Fault Diagnosis in Wireless Sensor Network using Self/Non-self Discrimination Principle

Prof. Pabitra Mohan Khilar

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Department of CSE, NIT Rourkela
India

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Seminar Outline

What is WSN

Distributed network of sensor nodes which are usually inexpensive, small in size, but having finite memory and low battery power.

Applications

- Military Application
- Health care monitoring
- Agricultural monitoring
- Forest fire detection

Motivation

- Fault diagnosis in WSNs is an emerging and important field in both academic as well as industry.
- WSNs are more prone to failure as they are deployed in human inaccessible and hostile environment.
- In order to maintain the network's Quality-of-service (QOS), it is very important for WSN to be able to detect the faults and diagnosed it at right time.
- Inspired by the techniques and principles of the human immune system (HIS) AIS takes the benefit for solving various types of complex computational problems.

Literature Survey

Authors	Types of Fault Detection
Laurentys et al. [7]	Fault detection
Li et al. [8]	Anomaly detection
Gao et al. [12]	Motor fault detection
Alizadeh et al. [13]	Detection & isolation in wind turbines

System Model

- All the sensor nodes are static in nature, having same initial energy and transmission range.
- The links in the network are assumed to be fault free.
- The sensor nodes are homogeneous in nature.

Self/non-self Discrimination Principle

- One of the main purpose of the immune system is to find out all the cells or molecules in the body and categorize them into self(fault free) and non self (faulty).
- Self - acceptable data
- Non self - measured data

Censoring

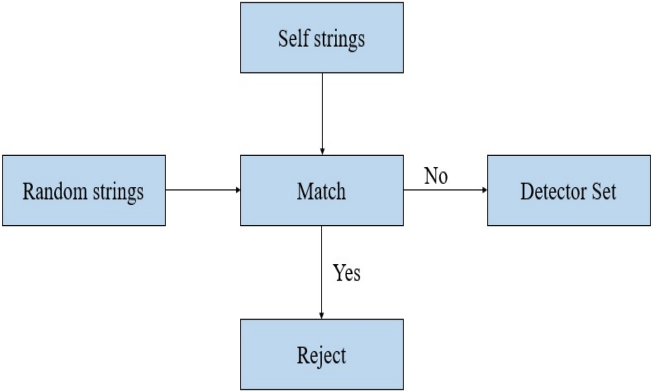

Figure 1: censoring

Detection

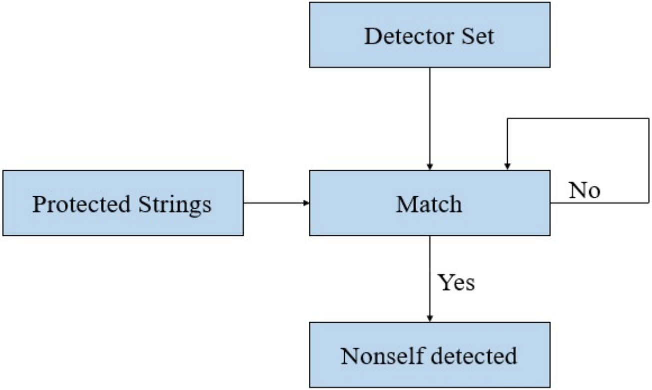

Figure 2: Detection

Proposed Work

The proposed work comprises of two phases.

- Detector generation phase
- Matching phase

Detector generation phase

- In this phase, a detector set consisting of a set of binary strings is generated randomly which is used to detect faulty nodes. It is necessary to ensure that the detector set does not match with the self set.
- New patterns can then be collected from the monitoring scheme. These patterns are converted into and compared to the detector set in the suitable binary form. A pattern can expected to be non-self if it matches the detector set and then the necessary action can be taken accordingly.

Matching Phase

- Different matching rules such as binary matching, r-contiguous matching, r-chunk matching, hamming distance matching, and Euclidean distance matching rules are available in the literature.
- If the matching rule requires a precise match, the detector set should contain all possible string that might happen which is impractical and increase the computational overhead. For a match to take place, only r adjacent bits are needed to be identical. E.g., the strings "00111010" and "01111011" match when the r = 4 where r is matching threshold.

