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A SURVEY ON FAULT DETECTION TECHNIQUES IN WIRELESS SENSOR NETWORKS

Urmila
M. Tech Scholar-CSE,
BRCM CET, Bahal

Sunil Kumar
Asst. Professor-CSE
BRCM CET, Bahal

Dr. Sajjan Singh
Associate Professor-ECE
LPU, Jalandhar

***Abstract*: Wireless sensor networks (WSNs) are an important tool for monitoring distributed remote environments. As one of the key technologies involved in WSNs, node fault detection is indispensable in most WSN applications. It gives the detection of fault in WSN through different algorithm such as DFD Scheme, localized fault detection algorithm and CDFD algorithm. It is well known that the distributed fault detection (DFD) scheme checks out the failed nodes by exchanging data and mutually testing among neighbor nodes in this network, but the fault detection accuracy of a DFD scheme would decrease rapidly when the number of neighbor nodes to be diagnosed is small and the node's failure ratio is high. In this paper an improved DFD scheme to detect intermittently faulty sensor nodes and to rigorous power budget during fault analysis process on sensor node in wireless sensor network**

Keywords: Wireless Sensor Network (WSN), Fault Analysis Distributed fault Detection (DFD) Algorithm**.**

I. INTRODUCTION

- A wireless sensor network is a collection of sensor nodes organized into a cooperative network
  - WSN are used to collect data from the environment.
  - A sensor network consists of multiple detection stations called sensor nodes, each of which is small, lightweight and portable.
  - The nodes in the network are connected via Wireless communication channels.
  - Each node has capability to sense data, process the data and send it to rest of the nodes or to Base Station.

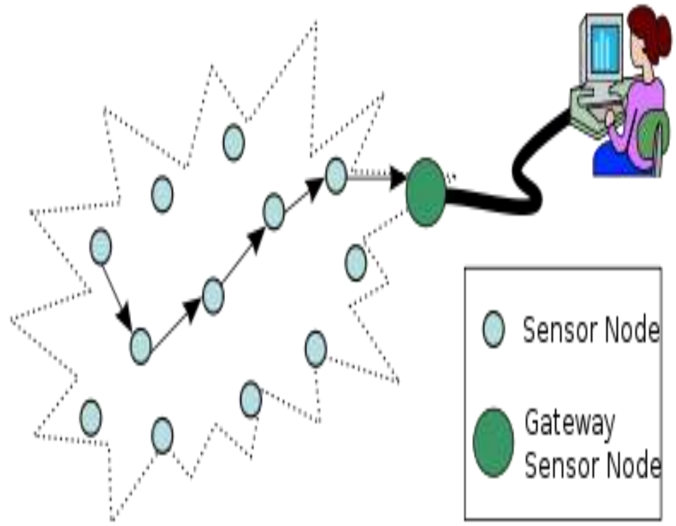

Fig.1 WSN Architecture

Wireless sensor network (WSN) is widely considered as one of the most important technologies for the twenty-first century. In the past decades, it has received tremendous attention from both academia and industry all over the world. A WSN typically consists of a large number of low- cost, low-power, and multifunctional wireless sensor nodes, with sensing, wireless communications and computation capabilities. Many researchers have been working towards fault detection in WSNs. One reason behind the growing popularity of wireless sensors is that they can work in remote areas without manual intervention. All the user needs to do is to gather the data sent by the sensors, and with certain analysis extract meaningful information from them. Usually sensor applications involve many sensors deployed together. These sensors form a network and collaborate with each other to gather data and send it to the base station. The base station acts as the control enter where the data from the sensors are gathered for further analysis and processing. In a nutshell, a wireless sensor network (WSN) is a wireless network consisting of spatially distributed nodes which use sensors to monitor physical or environmental conditions. These nodes combine with routers and gateways to create a WSN system. The WSN is made of nodes from a few to several hundred, where each node is connected to one or several sensors [2].

- Sensor and actuator - a device designed to sense the environmental functions like temperature.
- Controller - is to control the operations.
- Memory - for programming data storage.
- Communication - a device for receiving and sending data in excess of a wireless channel.
- Power Supply- supply of energy for the above processes.

