A Cross Layer Balanced Routing Protocol for Differentiated Traffics over Mobile Ad Hoc Networks

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Abstract. We propose a cross layer approach to achieve greater routing performance for applications with real time constraints in Mobile Ad Hoc Networks. Interactions between MAC, Network and Application layers are fully exploited to get accurate information about the end-to-end path quality, and the applications’ characteristics. The improvements provided by our scheme come from considering a service class differentiation, a balanced routing protocol and a path quality cost function as well. It aims to enhance the routing performance for real time applications to meet the QoS requirements defined by the ITU-G1010 recommendation. The simulation results and analysis show that our contribution achieves a good performance and capacity gain.

Keywords: MANET, Link Quality, Path Quality, Traffic Class Differentiation, Cross Layer Design, Balanced Routing.

1 Introduction

Since real time applications present one of the main critical services in wireless and mobile networks, many protocol designs have been proposed to enhance the application QoS: Quality of Service and the QoE: Quality of Experience in such networks. Some existing contributions [1-6] deploy prediction methods to get information about the link quality and route the data packets through the best link. Other contributions [7-13] use cross layer approach to exploit the essential information derived from lower layers. In this paper, we aim to help the routing process to select stable and quality aware routes based on the application’s requirements. Our contribution combines the cross layer and the prediction approaches to enhance the routing of real time application in MANETs. We define an enhanced cross layer design that takes into account the network and applications features. Prediction methods in MAC layer is deployed to get link quality information. Cross layer design between L3: Layer 3 and L2: Layer 2 is defined to get information about the whole path quality. In order to get information about the application characteristics, a cross layer design between L7 and L3 is defined. A new software entity is defined to manage the L7-L3 cross layer interaction. In order to define a routing protocol that fits the requirements of different application a per traffic balanced routing protocol is defined. This paper is organized as follows. We outline some cross layer approaches and prediction methods in section 2. Our cross
layer design approach is introduced in Section 3. Experimental results are reported in section 4, and finally we conclude and give some perspectives in Section 5.

2 Related Works

In this section, we first investigate some methods used to predict the network performance criteria like delay and packet loss ratio, and then we focus on the cross layer concept.

2.1 Prediction Methods Investigation

To get information about the link quality, prediction methods can be deployed. Accurate delay estimation in mobile and wireless networks stills a challenging issue. Some Research activities focused on this issue to improve the used methods and techniques for better efficiency and accuracy. According to [1], the delay at each wireless node is composed of input queuing delay, processing delay, output queuing delay, transmission delay, propagation delay, and retransmission delay. To implement the packet delay measurement at a node in 802.11 networks, authors in [1] propose to record the time when a packet enters the node ($t_1$) and the time when the data packet is acknowledged ($t_5$) after being relayed. The packet delay is calculated by $t_5 - t_1$.

Authors in [2] use Chaos neural networks to predict delay. The neural network can model unknown system with a given precision while keeping the computation cost minimized. To predict end to end delay, the authors process first to the delay measurement using the ping tool to collect RTT: Round Trip Time traces. The critical issue of neural network model is to determine the structure of the network. In MANETs, the structure of the network is dynamic since nodes can join or leave the network in dynamic way. To predict the link quality, the authors in [3] measure the link quality and then perform a prediction algorithm. To measure the link quality, a link layer assessment request is sent periodically. The delay is computed as the RTT of the request and its reply. The network node keeps a track of the past measurements and then predicts future link quality based on these measurements using the WLSR: Weighted Least Square Regression algorithm. The WLSR prediction algorithm applies weights to the measurements. It takes as input a window of measurements of a given QoS metric and predicts the value of the metric.

In Mobile Ad Hoc Networks, the packet loss is due to the following most dominant factors [1]: the buffer overflow, the transmission loss and the link breakages. The authors in [4] predict the network loss based on a Hierarchical model where the short term dynamics of losses is driven by 2-state Markov chains while long-term network losses are modeled by the HMM: Hidden Markov Model. Given a fixed window of several time units, the short term loss rate is the fraction between the number of loss packets in this window and the number of packets transmitted in it. The hidden state models longer-term events that change end-to-end loss statistics, e.g., router congestion, routing convergence, wireless signal fading. To achieve this, the authors constrain hidden state transitions to happen at large timescales [4]. Authors of [5] use a measurement method to predict the packet delivery of an IEEE 802.11n channel. According to [5], the wireless packet delivery can be accurately predicted using the CSI: Channel State Information measurements. The CSI provides more information than the RSSI: Received...