International Journal of Wireless Networks and Broadband Technologies
Volume 6 • Issue 1 • January-June 2017

A Study on Channel Sharing for Congestion Control in WSN MAC Protocols

Anwar Ahmed Khan, Institute of Business Administration, Karachi, Pakistan
Sayeed Ghani, Institute of Business Administration, Karachi, Pakistan
Shama Siddiqui, Institute of Business Administration, Karachi, Pakistan

ABSTRACT

Congestion control in Wireless Sensor Networks (WSNs) has been an area of interest for researchers for ensuring timely delivery of data. A number of Multi-channel MAC protocols have been proposed which guarantee parallel and collision free transmissions. This article proposes to evaluate an existing congestion control scheme that was developed for multi-channel WSN MAC protocols dealing with traffic of different priorities. The existing scheme proposed prioritized channel sharing mechanism for nodes based on the Received Signal Strength (RSS) of each priority. The authors analyze the performance of the proposed scheme by comparing it with other channel sharing mechanisms. Four cases of hybrid channel sharing mechanisms, namely complete partitioning, complete sharing, partial sharing and prioritized sharing have been studied in this work for 2 traffic priorities. The authors have modeled the schemes for WSN applications where each node may have traffic of different priorities. Major objective of the article is to facilitate the high-priority traffic, while efficiently maintaining the network utilization through reducing the number of idle channels. The analytical model has been developed using 2-dimensional Continuous Time Markov Chains (CTMC), and MATLAB has been used for the implementation. Complete sharing and Prioritized sharing are found to be the most efficient channel sharing schemes based on the network utilization and total throughput.

KEYWORDS

Channel Sharing, Congestion, Continuous Time Markov Chains (CTMC), Priorities

1. INTRODUCTION

In a large number of emerging WSN applications, congestion has proved to be a major challenge, for which many solutions have been provided in the past studies (Uppal, Kumar, & Singh, 2014; Prabha, 2015; Ahmad, Jabbar, Paul, & Rho, 2014). Development of multi-channel MAC protocols has mainly been motivated by the urge to control the congestion and minimize the delay (EkbataniFard & Monsefi, 2012). A WSN node is able to have parallel and collision free transmissions with the aid of Multi-channel protocols, resulting in improved energy, delay and throughput performance (Uppal, Kumar, & Singh, 2014). Due to the recent active research in multi-channel protocols, it becomes essential to investigate the comparative performance for each protocol using techniques such as queuing analysis (Park & Hwang, 2013; Sikandar & Kumar, 2014; Nieminen, Björkbom, Jäntti, & Eriksson, 2012).

In most of the existing MAC protocols, the number of channels are divided based on the traffic priority (Donmez, Isik, & Ersoy, 2014; Min, Kim, Kwon, & Lee, 2013; Wang, Li, Sohraby, Daneshmand, & Hu, 2007; Yaghmaee & Adjeroh, 2009; Patel & Khare, 2014). The traffic priority

DOI: 10.4018/IJWNBT.2017010102

is generally set at the time of deployment based on the data type. Similarly, setting priority of nodes based on dynamic factors such as RSS offers significant help in making the WSN suitable for real time applications.

A number of channel allocation strategies have been proposed in the past, however, majority of them focused on the wireless cellular (Epstein & Schwartz, 2000) & mesh networks (Skalli, Ghosh, Das, & Lenzini, 2007), WiMAX or Wi-Fi (Andrews, Kondareddy, & Agrawal, 2010). Also, most prioritized sharing algorithms proposed for WSN focus on offering service to the high priority traffic neglecting the low priority, even if network resources are available. For this work, a research gap is thus identified for performing the comparative analysis of channel sharing mechanisms in WSNs.

In the present study, we evaluated an existing congestion control scheme developed for multichannel WSN (Park & Hwang, 2013) which proposed to use prioritized channel sharing mechanism for the nodes based on the RSS of packets. Congestion was categorized as light and heavy, and the control mechanisms for each category and node priority were developed. The authors proposed to use prioritized sharing due to which the low priority traffic might not find a channel even if it is idle. Furthermore, the analysis was provided for the total system throughput and performance for low and high priority traffic was not evaluated separately. In contrast, we do not prioritize the nodes based on the RSS but instead allow the application layer to set the priorities as per the requirements. The schemes are mainly developed for the WSN applications where each node may have data of different priorities. For example, if in an intrusion detection system, a WSN node is embedded with multimedia and temperature sensors, the priority of the multimedia traffic will be higher despite of the large size of packets. On the other hand, if the similar sensor node has to operate in a forest-fire monitoring system, the temperature sensor would be assigned a higher priority. Furthermore, we do not only study the prioritized sharing but also the other channel sharing mechanisms.

As described above, the major contribution of the present work is to study four channel sharing mechanisms of complete partitioning, complete sharing, partial sharing and prioritized sharing, aiming at improving the resource utilization for multi-channel WSNs. Analytical model for each of the above sharing mechanisms has been developed and the same has been implemented in MATLAB. Two channels & two types of traffic with different priorities have been modeled. The detailed analysis of blocking probability and throughput has been provided for both traffic priorities instead of limiting to the high priority only. The suggestion for best channel sharing scheme in different application scenarios has been made based on the analysis. To the best of our knowledge, this is the first detailed study that attempts to investigate and compare channel sharing schemes for the multi-channel WSN MAC protocols.

The rest of this paper has been organized as follows: section 2 briefly describes some of the recent works done in the area; section 3 details the research methodology; section 4 presents the analytical model; section 5 presents the results and discussions. Finally, section 6 concludes the work by summarizing the findings and indicating the directions for future research.

2. LITERATURE REVIEW

Various congestion control mechanisms have been developed in the past focusing on resource allocation and channel assignment techniques for wireless cellular & mesh networks, WiMAX and Wi-Fi. In WSNs, congestion control has mainly been achieved through traffic prioritizing and developing multi-channel WSN MAC protocols. Queuing analysis has been an important technique for assessing the performance of congestion control solutions and MAC protocols in WSN. This section highlights some of the prominent works done in these areas.

Prioritized Resource Sharing algorithm for WiMax-WiFi integrated networks has been proposed by Andrews, Kondareddy, & Agrawal (2010). The mechanisms of complete sharing, complete partitioning and hybrid sharing for WiMax-WiFi integrated networks have been analyzed and the shortcoming have been identified. The proposed resource sharing scheme aims at improving the