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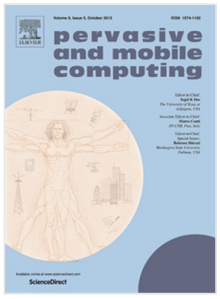

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Routing in Wireless Sensor Networks for Wind Turbine Monitoring

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Abstract

Smart wireless sensor devices are rapidly emerging as key enablers of the next evolution in wind turbine monitoring. The potential for in-situ monitoring of turbine elements, employing methodologies that are not possible with existing wired technology, make it possible to attain new levels of granularity and autonomy in the monitoring of these structures. Wireless sensor devices are limited in terms of communication by the range of their radio modules and, thus, need to form networks in order to transfer data from distant points. Routing protocols are primary enablers of such ad hoc wireless sensor networks and these require the implementation of reliable and energy-efficient mechanisms to maximise network reliability and availability. Existing routing protocols cannot be directly applied to the monitoring of wind turbines without addressing the unique context and operational characteristics of these structures in multi-hop wireless communication. This work identifies the potential effects associated with the operation, environment and structure of wind turbines in wireless sensor network multi-hop communication, and proposes and evaluates a reliable routing protocol for wireless sensor networks employed in these domains.

Keywords: Wireless Sensor Networks, Wind Turbine Monitoring, Routing Protocol, Gradient Routing

1. Introduction

Wind turbine generators are commonly deployed in remote environments with difficult access and changeable meteorological conditions that can affect the reliability, operation and behaviour of mechanical and structural components - such as blades, tower, nacelle, gearbox, generator, etc. Moreover, the wind turbine blades can rotate at varying velocities, producing unpredictable effects in the vibration characteristics of different parts of the wind turbines [1]. Reliable monitoring of these structures is a key step in identifying variations in their efficiency of operation, and in avoiding major failures which can result in mechanical or structural malfunctioning, breakage and significant financial loss [2, 3]. The use of wireless sensors has been proposed as a solution to monitoring multiple components inside and outside these structures, principally targeting scenarios where wired instrumentation is impractical or difficult to install [4, 5, 6]. Unobtrusive wireless sensors can be embedded in the components of wind turbines so that they can monitor and wirelessly transmit a variety of parameters of the structure. Data is transferred among those sensor devices, to and from a set of sink nodes, which are capable of establishing connectivity with other networks such as the Internet. This follows the monitoring paradigm where data flows between the wireless sensor network and the centre for data processing and control. While this is the traditional monitoring paradigm, we need to consider that wireless sensors integrate memory and processing capabilities to perform computational activities and that we should leverage these resources to alleviate the burden of wireless communication [7]. In other words, we should pre-process data onboard sensor devices, or within the sensor network (also known as in-network processing), to reduce the communications traffic within the wireless sensor network [8]. There are some key advantages in following such an approach:

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