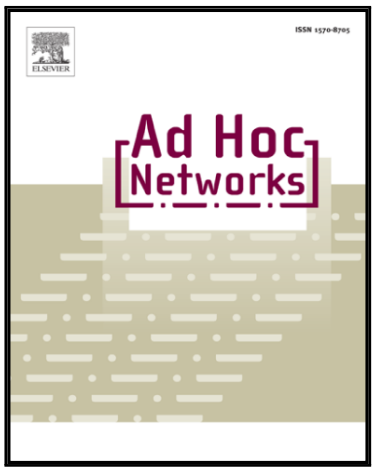

On the performance of adaptive coding schemes for energy efficient and reliable clustered wireless sensor networks

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On the performance of adaptive coding schemes for energy efficient and reliable clustered wireless sensor networks

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Abstract

Clustering is the key for energy constrained wireless sensor networks (WSNs). Energy optimization and communication reliability are the most important consideration in designing efficient clustered WSN. In lossy environment, channel coding is mandatory to ensure reliable and efficient communication. This reliability is compromised by additional energy of coding and decoding in cluster heads. In this paper, we investigated the trade-off between reliability and energy efficiency and proposed adaptive FEC/FWD and FEC/ARQ coding frameworks for clustered WSNs. The proposed schemes consider channel condition and inter-node distance to decide the adequate channel coding usage. Simulation results show that both the proposed frameworks are energy efficient compared to ARQ schemes and FEC schemes, and suitable to prolong the clustered network lifespan as well as improve the reliability.

Keywords: Wireless Sensor Networks, Clustering, Channel coding, Energy efficiency, Reliability

1. Introduction

Wireless sensor network (WSN) is one of the most promising technologies due to their unique characteristics, low cost, easy deployment and flexibility [1]. This emergent technology has attracted significant attention in recent years in many applications [2, 3]. WSN is composed of numerous sensor nodes dispersed autonomously in specific area of interest to gather a physical parameter or monitor environmental conditions [4]. Nodes typically powered by small and limited batteries which replacement is very difficult and expensive in hostile environment. Thus, nodes are expected to be stand-alone and able to run for many months or even years without batteries replacement [5]. Therefore, reducing energy consumption in order to prolong network lifespan is the most crucial requirement and challenge consideration for WSN [6, 7].

Communication reliability is another crucial factor in low power WSN [8, 9]. In highly lossy environment, the radio signal is often affected by noise, interferences, multipath fading and shadowing. These encountered undesirable impairments result in significant packet loss and delayed receiving. The increase of transmission energy results in successful and reliable transmission. However, the rise of transmission energy profoundly affects the sensor nodes energy and the network lifetime. Designing optimal WSN entails providing reliable communication with the minimum required energy consumption. Using error control coding (ECC) is an efficient strategy commonly used to lower the required transmission energy along with protecting the transmitted packets from errors and packet loss [10, 11]. In low power application such as WSN, applying adaptive and low power ECC techniques is a primordial requirement [12]. Moreover, a WSN requires a powerful channel coding scheme when the transmission distance outweighs certain threshold level. Although advanced coding schemes provide higher coding gain, they require higher energy consumption with their complex decoding algorithms. If the extra energy consumption at the decoder exceeds the transmitted power savings due to the use of coding, then coding would not be energy-efficient compared to an uncoded system. Thus, a trade-off between reliability and energy depletion should be considered in order to optimize the error control schemes in WSN [13].

Network architecture and routing design are relevant factors which affect reliability and energy efficiency in WSN [14]. Clustered networks based on clustering routing are widely adopted in WSN to manage the energy efficiency [15, 16, 17]. In cluster-based architecture, two types of nodes coexist in the network and form clusters. Source nodes (S) which sense, encode and transmit their data, and cluster heads (CH) which receive and decode data in one hand, and then aggregate, encode and transmit the data to the base station (BS) in the other hand. Indeed, when a node is selected as a CH, the computation and energy burden become completely important. In this case, using powerful coders and complex decoders intensely affects and worsens the CH energy and the network efficiency. In the last few years, a large literature has been emerged on clustered WSN in various applications. However, most of existing approaches have focused on the design of routing protocols, compression techniques and multiple access architectures [18, 19, 20, 21]. These approaches commonly assume that the transmitted sensors readings are well received by collector nodes (CH/Sink) without packet loss during the transmission and without coding effect on the system.

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