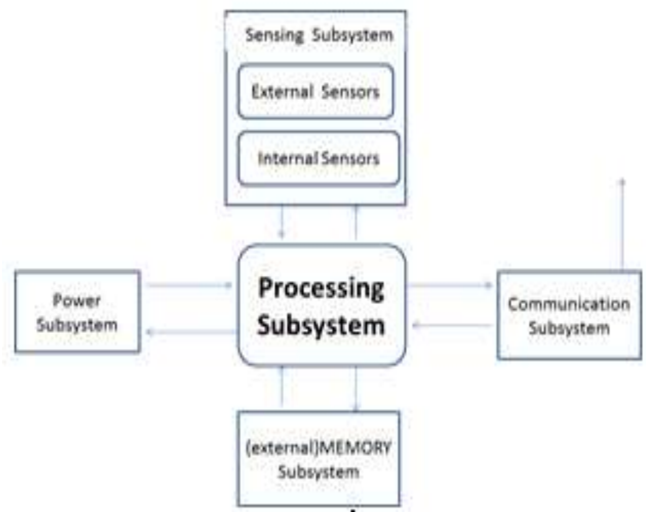

Fig.2 Wireless sensor node

The topology of the WSNs can diverge from a simple star network to an advanced wireless mesh network. The propagation technique among the nodes of the network could be routing. Wireless sensor networks the power lies in the capability to deploy large numbers of small nodes that assemble and construct themselves. In addition to radically decreasing the installation costs, WSN have the potential to dynamically adapt to changing environments. Adaptation mechanisms can lead to changes in network topologies.

II. FAULT IN WSN

The node status in WSNs can be divided as [5] Node faults in WSNs can be divided into 2 types:
Hard Faults: is when a sensor node cannot interact to other nodes because of the failure of a certain module (e.g., energy depletion of node)
Soft Faults: failed nodes can continue to work and interact to other nodes, but the data sensed or transmitted is not correct.

2.1 FAULT MANAGMENT PROCESS

Fault management process is divided into three phases:

- Fault detection
- Fault diagnosis
- Fault recovery

2.2 FAULT DETECTION: AN OVERVIEW

Fault detection is the first phase of fault management, where an unexpected failure should be properly identified by the network System. The existing failure detection approaches in WSNs can be classified into two types: centralized and distributed approach.
Detection of faulty sensor nodes can be achieved by two mechanisms i.e. self-detection (or passive-detection) and active-detection. In self-detection, sensor nodes are required to regularly monitor their residual energy, and identify the probable failure. In this scheme, we consider the battery depletion as a main cause of node rapid death. A node is termed as failing when its energy drops below the threshold value. When a common node is failing due to energy depletion, it sends a message to its cell manager that it is going to sleep mode due to energy below the threshold value. This requires no recovery steps. Self-detection requires less in-network communication to conserve the node energy and is considered as a local computational process of sensor nodes.

CENTRALIZED APPROACH

Centralized approach is a common solution to identify and localize the cause of failures or suspicious nodes in WSNs. Usually; a geographically or logically centralized sensor node takes responsibility for monitoring and tracing failed or misbehavior nodes in the network. The central node has unlimited resources and is able to execute a wide range of fault management maintenance. They also believe the network lifetime can be extended if complex management work and message transmission can be shifted onto the central node. The

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central node normally adopts an active detection model to retrieve states of the network performance and individual sensor nodes by periodically injecting requests into the network. It analyzes this information to identify and localize the failed or suspicious nodes. In the base station uses marked packets (containing geographical information of source and destination locations etc) to probe sensors. It relies on nodes response to identify and isolate the suspicious nodes on the routing paths when an excessive packet drops or compromised data has been detected. In addition, the central manager provides a centralized approach to prevent the potential failure by comparing the current or historical states of sensor nodes against the overall network information models. As a summary, the centralized approach is efficient and accurate to identify the network faults in certain ways.

DISTRIBUTED APPROACH

Distributed approach encourages the concept of local decision making, which evenly distributes fault management into the network. The goal of it is to allow a node to make certain levels of decision before communicating with the central node. It believes the more decision a sensor can make, the less information needs to be delivered to the central node. In the other word, the control centre should not be informed unless there is really a fault occurred in the network.

- NODE SELF DETECTION: A self detection model to monitor the malfunction of the physical components of a sensor node via both hardware and software interface has been proposed by number of researchers. Self-detection of node failure is somehow straightforward as the node just observes the binary outputs of its sensors by comparing with the pre-defined fault models.

- NEIGHBOR COORDINATION**:** Failure detection via neighbor coordination is another example of fault management distribution. Nodes coordinate with their neighbors to detect and identify the network faults before consulting with the central node. In addition, a node can also query diagnostic information from its neighbors (in one-hop communication range). This allows the decentralized diagnostic framework to scale easily to much larger and denser sensor networks if required**.**

III. DFD ALGORITHM

Algorithm for DFD Exciting Scheme [2]

p : probability of failure of a sensor;

k : number of neighbor sensors;

S : set of all the sensors;

$N(S_i)$: set of the neighbors of S_i;

x_i : measurement of S_i;

d_{ij}^{t} : measurement difference between S_i and S_j at time t,

$d_{ij}^{t} = x_i^t - x_j^t$;

$\Delta t_l = t_{l+1} - t_l$;

