

# A Survey on Fault tolerant Wireless Sensor Network

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**Abstract**—Wireless sensor network is made of distributed wireless sensor node which sense environment variables and report to base station. Wireless sensor network are increasingly applied in industrial and defense applications. Faults happen in sensor network due to reasons like environmental disturbance and battery energy depletion. Also sensors fail transiently or permanently due to manufacturing defect. In field, due to fault of sensor nodes, the applications built on events from sensors is bound to fail and may cause severe damages. In this work, we review the different kinds of faults that occur in sensor network and fault tolerant mechanism proposed to solve those faults.

## I. INTRODUCTION

Wireless sensor networks (WSNs) have received significant attention in recent years due to their potential applications in military sensing, wildlife tracking, traffic Surveillance, health care, environment monitoring, building structures monitoring, etc. WSNs can be treated as a special family of wireless ad hoc networks. A WSN is a self-organized network that consists of a large number of low-cost and low powered sensor devices, called sensor nodes, which can be deployed on the ground, in the air, in vehicles, on bodies, under water, and inside buildings. Each sensor node is equipped with a sensing unit, which is used to capture events of interest, and a wireless transceiver, which is used to transform the captured

events back to the base station, called sink node. Sensor nodes collaborate with each other to perform tasks of data sensing, data communication, and data processing. Nodes in WSNs are prone to failure due to energy depletion, hardware failure, communication link errors, malicious attack, and so on.

When a number of sensors fail for whatever may be the reason the resulting network topology may be disconnected which in result is considered as a failure of set of nodes. The nodes that have not failed become disconnected from the rest of the network.

The application built on sensor network will be affected because of sensor node failure and especially if it is safety related applications and because of node failure, critical events are missed and disasters happen the loss is tremendous. Fault tolerance must be provided in the network, so that even in case of node failures, the critical events are not missed. Also certain times faults can be introduced in the path by forged packets by attackers or faults can introduced due to dissemination. Also with increasing application of mobile agents, faulty agents can be disseminated into network. In this we survey the different kinds of faults in the wireless sensor network and provide analyze the pros and cons of fault detection and fault management techniques in the sensor network.

## II. SURVEY

In [1], authors proposed a real time QOS based routing and fault tolerant mechanism for handling real time traffic in wireless sensor network. Congestion, link failure and void problems are handled in this solution. The approach is based on designing redundant path for transmission to handle QOS and faults. But energy is consumed fast and the life time of the network is reduced.

In [2], authors proposed a 1-hop neighbor sensor monitoring to detect faults and the faulty node is isolated from network temporarily and if fault persists the node is isolated permanently. Faulty nodes are not isolated in this approach and due to this network partitions happen. This approach can detect faults in the data sensed by sensors but it cannot detect data forward faults.

In [3], authors proposed an approach for placing more nodes in the network but splitting them to active and redundant nodes. Redundant nodes are first kept in sleep position and then woke up to compensate the coverage lost due to fault in active node. But this approach is not scalable for bigger networks as the cost of redundant nodes will increase.

In [4] authors proposed Least-Disruptive topology Repair algorithm to move the nodes to avoid network partition problem. The network partition is measured and nodes are relocated to cover the network partition. It is not always possible to relocate the nodes in an attended environment and also the number of relocation in this approach is high.

In [5] authors proposed a clustering based fault recovery using redundant nodes. Some nodes within cluster are kept in sleep state and activated to cover for coverage loss. The approach is not optimized for multiple faults.

In [6] authors proposed a fault node recovery algorithm when sensor nodes shutdown due to energy depletion. The idea of fault tolerance is

based on reused routing path in this work. The approach can work only for dense sensor network.

In [7] authors proposed a heterogeneous relay node based approach for fault tolerance. Nodes have different transmission radius. Each node has two paths and in case of faults, redundant paths are used. But this approach is complex at sensor nodes with different routing paths.

In [8] authors proposed an energy aware fault tolerant method called Informer homed routing. The network is clustered and fault is handled in two modes within cluster and inter cluster. Due to this energy is conserved. The approach does not deal with cluster head becoming faulty.

In [9] authors proposed a distributed hierarchical Wireless sensor network architecture for fault management. To locate and analyze fault Gateway devices are added into the network. Agents move around to detect faults. This approach is of high overload because of additional network components.

