ANALYSIS OF IEEE 802.15.4 WITH NON-BEACON ENABLED CSMA/CA BY MATRIX GEOMETRIC METHOD

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ABSTRACT

Recently, there has been a significant increase in research of wireless sensor networks (WSN). Network communication requirement of WSN is different from that of the traditional network because the traditional performance criteria of network are throughput, latency and fairness, whereas in WSN, energy efficiency become more important. Making a system energy efficient in WSN is a challenging research topic and researchers have developed many algorithms [1,2,3].

In this paper, we propose an analytical model of IEEE 802.15.4 which is standardized toward low complexity, low power consumption and low data rate wireless data connectivity. This standard allows two network topologies: star and peer-to-peer. In a star topology, every sensors must communicate through PAN coordinator. In a peer-to-peer topology, all devices can communicate each other if both devices are within a physical range. In a star topology, network uses two types of network channel access mechanism. One is based on the slotted CSMA/CA in which slots are aligned with the beacon enabled. Another access mechanism is based on the unslotted CSMA/CA without beacon frame.

This paper concentrates on the MAC performance of the IEEE 802.15.4 network with star shaped non-beacon mode and unslotted CSMA/CA channel access mechanism under non-saturated modes. We believe that many WSN applications such as [4] would benefit from this analytical model. Our approach is to model the stochastic behavior of one device as a discrete time Markov chain. Our Markov chain model is different from one of IEEE 802.11 [5], since no freezing of backoff counter operates during the transmission of other devices and two CCAs are needed in IEEE 802.15.4. Park et al. [6] also proposed analysis on IEEE 802.15.4 but they focused on saturated mode where devices have always packets to send.

In this paper, we investigate MAC performance of the IEEE 802.15.4 in non-saturated mode, where the packet arrival process to device follows Bernoulli process. We construct 3-dimensional Markov chain by adding the information of queue length, whose one-step transition probability matrix P has a form of QBD type. We derive the steady state distribution of the Markov chain by applying the matrix geometric method and probability generating function of HoL-delay of a packet. We obtain several performance measures such as non-saturation throughput, HoL-delay of a packet, average energy consumption and packet loss probability.

REFERENCES

1. Rajendran,V., Obraczka, K and Garcia-Luna-Aceves, J.J, *"Energy-efficient collision free*

medium access control for wireless sensor networks”, In: SenSys, pp.181-192, 2003.

2. Ye, W., Heidemann, J.S. and Estrin, D. , ”Medium access control with cooordinated adaptive sleeping for wireless sensor networks”, IEEE/ACM Trans. Netw., Vol. 12, PP.493-506, 2004.
3. Polastre, J., Hill, J. and Culler, D.E., ”Versitile low power media access for wireless sensor networks”, In: SynSys., pp.95-107, 2004.
4. Timmons, N.F and Scanlon, W.G , ”Analysis of performance of IEEE 802.15.4 for medical sensor body area networking”, In: Proc. of IEEE SECON 2004, 2004.
5. Bianchi, G,”perfformance analysis of IEEE 802.11 distribited coordination function”, IEEE Journal on selected area in Communications, vol.18, pp.535-547, 2000.
6. Park,T., Kim, T., J.Y.Choi, Choi, S., and Kwon, W.,Throughput and energy consumption analysis of IEEE 802.15.4 slotted CSMA/CA, Electronic Letters 41(18), 2005.