$\Delta d_{ij}^{\Delta t_l}$: measurement difference between S_i and S_j from time t_l to t_{l+1}, $\Delta d_{ij}^{\Delta t_l} = d_{ij}^{t_{l+1}} - d_{ij}^{t_l} = (x_i^{t_{l+1}} - x_j^{t_{l+1}}) - (x_i^{t_l} - x_j^{t_l})$;

c_{ij} : test between S_i and S_j, $c_{ij} \in \{0,1\}$, $c_{ij} = c_{ji}$;

$\theta 1$ and $\theta 2$: two predefined threshold values;

T_i : tendency value of a sensor, $T_i \in \{\mathrm{LG}, \mathrm{LF}, \mathrm{GD}, \mathrm{FT}\}$;

Sensors are considered as neighboring sensors if they are within the transmission range of each other. Each node regularly sends its measured value to all its neighbors. We are interested in the history data if more than half of the sensor's neighbors have a significantly different value from it. We can find the current measurement is different from previous measurement. If the measurements change over the time significantly, it is more likely the sensor is faulty [2]. A test result C_{ij} is generated by sensor S_{ij} based on its neighbor S_j 's measurements using two variables and two predefined threshold value. If a sensor is faulty, it can generate arbitrary measurements. If C_{ij} is 0, most likely either both S_i and S_j are good or both are faulty. Otherwise, if C_{ij} is 1, S_i and S_j are most likely in different status.

STEP-1

Each sensor S_i, set $c_{ij} = 0$ and compute d_{ij}^{t};

IF $|d_{ij}^{t}| > \theta 1$ THEN

Calculate $\Delta d_{ij}^{\Delta t_l}$;

IF $|\Delta d_{ij}^{\Delta t_l}| > \theta 2$ THEN $c_{ji} = 1$;

STEP-2

IF $\sum_{S_j \in N(S_i)} c_{ij} \le \lceil |N(S_i)|/2 \rceil$, where $|N(S_i)|$ is the number of the S_i's neighboring nodes THEN

$T_i = \mathrm{LG}$;

ELSE $T_i = \mathrm{LF}$;

Communicate T_i to neighbors;

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STEP-3

$$\text{IF} \sum_{S_j \in N(S_i) \text{ and } T_j = \text{LG}} (1 - 2c_{ij}) \geq \lceil |N(S_i)|/2 \rceil$$

THEN

$T_i = \text{GD};$

Communicate T_i to neighbors;

STEP-4

IF $T_i = \text{LG}$ or $T_i = \text{LF}$ THEN

IF $T_j = \text{GD}\ \forall S_j \in N(S_i)$ THEN

IF $c_{ij} = 0$ THEN

$T_i = \text{GD};$

ELSE $T_i = \text{FT};$

ELSE repeat

Communicate T_i to neighbors;

STEP-5

FOR each S_i, IF $T_j = T_h = \text{GD}$

$\forall S_j, S_h \in N(S_i)$, where $j \neq h$,

and IF $c_{ji} \neq c_{hi}$ THEN

IF $T_i = \text{LG}$ (or LF) THEN

$T_i = \text{GD}$ (or FT)

IV. CONCLUSIONS

In the Distributed Fault Detection (DFD), there are various algorithms to determine the faulty nodes. We assume the case of power failure as there is no recovery techniques in those areas. Therefore we have to change the direction of information when transmitted from a Sensor Node to the Receiver Node. This paper has presented a new strategy for power control in WSNs where operational longevity is an issue. As the deployment of Thousand Numbers of Sensor Nodes in Area needs Energy Performance. The new approach provides a methodology for the Retracing of Optimal Path with an Energy Efficiency and Accuracy. The goal of this paper is to identify the most important types of faults, techniques for their detection and diagnosis, and to summarize the first techniques for ensuring efficiency of fault resiliency mechanism.

Fig. 3 Comparative Chart for Existing Fault Detection Techniques in Wireless Sensor Networks

Name of technique	Working principle	Advantage	Disadvantage
Centralized Fault Detection	Centralized sensor node takes responsibility of identifying and locating the failed or misbehaved node	Accurate and Fast for identifying faulty node.	Central node becomes single point of data traffic concentration and also causes high volume of message and quick energy depletion
On-line Fault Detection	Approach applied on arbitrary type of fault model, with probability based identification of faulty nodes	Accuracy in presence of Gaussian noise even for relatively sparse networks.	Effort restricted only to faults in sensors rather than taking other communication and computation units of a node into consideration
WATCHDOG	A node can listen on its neighbor if data packets have not been transmitted properly by its neighbors it is currently routing to.	Encourages concept of local decision making. More decision a node makes the less will be required to deliver to sink node	Slow and error prone as it is always difficult to keep an eye on all its neighbors
Distributed Fault Detection	Detecting faulty node and when the sensor fault probability increase the fault detection accuracy and the false alarm rate increase.	To eliminate the delay and increase the accuracy	The path is somewhat large

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