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Wireless Network architecture for Diagnosis and Monitoring Applications

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Abstract— This paper describes a distributed wireless network architecture for remote diagnosis and monitoring. A windmill farm is considered as a target application, which is further grouped into small clusters of windmills communicating with each other for the purpose of distributed diagnosis. Wireless links are commonly used for long-range communication in SCADA systems. In order to extend wireless networks for remote diagnosis applications, strict requirements on availability, robustness, reliability and performance have to be satisfied in order to meet industrial standards. This paper is intended to present a wireless network architecture for tele-operation of large industrial applications.

Keywords- *Wireless network, Condition monitoring, Distributed diagnosis, Windmill farms*

I. INTRODUCTION

Wireless networks are getting popular due to their flexibility of design, reduced costs, better power management, ease in maintenance, and easy deployment in remote and hard-to-reach areas where conventional wired infrastructure is difficult to install. They have been successfully deployed in many industrial applications such as maintenance, monitoring, control, security, etc [1]. Thus, the dependence of control and diagnosis of industrial systems on physically connected communication infrastructure has been relaxed by the developing wireless technologies, ranging from wireless sensor networks to broadband networks [1], [2].

In this paper, we consider the utilization of wireless networks for data transfer needs of condition monitoring, maintenance and remote diagnosis. Network architecture is proposed for condition dependent monitoring and fault diagnosis of large scale distant windmill installation. The focus is to address the issues faced by wireless communication systems to deliver diagnosis data on different supervision levels. Thus it is a network/diagnosis co-design problem. The level of intelligence associated with each diagnosis segment will result in overall distributed diagnosis scheme. In addition, the operational challenges are exacerbated when different RF links have to be used to satisfy the requirements of bandwidth, payload, delay, jitter, range, noise immunity, interference rejection and cost for communication [3], [4].

II. CONTEXT

Diagnosis and Monitoring of industrial systems inherently requires a distributed approach, which offer some widely recognized advantages like the possibility of enhanced reliability due to component redundancy, improved performance by exploiting concurrency and better resource management and utilization through sharing. A local performance measure thus plays an important role in distributed hierarchy. The goal of communication, at different levels, for monitoring and supervision of windmill farms, can be achieved with low cost wireless network architecture, taking into account the constraints of noise, interference, bandwidth limitations and security [5], [6]. A compromise between requirements and limitations will result in a promising solution of the stated problem.

III. PROPOSITION OF A GENERAL ARCHITECTURE

The network based communication architecture can be visualized at various levels, each of which having their own constraints (end to end QoS, time delays, distance, network traffic, packet bursts, multi path effects, EMI etc). The terminology used to represent a cluster of windmills installed within a closer distance is termed as a ‘Farm’. While a group of windmill farms is jointly labeled as a ‘Park’.

A. Windmill Based Network (WBN)

The WBN is composed of sensors connected to each subsystem. The data acquisition of various components of a windmill is performed by a local supervisor node. The windmill based network is essentially a low power wireless mesh network. Each sub component of windmill e.g. gear box, generator, nacelle etc have sensors attached to them, which send data to the local supervisor node through a wireless network. The parameters of interest include vibration data of gear box and generator, health indicator signals of electrical subsystems, generated voltage, status of AC/DC/AC block, Gear box oil temperature etc.

B. Farm Based Network (FBN)

This network will be responsible for the communication within the various windmills of a farm for control and

diagnosis purpose. The exchange of data is between individual windmills as well as with the farm supervisor node, which is responsible for the data management and diagnosis decision at the farm level. The information of interest may include the wind direction relative to windmill farm, voltage generated by each individual turbine and condition monitoring parameters to decide and optimize farm productivity.

C. Inter-Farm (Park) Based Network (PBN)

The communication task between various distributed windmill farms of a region is taken care by an inter-farm network. Fig.1 shows a PBN composed of many FBNs. One of the tasks for this level of communication can be as simple as to exchange diagnosis information to ensure interrupt free voltage stabilization to the grid with optimized use of windmills with changing electrical loads.

D. Distant Supervision Network (DSN)

This level of communication network will involve long distance communication between windmill parks that are distributed usually far away (especially for the case of offshore windmills) and the supervisor at the diagnosis centre.

IV. NETWORK BASED DISTRIBUTED DIAGNOSIS

The distributed diagnosis concept of windmill farms is based on the network resources available at different levels. Typically, faults in windmill subsystems develop slowly e.g. contamination of oil in gear box, rise in temperature of generator windings, excessive nacelle vibration due to structural faults etc. So the measurement data from sensors related to condition monitoring may not be time critical. The measurement data can be processed and analyzed at different levels of the network. The amount of data to be transferred can be reduced sufficiently by emphasizing local analysis.

The measurement parameters traditionally used in vibration measurements are displacement (μm), velocity (mm/s) and acceleration (m/s^2). ISO 10816-3 classifies vibration velocity amplitudes in the frequency range of 10 to 1000 Hz as a function of turbine output [7]. Impact-like phenomena, such as bearing and gear faults, friction and insufficient lubrication, can be studied by means of acceleration measurements more effectively than using velocity measurements. For wind turbines, gear manufacturers have defined typical frequency range of 10 Hz to 100 Hz. The frequency information of vibrations is continuously monitored at a higher rate and a local check is maintained on permissible amplitude of the vibration.

In addition, sensor faults of individual windmills can be detected and a collaborative monitoring system at the farm based network (FBN) will diagnose and improve farm based electricity generation. For example, in case of anemometer fault at one windmill, farm supervisor node can estimate and

still maneuver the faulty windmill for optimum wind direction based on data received from other anemometers of the farm windmills.

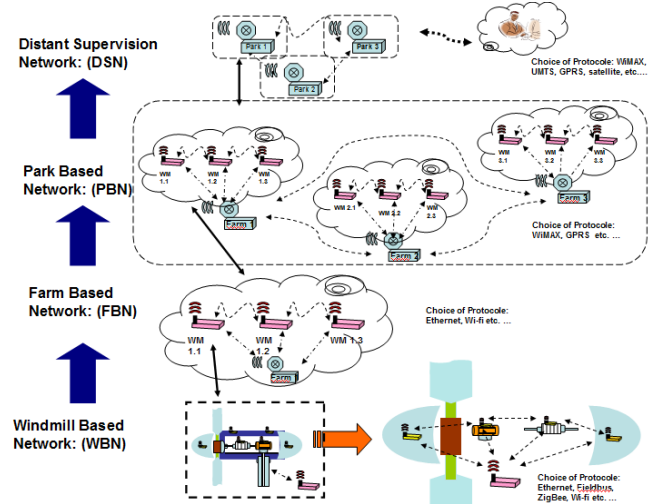


Figure. 1. General hierarchical Network architecture

V. CONCLUSION

In this work, an approach for distributed hierarchic network architecture is proposed for the applications of tele-diagnosis and distant monitoring of a distributed windmill energy generation system. Network simulation with different heterogeneous architectures and protocols is being performed to visualize the constraints, taking into account geographic terrain for long distance communication. In addition, diagnosis tasks at each level of communication need to be allocated for distributed monitoring. This concept can be extended to energy generation from heterogeneous sources (e.g. Wind, Solar, Fuel cells, Hydroelectric etc.) and their collaborative monitoring by utilizing heterogeneous wireless networks [8].

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