

# An Analytical Model of Delay in Multi-Hop Wireless Ad Hoc Networks

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## Abstract

Several analytical models of different wireless networking schemes such as wireless LANs and meshes have been reported in the literature. To the best of our knowledge, all these models fail to address the accurate end-to-end delay analysis of multi-hop wireless networks under unsaturated traffic condition considering the hidden and exposed terminal situation. In an effort to gain deep understanding of delay, this paper firstly proposes a new analytical model to predict accurate media access delay by obtaining its distribution function in a single wireless node. The interesting point of having the media access delay distribution is its generality that not only enables us to derive the average delay which has been reported in almost most of the previous studies as a special case but also facilitates obtaining higher moments of delay such as variance and skewness to capture the QOS parameters such as jitters in recently popular multimedia applications. Secondly, using the obtained single node media access delay distribution, we extend our modeling approach to investigate the delay in multi-hop networks. Moreover, probabilities of collisions in both hidden and exposed terminal conditions have been calculated. The validity of the model is demonstrated by comparing results predicted by the analytical model against those obtained through simulation experiments.

*Key words:* Analysis, Delay, Exposed Terminal, Multi-Hop, Wireless Ad hoc Networks.

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## 1. Introduction

Wireless ad hoc networks (WANs) consist of several numbers of nodes which communicate with one another in an unattended collaborative manner. Any two nodes within the given Euclidean distance can communicate directly. In such networks, a data packet may be forwarded by several intermediate nodes till it reaches the destination. The wireless media in these networks is a shared and scarce resource therefore, a well-defined MAC protocol plays a prominent role in performance of a WAN. Due to lack of a centralized control, MAC protocols must be implemented in a distributed manner in ad hoc networks. Distributed coordination function (DCF) access mechanism of IEEE 802.11 as the basic standard for MAC layer has gained common popularity in ad hoc networks [? ]. Although the basic characteristics of IEEE 802.11 DCF are well understood, this paper suggests required analytical models to evaluate dynamic performance of WANs in terms of multi-hop delay analysis. This aim is achieved by proposing a local queueing system to address delay analysis of multi-hop wireless networks under unsaturated traffic condition.