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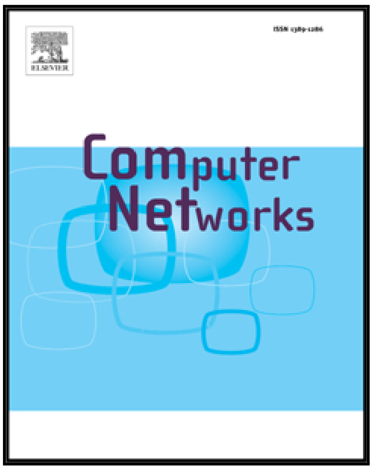


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# Distributed Connectivity Restoration in Multichannel Wireless Sensor Networks

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**Abstract**

Wireless sensor networks (WSNs) are widely used in various domains. However, the specificity of the nodes deployed in these networks makes them prone to failures. To overcome this problem and guarantee the continuity of the network functioning in the presence of node failures, fault tolerance mechanisms need to be designed and integrated to ensure the correct WSN operation. In addition to node failure, the interferences present a serious problem in WSNs. Such a problem is commonly solved by using multichannel communications. Thus, in this paper, we propose a distributed solution, called Connectivity Restoration for Multi-Channel WSNs (CR-MC), to recover from a connectivity loss for multichannel WSNs. The main task of this approach targets the restoration of the connectivity and the reassignment of the channels in a multichannel network after the failure of an articulation node whose failure leads to the network partitioning. CR-MC uses only the neighborhood information to execute the recovery and the channel reassignment tasks. On the other hand, if we consider multi-hop WSNs, a routing tree is generally constructed to disseminate the information to the sink node. Hence, the radio channels should be assigned with a great care to respect these network particularities. In this context, we propose a second solution, called Connectivity Restoration for Routing based Multi-Channel WSNs (CR-RMC) that exploits the routing tree as well as the vicinity information while allocating the channels. We compare the performance of the two proposed approaches CR-MC and CR-RMC by evaluating them through simulations.

*Keywords:* Articulation node failure, Connectivity restoration, Failure recovery, Fault tolerance, Wireless sensor networks

## 1. Introduction

In the recent years, the deployment of wireless sensor networks (WSNs) [1] have won a great notoriety in different domains going from simple data collection to critical system monitoring and control. More and more researchers have dedicated their work to improve the reliability and efficiency of WSNs regarding the requirements of different applications. However, the characteristics of sensor nodes (limited CPU, limited memory, limited battery, wireless communications, etc.) and the harsh environment, in which they are deployed, negatively affect the reliability of WSNs and even lead to the network failure. On one hand, a node failure, caused by energy depletion or any other problem, may partition the network into disjoint parts; where some of these parts get disconnected from the sink. On the other hand, the collisions/retransmissions phenomena caused by interferences between senor nodes, will demand extra energy consumption, thus causing the premature failure of some nodes.

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The problem of the interference ratio minimization has been widely discussed in literature, and the common technique used to handle such a problem is to use multichannel communications. Since the integration of multi-channel radios in wireless sensor devices, many interesting researches have been dedicated to optimally exploit the benefits of multi-channel communications in WSNs [2, 3, 4, 5, 6, 7]. The proposed mechanisms minimize the interference ratio and hence the collision/retransmission ratio. However, the probability of node failure remains high. Thus any node may fail due to energy depletion or any other factor. In many applications, the WSNs are deployed in unreachable or dangerous environments. Therefore, a node battery exchange is unfeasible. Moreover, the replacement of a failed node by a new node is impossible. The problem becomes even more critical when the failed node is an articulation node (articulation point AP) -a particular node whose deficiency leads to a connectivity loss- and hence, the network is partitioned into isolated segments as depicted by figure 1. To overcome this problem, the WSN needs to be reorganized to restore the connectivity. The main idea in the network reorganization is to relocate some nodes around the failed node with minimum impact on the network initial topology.

In this paper, we focus on fault tolerance mechanisms