SNSD Algorithm

Input: *Self_data*;
Output: Detection of non-self;
Initialize: *Detector_set* $= \phi$;
while ($\neg$ Stop condition()) **do**
    Detectors $\leftarrow$ Generate Random Detectors();
    for ($Detector_i \; \epsilon \; Detector\_set$) **do**
        if ($\neg$ Matches (*Detector_i*, *Self_data*)) **then**
            Detector_set $\leftarrow$ *Detector_i*;
        end if
    end for
end while
Return (Detector_set);
Match the *protected_string* with the *Detector_set*;
if (Matches (*protected_string*, *Detector_set*)) **then**
    Non-self detected;
end if

Experimental Results and Discussions

Simulation Parameters

Parameter	Value
Total nodes	500
Simulation time	200s
Transmission range	200m
Channel rate	250 kbps
MAC Protocol	IEEE 802.15.4
Propagation model	TwoRayGround
Initial Energy	10j
Packet size	512 bytes
Packet rate	1 pkt/sec
Antenna type	Omni Antenna
Grid size	500×500 m^2
Network type	Arbitrary network

Performance metrics

- Detection Accuracy (DA) : Ratio between the no. of faulty sensor nodes detected as faulty to the total number of faulty sensor nodes present in the network.
- False Alarm Rate (FAR) : Ratio between the no. of fault free sensor nodes detected as faulty to the total no. of fault free sensor nodes present in the network.
- False Positive Rate (FPR) : Ratio between the no. of faulty sensor nodes detected as fault free to the total no. of faulty sensor nodes present in the network.

DA vs. Percentage of Faulty Sensor Nodes

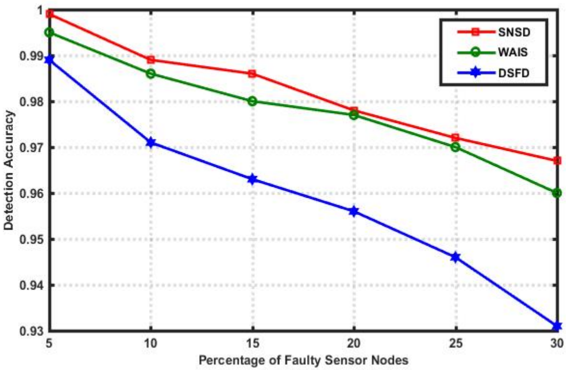

Figure 3: DA vs. Percentage of Faulty Sensor Nodes

FAR vs. Percentage of Faulty Sensor Nodes

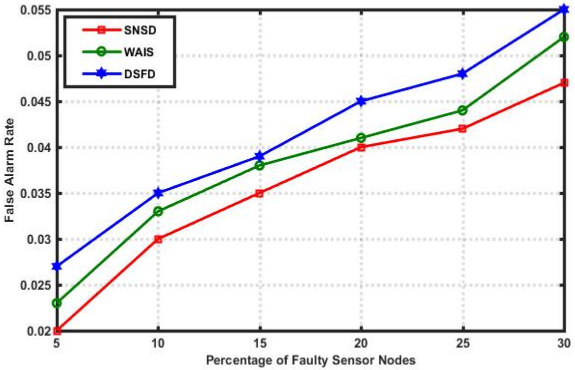

Figure 4: FAR vs. Percentage of Faulty Sensor Nodes

FPR vs. Percentage of Faulty Sensor Nodes

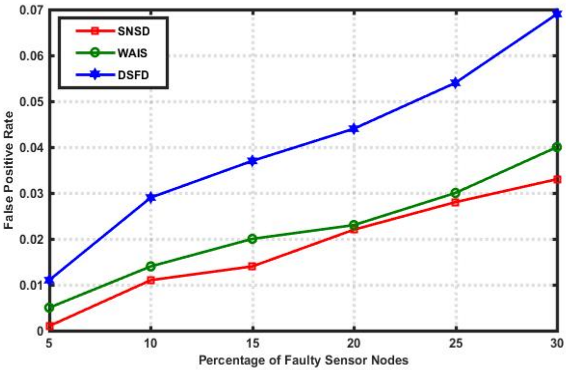

Figure 5: FPR vs. Percentage of Faulty Sensor Nodes

Conclusion & Future Scope

- A self/non-self discrimination principle of AIS has been proposed to detect faulty nodes.
- The performance of the algorithm is evaluated by using the performance metrics. where it is shown that, the SNSD algorithm gives a better result than the WAIS and DSFD in terms of detection accuracy, false alarm rate, and false positive rate.
- In future, we will use other artificial immune system techniques to diagnose different types of faults in wireless sensor network.

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Thank You