ANALYTIC MODEL OF IEEE 802.15.4 FOR BOTH UPLOAD AND DOWNLOAD TRAFFIC

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ABSTRACT

This paper proposes an analytical model of IEEE 802.15.4, which is a standard toward low complexity, low power consumption and low data rate wireless data connectivity. In this paper, we concentrate on the MAC performance of the IEEE 802.15.4 LR-WPAN with non-beacon mode and non-saturated condition in a star topology. Our approach is to model stochastic behavior of one device as a discrete time Markov chain. First, we model each stochastic behavior of upload traffic and download trffic, seperately. Secondly, we model both upload and download by combining the model of upload traffic and the model of download traffic. For each case, We obtain five performance measures : throughput, packet delay, number of backoff, energy consumption and packet loss probability. Our results are used to find optimal number of devices with some constraints on these measures.

INTRODUCTION

Wireless Sensor Network(WSN) will adopt IEEE 802.15.4 as transmission protocol and also will be one of an end systems of USN. Therefore IEEE 802.15.4 will be a key role at WSN where energy consumption is an important factor.

IEEE 802.15.4 low rate WPAN (LR-WPAN) allows two network topologies: star and peer-to-peer. In a star topology, every sensor must communicate with a PAN coordinator, while in a peer-to-peer topology, all devices can communicate each other as long as both devices are within a physical range. In a star topology, network uses two types of network channel access mechanism. One is non-beacon mode based on unslotted CSMA/CA channel access mechanism. When a device wishes to transmit data packets or MAC commands, it shall wait for a random period. If the channel is found to be idle, following the random backoff, the device shall transmit its data. If the channel is found to be busy, following the random backoff, the device shall wait for another random period before trying to access the channel again. The other is beacon-enabled mode based on slotted CSMA/CA channel access mechanism that the backoff slots are aligned with the start of the beacon transmission. When a device wishes to transmit data packet, it shall locate the boundary of the next backoff slot and then wait for a random number of backoff slots. If the channel is busy, following this random backoff, the device shall wait for another random number of backoff slots before trying to access the channel again. If the channel is idle, the device can begin transmitting on the next available backoff slot boundary.

This paper is concerned with the MAC performance of the star-shaped IEEE 802.15.4 network operated in non-beacon mode with unslotted CSMA/CA channel access mechanism. Our

approach is to model stochastic behavior of one device as a discrete time Markov chain. Our Markov chain model of IEEE 802.15.4 is different from one of IEEE 802.11 [2], since no freezing of backoff counter operates during transmission of other devices and CCA are needed in IEEE 802.15.4. Pollin *et al.*[3] and Park *et al.*[4] also proposed analysis for upload traffic on IEEE 802.15.4 under saturation condition where devices have always packets to send.

In this paper, first of all, we model each stochastic behavior of upload traffic and download trffic, seperately. Secondly, we model both upload and download by combining the model of upload traffic and the model of download traffic. For each case, We obtain five performance measures : throughput, packet delay, number of backoff, energy consumption and packet loss probability. Our results are used to find the optimal number of devices with some QoS constraints on these measures.

This paper is organized as follows. In Section 2, we describe the MAC procedure for upload and download in non-beacon enabled mode. In the Section 3, several important assumptions in this paper are explained. In the Section 4 and Section 5, we find the analytic models of upload traffic and download traffic of 802.15.4 under unsaturation condition and obtain performance measures from our analysis, respectively. In the Section 6, we make the analytic model of both upload and download traffics by combining the model of upload traffic in Section 4 and the model of download traffic in Section 5 and obtain performance measures.

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