile Ad Hoc Networks

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Abstract

Quality of group communication using mobile ad-hoc networks depends on various factors like channel fading, signal quality, path loss, transmission and reception power of mobile nodes, mobility, link life and battery backup. Different layers are involved in communication, but the behavior of these layers is isolated with each other and overall network performance may effect from their operations. A cross-layer approach can extract the critical information from multiple layers which can be further utilized to enhance the overall network performance and Quality of Service (QoS). In this paper, Cross-layer Multicast Routing (CLMR) is introduced to enhance the QoS using a tree-based multicast routing protocol. In order to achieve QoS, optimization of the tree operations and tree management cost has been done. CLMR exploits the functionality of PHY layer, Application layer and Routing Layer for QoS oriented communication. Performance of CLMR is analyzed using Multicast Ad-Hoc On-Demand Distance Vector (MAODV) routing protocol under various parameters, i.e. Throughput, Delay, Packet Delivery Ratio, Link Cost and Energy Consumption.

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Keywords: MANET; Cross-layer; Multicast; Group Communication; MAODV

1. Introduction

Mobile ad-hoc network (MANET) uses low-frequency wireless links for group communication. Due to the low frequency of wireless link data transmission suffers from the behavior of the layers being used for network

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operations. The traditional layered approach is not supportive enough to achieve QoS due to the inherent nature of the MANET. In the cross-layer technique, information sharing takes place between nonadjacent layers to optimize the overall performance of the network. Following are some issues related to these layers:

i) PHY Layer: Nodes consume energy in transmission and reception of the data related to routing information, the user's data and data related other network operations. In case of excessive energy consumption, the battery may be exhausted during data exchange and thus may result in link breakage. A low battery may affect the wireless transmission range also and drop the ongoing communication. Therefore, it's required to optimize the energy consumption w.r.t above discussed factors for better and uninterrupted communication [1][2].

ii) MAC Layer: This layer manages the access to the wireless medium and it's fair utilization. It is also responsible to control the contention and collision level over the shared wireless channel. If the MAC layer fails to manage the designated operations, then a lot of packet retransmission may take place and consume more energy than required. If this fact can be passed on to PHY layer, energy consumption can be optimized. Therefore, a cross-layer solution may be used to optimize the operations for each layer. [3-11].

iii) Network Layer: This layer keeps the track of each link and the data rate required for communication. Due to node's mobility, the network topology changed frequently that cause the frequent updates in routing information. This frequent updates in routing information may cause frequent link breaks. Route reconfiguring may consume unwanted energy, results in depletion of node's battery. In order to send their data after route reconfiguring multiple nodes can try to access the channel at the same time, and cause collision over the wireless channel [16] [17].

iv) Transport Layer: It controls the congestion over a network. The congested network may bring down the overall network performance. A cross-layer solution may be used for MAC and transport layer for performance optimization [18][19][20].

By using the cross-layer interaction between layers many QoS parameters like energy, security, tree management cost and various control overhead can be optimized for improved performance. A typical hypothetical cross-layer design can be shown as in figure 1, in which PHY, MAC, and Network layer are exchanging their information to form upper layer information, similarly, Application and Transport layer form a lower layer information. And further these two cross-layer exchange their information to form cross-layer interaction.

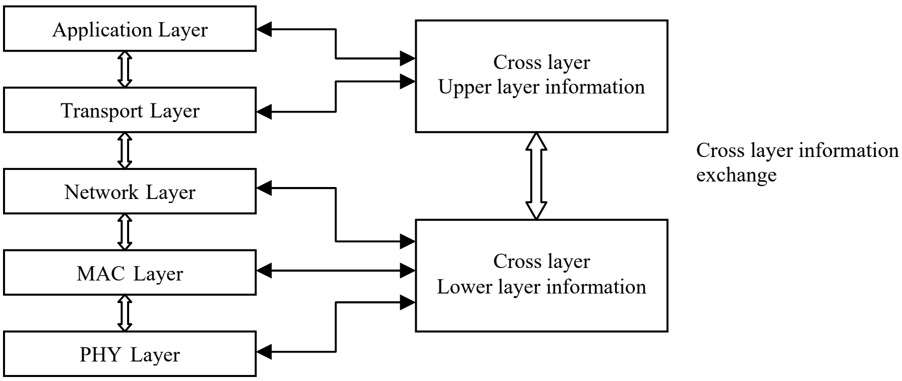

Fig. 1. A typical cross-layer design

1.1 Common cross-layer solutions

- For PHY layer, a cross-layer solution can be used to optimize the power for wireless links in such a way that maximum transmission range can be ensured [1][2].
- At the network layer, optimal route selection schemes may be deployed to adopt the dynamic topology [14][15].
- Congestion control at end terminals may be used for reliable communication at the transport layer [12] [13].

1.2 Why cross-layer multicast?

Multicasting can reduce the communication cost, but still, there are some issues which may degrade the performance of routing protocol. Depends upon the Routing operations (Tree-based/Mesh-based), the protocol may consume the