Channel-Aware Relay Node Placement in Wireless Sensor Networks for Pipeline Inspection

Wireless sensor networks (WSNs) provide an effective approach for underground pipeline inspection. Such WSNs comprise sensor nodes (SNs) and relay nodes (RNs) for information sensing and communication. WSNs can perform accurate and realtime inspection, especially in adverse environments. However, transmitting information between underground and aboveground nodes is very challenging. First, in-pipe SNs conducting controlled maneuvers underground are mobile. Second, SNs need to transmit the information wirelessly to aboveground base stations (BSs). In addition, radio propagation is complex because radio waves travel in a multi-medium environment. Finally, the SNs have limited energy supply. Therefore, proper deployment of a WSN is critical to providing reliable communications and efficient inspection. This paper presents a channel-aware methodology for deploying aboveground RNs in WSNs for underground pipeline inspection. Specifically, first, the paper provides a path loss model for radio propagation over multiple transmission media. Then, based on the path loss model a method is developed for optimum placement of the RNs so as to minimize the energy use of SNs and allow reliable communications. This method takes into account characteristics of the wireless channels, power consumption constraint, pipeline coverage requirement, and the limit of the number of the RNs. We provide an algorithm for optimization of RN placement and SN's power consumption. Simulation results show the efficacy of the proposed framework.