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Leach Based Hierarchical Routing Protocol for Monitoring of Over-ground Pipelines Using Linear Wireless Sensor Networks

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Abstract

The low cost and better processing power and energy efficiency makes it possible to use large numbers of sensors in a wide variety of applications including environmental monitoring, military, ecology, agriculture, inventory control, robotics health care and various types of pipelines. In monitoring the pipelines, a special class of sensor defined as Linear Wireless Sensor Networks (LSNs) is required having its special characteristics as far as routing is concerned.
In this paper a three layered architecture has been proposed for monitoring, and protection of over-ground oil, gas, and water pipelines using wireless sensor networks. The three layers include on the ground, on the pipeline and underground layer. This paper also proposes a architecture a *Leach Based Hierarchical Routing Protocol* for linear structure wireless sensor networks (LBHRP) for the above mentioned architecture.

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1. Introduction

A Wireless Sensor Networks (WSN) can be defined as a group of sensors where each node is capable of

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collecting, processing and communicating the information to some other sensor(s) till the desired information reaches to the destination (i.e., base station) where necessary actions may be taken on the data received from the sensor network.

Due to their extensive use in a variety of applications such as defense, civil, health care, environmental, monitoring the infrastructure WSNs is a research area actively persuaded by the researchers. Few new wireless sensor network (WSN) topologies have been proposed in recent years. In several WSN applications the nodes are to be deployed in linear fashion and forming a linear topology in which the data is collected over a long chain of nodes connected to a sink. Monitoring of highway, gas, oil and water pipelines (over ground and underground) are some of the examples of such topologies. These structures are generally very long and the distance covered from end to end can vary from several hundred meters to hundreds of kilometers in very tough or uninhabited environments. In each sensor node in the system, there is a detection module composed of various type of sensors embedded in the node to monitor any change in the current condition. The WSN used for monitoring this type of infrastructure are called Linear wireless Sensor Networks (LSN).

Consider the case of a long pipe line (Oil, Gas & water) whether it is over ground or underground. The sensors are placed along with the pipeline, here the sensor nodes are placed linearly and hence there is a requirement of linear topology. In addition, there are unexpected threats like leakages in pipelines due to natural disaster, corrosions, and cracks in pipelines. Because of this there may be large economic loss, and environmental pollution or risk of personnel injuries. Thus, the security and maintenance of these pipeline infrastructures is one of the major issues, these issues can be resolved with the help of WSN.

A number of routing protocols have been proposed for wireless sensor networks [1]. Most of these protocols are using the mesh topology. However, in case of pipelining and LSNs the mesh topology is not suitable.

In LWSN, the successful end-to-end delivery of the complete data (data should not be lost during transmission) is required, and delivery of the packet should be in the appropriate timeframe. The main constraints in linear topology is that the number of neighbor nodes are limited and because of this the feasible transmission routes are almost fixed, so if any of the nodes get die, the chances of failure of data delivery are more as compare to the traditional WSNs. Besides critical node failures and energy exhaustion, failures can also occur due to increased number of retransmissions which results in higher packet collision rate and traffic congestion. Hence, the routing protocols designed for non linear WSNs cannot be directly applied in LSNs.

Therefore, in this paper, an architecture consisting of three layer sensor nodes namely over ground layer, on pipeline layer and underground layer has been proposed. Additionally, LBHRP (Leach Based Hierarchical Routing Protocol) a hybrid routing protocol for LWSN for heterogeneous sensor nodes has also been presented.

The rest of paper is organized as follows. Section 2 provides a short overview of the related work in LWSN routing protocols. Section 3 presents the proposed system model and architecture. Section 4 describes the working of the algorithm. The last section concludes the paper.

2. Related Work

In recent years, several routing protocols proposed for LWSNs have been proposed by the researchers. A survey on the applications, issues and classifications of LSN has been shown in [1, 2]. In [3], the authors have discussed and compared various architectures of sensor networks suitable for underwater pipeline monitoring. Apart from the comparison three reliability factors have also been compared namely network connectivity, continuity of power supply, and the physical network security.

A number of routing protocols have been proposed by the researchers. In [5] a distributed topology discovery algorithm for LSN has been discussed. An energy-efficient and localized power-aware routing in LSN has been proposed in [6, 7]. In [8], an energy-balanced data gathering algorithm for Linear Wireless Sensor Networks has been proposed. For balancing the load of the network and extending the life of the network, an energy-efficient node placement scheme in LSN has been proposed in [9]. In [10] a routing algorithm for monitoring the oil pipelines using Ant Colony Optimization and Genetic Algorithm has been proposed for maximizing the coverage of the pipe, producing a connected network, and prolonging the overall network lifetime. For monitoring the natural gas pipelines author in [11] proposed a hierarchical leak detection and localization method using multi-classifier model based on SVM. Authors in [12] have proposed and compared the various sensors network architectures for