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Congestion control algorithms in wireless sensor networks: Trends and opportunities

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Abstract Congestion control is an extremely important area within wireless sensor networks (WSN), where traffic becomes greater than the aggregated or individual capacity of the underlying channels. Therefore, special considerations are required to develop more sophisticated techniques to avoid, detect, and resolve congestion. The constrained resources of the WSN must be considered while devising such techniques to achieve the maximum throughput. Various approaches have been introduced in the past few years that include routing protocols aided with congestion detection and control mechanism, and dedicated congestion control protocols. In the former schemes, the congestion avoidance is performed by the sink node that causes topology reset and bulk traffic drop. As a consequence, the latter mentioned congestion control protocols addressing the congestion avoidance, detection, and resolution were introduced at the node level. In this paper, we explore mechanisms for controlling congestion in the WSNs and present a comparative study. The congestion control schemes are categorized as centralized with partial congestion control and distributed with dedicated congestion control.

Contents

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0. Introduction

Wireless sensor networks (WSN) (Rekha et al., 2010; Flora et al., 2011) consists of various wireless devices installed with various types of sensors to collect information from the environment. The collected information is relayed from sensor to sensor, using a multi-hop routing protocol towards the desired destination, called sink. At the sink, data aggregation and analysis takes place. The sensor nodes are limited in battery power, memory, and processing capabilities (Flora et al., 2011; Zhang et al., 2012). The aim of various routing schemes is to optimally utilize the resources of WSN to achieve the maximum throughput. Initially, researchers mainly focused on the design of trivial routing schemes to enable data transfer in the WSN. Later on, researchers realized that there must be an efficient mechanism to address the problem when the overall traffic or single link traffic becomes greater than its individual capacity (Rekha et al., 2010; Flora et al., 2011). Such a mechanism is termed as congestion control. Congestion control is of critical importance, as congestion control helps in preventing loss of traffic in bulk. Congestion control is a critical area of research as time variant quantities, such as network traffic and that buffer frequently changes with time (Liu et al., 2012; Wang and Qian, 2011; Tao and Yu, 2010; Ee and Bajcsy, 2004). The priority mechanism must be enforced to ensure the drop of low priority packets in inevitable circumstances. As WSN are resource constrained, a WSN designer must pay attention to the congestion control to achieve maximum lifetime of network by optimally utilizing limited available resources (Rekha et al., 2010; Flora et al., 2011; Lee and Kwangsue, 2010; Sergiou et al., 2007).

Existing congestion control techniques have some limitations, such as (a) optimal estimation of traffic load at congested link, or paths, and along the alternate paths for traffic diversion. (b) The traffic distribution along the alternate paths is not based on the traffic estimation (Tao and Yu, 2010; Ee and Bajcsy, 2004). (c) The priority mechanism is based on hop count rather than actual delay a packet suffers from source to sink (Tao and Yu, 2010; Ee and Bajcsy, 2004; Cheng et al., 2011; Liu et al., 2011). The aforementioned defames the popularity as a practical model. Therefore, more adequate techniques are required to ensure congestion control aided by a sophisticated routing. The details of the previously proposed possible protocols and their comparison along with their in-depth study, working mechanism, and performance metric are discussed in detail in the subsequent sections.

This work is organized as follows. Section 3 presents a brief description of congestion control mechanism proposed in the previous schemes. A pictorial depiction is also detailed to provide an in-depth understanding of the techniques. The qualitative analysis of the schemes with respect to the parameters specified as criteria of each congestion control scheme introduced is also summarized. Existing survey reviews are also elaborated and the shortcomings of the existing survey papers regarding congestion and how this work contributes by overcoming that effectively, is also discussed. Existing protocols are examined thoroughly in Section 4 for standard Quality of Service (QoS) and the performance parameters specified for the congestion control within the WSN. The open issues emerging from our discussion are discussed in Section 5. In Section 6, we conclude our work.

1. Related work

1.1. Existing survey review

Rekha et al. (2010) provided a well-organized work unfolding the exact functionality and techniques employed within the existing literature, and comparative study is performed. The paper presented a graphical illustration that is helpful for the understanding of the readers, particularly where technical functionality is elaborated. The papers reviewed in the survey were balanced in numbers and presented the latest congestion control schemes that enable the reader to get effectively benefited from the complete literature review. Alternatively, Flora et al. (2011) in his survey discussed existing congestion control techniques and incorporated a balanced number of quality citations. Haresh M. Rathod et al. organized their work (Rathod and Buddhadev, 2011) to have an edge by presenting a tabular comparisons of existing congestion control protocols. To summarize, existing surveys found in the literature provides a comprehensive review of old congestion control schemes, Therefore, there is a need for a comprehensive survey that provides a detailed review of old as well as latest congestion control schemes, provides taxonomy, and identifies open research issues. With these issues in mind, we write this survey.

1.2. Congestion control schemes

Congestion control schemes found in the literature can be divided into two main categories namely: (a) Centralized Congestion Control Schemes containing routing protocols

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