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AN INVESTIGATION INTO THE APPLICABILITY OF WIRELESS SENSOR NETWORKS FOR CONDITION MONITORING

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PURPOSE AND SCOPE

This report discusses the emerging technology of Wireless Sensor Networks (WSNs), the applicability of WSNs for use in substations, and in particular, the use of WSNs for condition monitoring. The results of a trial using a commercially available environmental monitoring WSN system (Crossbow's MEP-SYS410CA system) are detailed.

PART 1 – REPORT DETAILS

1 COMMUNICATION FOR CONDITION MONITORING

1.1 Background

To achieve benefit from condition monitoring it is essential that not only are the sensors reliable but also that there is easy access to the data for analysis. Traditionally, dedicated communication links, usually phone lines run across the substation compound, have been installed to access condition monitoring systems which have been typically installed permanently or on a long-term basis. These hard-wired links are time consuming, and often disruptive, to install and typically cost £10000 to £20000 per link.

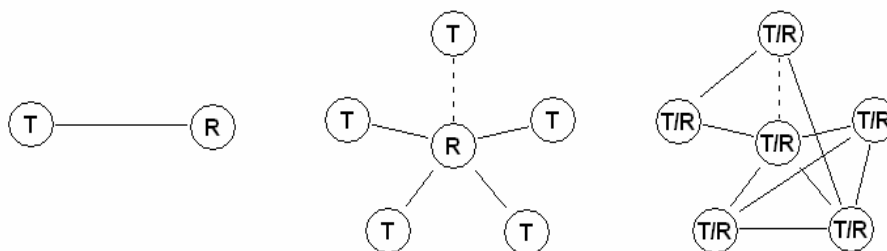
In recent years real business benefit has been achieved from more reactive condition monitoring (often referred to as “nursing”) of assets in poor condition. This change in emphasis has driven a need to find more flexible communication methods, which can be installed quickly and cheaply. This has led to the use of wireless communication technologies which offer these advantages. Moreover, a transmitter-receiver pair for the commercially available WiSNet system only cost ~£1500. Although limited in some ways, the WiSNet devices have proven very reliable and have provided National Grid with an economic means of radio communication for condition monitoring and the collection of data from a wide range of different sensors.

Unfortunately the supplier of WiSNet systems went into liquidation leading to the requirement to find another supplier of radio communication technology. This need to find alternative suppliers has prompted the testing of other products and has also provided the opportunity to investigate the emerging technology of wireless sensor networks (WSNs). WSNs potentially offer many advantages over existing point-to-point communication techniques including increased reliability, flexibility and localised data processing. This additional functionality offers many potential new options for the ways in which condition monitoring data is collected and how it is processed.

1.2 Wireless Sensor Networks

To understand the difference between WSNs and traditional point-to-point communication systems consider the three communication topologies below. The circles represent nodes, which either contain a transmitter, receiver or a combined transmitter and receiver. In the field of WSN the nodes are often referred to as *nodes*. The solid lines represent strong communication links between the nodes whilst the dotted lines represent weak intermittent communication links.

The first single pair of transmitter and receiver is the simplest form of radio communication. Data from one transmitter is sent to one receiver in one direction. This may be made more useful by progressing to a star topology where many transmitters send data to one receiver in one direction (WiSNet is an example of a star topology network). The dotted line indicates there is a weak communication link and so data from the corresponding transmitter cannot always reach the receiver. However, the third fully connected network is made up of combined transmitters and receivers so data can be sent in both directions between any two nodes. Although the dotted line remains there are two other paths for data to flow. In fact despite many missing communication links in this example, every node has two or more paths for data to flow which increases the reliability of data transmission. This also allows the network to be more flexible so that data can be transmitted over greater distances and from nodes without a direct line of site to the base station. The ability of data to move through intermediate nodes is known as multi-hopping.



The benefits of multi-hopping also eliminates the effort required to achieve finding a line-of-sight between the nodes and the base station during installation. It also allows less energy to be used to transmit data, assuming the majority of energy used at a node is used to transmit data. This is because a reduction in distance due to the introduction of intermediate nodes corresponds to a reduction in power squared.

Another key aspect of a WSN node, in addition to the onboard combined transmitter and receiver, is the integrated microcontroller. This provides some processing ability and is necessary to perform multi-hop communication. It also enables the network to be reconfigured so data can be rerouted if a communication link is lost. The onboard processing power is desirable with respect to condition monitoring as it allows some data fusion before the data is transmitted. This has the potential to save energy and monitor assets in innovative ways that may enable more accurate and detailed condition monitoring information.

The following figure presents a holistic view of a condition monitoring WSN. The chosen elements represent the most detailed resolution possible without compromising their generic nature, with the top five elements representing software and the bottom seven elements representing hardware.

This generalised view of a communication device is common in the field of communications research and may be broadly used to indicate the desegregation of research topics in the academic/industrial world. This does nevertheless overly simplify the problem since it is important not to consider these elements in isolation as they all affect the operation of the motes and often interrelate. Nevertheless it has become apparent during the course of this investigation that throughout the development of WSNs much of the initial research has focused on the individual elements at the cost of integrating these elements to form a working network.

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