# Quality of Service Issues in Mobile Ad Hoc Networks

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**by**
**Nityananda Sarma**

*Under the guidance of*
**Prof. Sukumar Nandi**

Department of Computer Science and Engineering
Indian Institute of Technology Guwahati
Guwahati - 781 039, INDIA
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# Abstract

Multihop wireless network has emerged recently as an evolution of wireless network technology and are likely to be the integral part of future communication environment. In this context, support for Quality of Service (QoS) is becoming an inherent necessity rather than an additional feature of the network. Due to lack of a centralized control, highly dynamic nature of topology and existence of variable and limited shared resources, traditional approaches for supporting QoS in the Internet can not be applicable to mobile ad hoc networks (MANETs). Given that quality of service provisioning in MANETs is extremely challenging and is a multi-layer problem, this thesis takes a holistic view to this QoS issue by identifying the key components of an overall MANET QoS framework. We take minimum throughput and maximum delay as the applications' QoS requirements to be supported by the QoS mechanisms developed in this dissertation.

We begin by developing two dynamic priority based QoS-aware MAC protocols which are based on legacy IEEE 802.11 DCF and hence can easily be integrated into existing systems without much difficulty. Our first scheme, called Priority based QoS-aware MAC protocol (PQAMP) is designed for achieving enhanced level of service differentiation to provide QoS for real-time traffic along with maximizing network utilization in a multihop environment. By assigning highest priority to relay traffic, PQAMP reduces packet's end-to-end delay for real-time traffic and at the same time improves network utilization. Further, it supports a minimum level of service for best-effort traffic. The second scheme called Strict Priority based QoS-aware MAC Protocol (SPQAMP) is designed to achieve a strict service differentiation to support QoS for real-time traffic without any service guarantee for best-effort traffic and with network utilization as compatible to IEEE 802.11 DCF. SPQAMP uses a resetting of backoff timer mechanism for best-effort traffic as an extra measure to provide strict prioritized channel access for real-time traffic. Due to strict service differentiation in SPQAMP, the amount of best-effort traffic present in the network can not affect the QoS provided to real-time traffic. Using both these schemes substantially improve the QoS support at MAC layer of MANETs.

Our investigation on existing QoS routing algorithms show that most of them choose the shortest path among the feasible paths and none of them take any measure to select QoS routes that endure longer time. In this direction, we develop a route stability model (RSM) to estimate stability of link and end-to-end path in MANETs, which has less control overhead, requires no extra hardware and has the potential to be applicable in most of the real-life mobility scenarios. By incorporating RSM through some route stability related fields in route request/reply messages, we propose a Route Stability based QoS Routing (RSQR) for MANETs. RSQR incorporates a soft resource reservation, a hop by hop admission control and applies route stability metric to improve the durability of established QoS route such that probability of the resource reservation to remain valid for duration of

data transmission is high. RSQR reduces QoS disruption due to expensive route recoveries and gives higher performance in terms of packet delivery ratio, average end-to-end delay and control overhead.

To further reduce the QoS disruption due to frequent and expensive route recoveries, we propose a Stability based Multipath QoS Routing (SMQR) protocol for MANETs. Reliability of multiple QoS-aware routes is improved through node-disjointness and stability properties of the discovered routes. Detection of potential route failures and switching to an available stable route before actual route breaks saves route recovery time as well as reduces possibility of packet loss during active communication using SMQR. Significant QoS performance improvements are observed in terms of average end-to-end delay, packet delivery ratio and maximum delay jitter.

Finally, we investigate QoS provisioning from multilayer perspective. In this direction, we propose a cross-layer QoS framework which maps QoS parameters across three layers of the protocol stack to support a stronger notion of per-class service guarantees in ad hoc networks. QoS mapping across protocol layers are realized through adaptation of relevant protocols based on both QoS parameters received from the upper layer and prevailing network condition. Per-class differentiated service is obtained through class-based scheduling in network layer and allocation of non-overlapping contention window at MAC layer. Further, MAC layer and network layer are made to adapt their behaviour based on both dynamic network conditions and QoS requirements of the admitted flows. Accordingly, MAC layer adaptation is carried out in the form of dynamic contention window adjustment per class, whereas network layer adaptation takes place in the form of rerouting or termination of existing flows.

**Keywords:** Mobile Ad Hoc Networks (MANETs), Quality of Service (QoS), QoS-aware Medium Access Control, Route stability, QoS routing, Multipath QoS Routing, Cross-layer QoS framework