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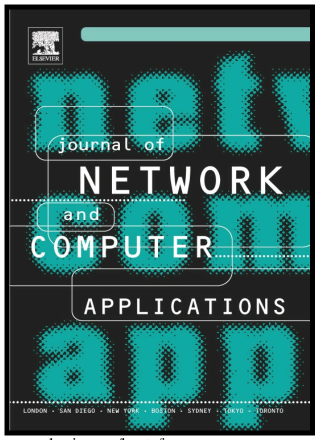

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A Self-Organizing Network Coordination Framework Enabling Collision-free and Congestion-less Wireless Sensor Networks

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Abstract

In recent years, wireless sensor networks (WSNs) have been widely used for controlling remote devices and also for gathering sensor data of distributed WSN devices. The WSNs support current Internet of Things (IoT) technologies in the background. However, it is becoming a salient issue that frequent packet delivery losses occur during data gathering on WSNs along with the increasing number of nodes. Two fundamental difficulties exist for MAC and upper layers on IEEE 802.15.4 standard: transmission collisions among two-hop away nodes, known as the "Hidden node problem," and traffic congestion during data transfer that engenders buffer overflow at nodes. To resolve these difficulties, we propose a self-organizing network coordination framework for WSNs that realizes an adaptive time-division transmission by nodes and also traffic congestion handling in a decentralized manner. Specifically, the framework is based on a decentralized time division technique using a simplified pulse-coupled oscillator model. By coordinating the transmission timing adaptively, each node sends messages without collisions. "Hidden node problems" as well as "Exposed node problems" will be prevented, in principle, when using our method. Additionally, to reduce traffic congestion in a decentralized manner, time slots in the transmission cycle on each node are used efficiently by additional algorithms: an "empty time slots utilization algorithm" and a "takeover algorithm of neighboring nodes' transmission slots". These are introduced for efficient large data gathering applications. We simulated a 60-node data gathering application and evaluated its superiority to a conventional WSN method using CSMA/CA on IEEE 802.15.4 standard. We also conducted hardware experiments using nine developed WSN nodes and confirmed our framework's feasibility in real situations targeted at real-time landslide detection with distributed WSN nodes.