k-Connectivity in Secure Wireless Sensor Networks with Physical Link Constraints - The On/Off Channel Model

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Random key predistribution scheme of Eschenauer and Gligor (EG) is a typical solution for ensuring secure communications in a wireless sensor network (WSN). Connectivity of the WSNs under this scheme has received much interest over the last decade, and most of the existing work is based on the assumption of unconstrained sensor-to-sensor communications. In this paper, we study the k-connectivity of WSNs under the EG scheme with physical link constraints; k-connectivity is defined as the property that the network remains connected despite the failure of any (k - 1) sensors. We use a simple communication model, where unreliable wireless links are modeled as independent on/off channels, and derive zero-one laws for the properties that i) the WSN is k-connected, and ii) each sensor is connected to at least k other sensors. These zero-one laws improve the previous results by Rybarczyk on the k-connectivity under a fully connected communication model. Moreover, under the on/off channel model, we provide a stronger form of the zero-one law for the 1-connectivity as compared to that given by Ya\u{g}an. We also discuss the applicability of our results in a different network application, namely in a large-scale, distributed publish-subscribe service for online social networks.

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