Analytical Modeling for reliability in cluster based Wireless Sensor Networks

Alaa Eldeen Sayed Ahmed
Electrical Engineering Dept.
Shoubra Faculty of Engineering, Benha University
Cairo, Egypt

***Abstract*— In most Wireless Sensor Networks applications users would expect to achieve good service in terms of reliable retrieved accurate data. One technique to improve the level of data accuracy is to use fault tolerance techniques such as redundancy that would cause the energy of the system to deplete quickly. In this paper we address the problem of reliable wireless sensor network and provide the design and the analysis of an algorithm that model cluster-based structured Wireless Sensor Networks with the objective of achieving suitable reliability level requirements to extend the whole system lifetime. Reliability is defined as the probability that a sensor node will perform its intended function during a specified period of time under stated conditions. We analyze the effect of redundancy on the system reliability and the energy consumption level of the Wireless Sensor Networks model. Throughout the analysis we derived an expression for both the reliability and the energy consumption in terms of redundancy level parameter. Parameterizing the reliability, MTTF and energy consumption would give the system designer the ability to select the suitable value of the redundancy level in order to satisfy different performance criteria such as maximizing the system reliability and achieving minimum energy consumption at the same time.**

Keywords—WSN; Reliability; Clustering; Fault tolerenr; Energy Efficiency

I. INTRODUCTION

Wireless Sensor Networks (WSNs) have been the favorite choice for the design and deployment of monitoring and control systems applications [1]. The most important advantage of using sensor networks is providing the ability to extend the computation processing power to human not accessible areas to facilitate the measuring of some physical phenomenon [2]. The entire WSNs sensor is dynamic in the sense that sensor nods or links may fail at any point of operation. Replacing faulty nodes are not an easy job so fault tolerance or reliability measure is a very important research challenge that needs to be solved. In several WSNs applications information are collected by sensors that are deployed in extremely harsh environment and hostile region that may lead to sensors failures. Clearly, there is a series reliability issues that need to be considered when dealing with WSN In order to keep whole process running. In clustered structures WSN sensor nodes failure may cause connectivity loss in some networks partitions and disconnects the cluster and leads to loosing the data [3].

Failures in sensor network cannot be tolerated and masked directly using the approaches employed with traditional wired or wireless network [4]. In WSN failures occur more frequently than traditional networks, where client machines, servers and routers most of the times operate in normal conditions. Also, most of the approached used with traditional networks doesn't take the device energy consumption into consideration since most of these device are fed with a fixed power supply.

Failures in sensor nodes may come from three different sources. One source is due to energy depletion of the sensor nodes, in other words when the node whole energy is consumed to answer different data request coming from users. Another source is due to sensor hardware faults including measurement, transmitting or receiving faults. The third source is due to failure in communication links between different sensor nodes. In this paper we mainly consider the first and second faults and assume reliable communication links.

To manage and handle the sensor nodes failures, a good mechanism is to use redundancy to help in detecting sensor failures, masking then correcting to allow the continuous operation of the WSN. However, redundancy may have an observable impact on the energy consumption rate of the system because the increased use of more redundant sensor nodes to achieve fault tolerance and increase the overall system reliability. So, there is a tradeoff need to be analytically formulated to allow system designer to achieve fault tolerance by applying the redundancy but with the minimum energy consumption.

The paper is organized as follows. In section 2, related work is reviewed. In section 3 we present the system model. The proposed algorithm is given in section 4. The probabilistic analysis of the algorithm is given in section 5, finally, section 6 introduces the conclusion.

II. RERELATED WORK

In this section, fault detection and reliability of WSNs related work is reviewed. In [5] authors applied correlation to the sensors measurements to detect nodes failures. They introduced a method to give weights to neighbors and then measure the difference of reading. A weighted median detection scheme (WMFDS) is proposed and evaluated. This algorithm considers only permanent faults.

In [6] the model introduced to evaluate the reliability is based on generating a fault tree of the whole Wireless Sensor Networks when faults occur. The presented model supports any kind of technology or different level of redundancy. However the model is not considering the effect of power consumption when evaluating the reliability. Beside that the routing algorithm used by the WSN is not taken into consideration.