In [10] authors propose an Active node based Fault Tolerance using Battery power and Interference model (AFTBI) in WSN to identify the faulty nodes using battery power model and interference model. Fault tolerance against low battery power is designed through hand-off mechanism where in the faulty node selects the neighboring node having highest power and transfers all the services that are to be performed by the faulty node to the selected neighboring node. Fault tolerance against interference is provided by dynamic power level adjustment mechanism by allocating the time slot to all the neighboring nodes. If a particular node wishes to transmit the sensed data, it enters active status and transmits the packet with maximum power; otherwise it enters into sleep status having minimum power that is sufficient to receive hello messages and to maintain the connectivity. In this approach, the initiation for fault tolerance is done by the faulty node and if the faulty node suffers sudden failure and shutdown, this approach does not work well.

In [11], authors proposed two algorithms named Full 2-Connectivity Restoration Algorithm (F2CRA) and Partial 3-Connectivity Restoration Algorithm (P3CRA), which restore a faulty WSN in different aspects. F2CRA constructs the fan-shaped topology structure to reduce the number of deployed nodes, while P3CRA constructs the dual-ring topology structure to improve the fault tolerance of the network. F2CRA is suitable when the restoration cost is given the priority, and P3CRA is suitable when the network quality is considered first. The network is deployed in a way to handle fault tolerance in both of these solution and the solution assumes the number of fault nodes that be in the structure. When the number of fault node assumption fails, the entire fault tolerance mechanism built into network fails.

In [12], authors proposed a redundant nodes based fault tolerant mechanism. The approach used k-connectivity based steiner approach to decide the optimal number of redundant nodes to be placed in the network. By optimizing the number of redundant nodes, the author tried to reduce the cost of sensor network. The approach lacked coverage ratio but increased the connectivity problem.

In [13], authors applied multi agent architecture for fault management. The multi agent system proposed by author had resource manager, a fault tolerance manager and a load balancing manager. Fault tolerance manager applied the idea of agent broadcast to move around and avoid faulty paths. The approach is scalable but suffers from energy depletion problem.

In [14], authors proposed Reuleaux Triangle approach, to characterize k-coverage with the help of Helly's Theorem and the analysis of the intersection of sensing disks of k sensors. Using a deterministic approach, authors showed that the sensor spatial density to guarantee k-coverage of a convex field is proportional to k and inversely proportional to the sensing range of the sensors. This is a deployment time approach which provides the number of sensors to be deployed in area based

on continuous coverage. But this kind of approaches fail when the particular area is destroyed also not suitable for random deployments.

In [15], authors presented a distributed fault detection and node management using cellular automata. Linear cellular automata runs in every node and every sensor node learns its own state using cellular automata. The faulty nodes are detected by temporal and spatial correlation of its data by neighboring nodes. The models for fault detection is learnt at many places and this redundancy results in energy depletion in sensor nodes.

### III. OPEN ISSUES

As we see the survey we notice following problems in the existing solutions.

1. Most approaches focus on data sensing faults only and relies on neighboring nodes to monitor faults and correct, increasing the overhead of neighboring nodes.
2. The degree of movement of sensors is not considered and obstacles on movement not considered for dynamic fault tolerance.
3. The variable coverage field where not all area of sensor network needs different coverage is not considered in the static schemes for fault tolerance where nodes are positioned during deployment time to provide fault tolerance.
4. Not all sensor fails in the network with same probability, depending on environment impact, the movement model for fault tolerance must be predicted and tolerance must be guided.
5. In most fault detection and fault tolerance, the energy of nodes selected for fault tolerance is not considered. The selection on nodes for fault tolerance must be based on multiple parameters like area of sensing, frequency of sensing, events being sensed

and energy of nodes , probability of node to fail etc.

#### IV. CONCLUSION

The paper summarizes the current works in the fault detection and fault tolerance. The fault tolerance approaches can be categorized into static and dynamic schemes. In static scheme, the tolerance is built into network during deployment by suitably placing the sensor nodes and finding the node deployment density. In dynamic scheme node moves to maintain coverage and connectivity.

We identified the open area of research in both static and dynamic and our future work will be on these open areas proposing efficient solution for the same.

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