Five-Number Summary Method for Fault tolerance in Wireless Sensor Network

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Abstract- Wireless sensor network is a collection of sensor, which senses the data and perform the action, according to data. Where as wireless sensor and actor networks (WSANs) contain a group of sensors and actors connected via wireless medium. The sensor node senses the data and then transfers it to the actor. The actor performs the action according to the data. Sensor nodes in wireless sensor and actor network, have some hardware and software restrictions. Due to which, fault may occur in sensor as well as in network. However, some research emphasises on the link fault without considering the fault in sensing the data. Because of this, the node may sense incorrect data and perform the incorrect action. To solve this issue, Five Number Summary method for fault tolerance (FNSMFT) may be used.

Index Terms- Communication throughput, fault, sensor, five number summary method, fault tolerance, wireless sensor network and actor network.

I. Introduction

Wireless sensor network contains large number of sensors and a small number of resources. Sensors are low cost, and low power devices whose range, computation, and wireless communication will be limited. Nodes must be capable to give better processing capabilities, longer transmission radius, and larger battery energy. Wireless sensor and actor networks (WSANs) contain a group of sensors and actors connected via wireless medium. In this, sensors collect the information and actor performs the appropriate actions depending on the sensed data. WSAN can be divided into two parts: semi-automated and automated architectures, it depends on the functionality of actor nodes. When sensors send the sensing data to sink, sink sends the action commands to actor nodes to perform the action as shown in Fig. 1. So, due to semi-automated architecture there is no need to develop new algorithms and protocols for communication and coordination. However, actor nodes may delay in performing the action because of waiting the instructions from sink [2]. To solve this problem, the automated architecture is proposed.

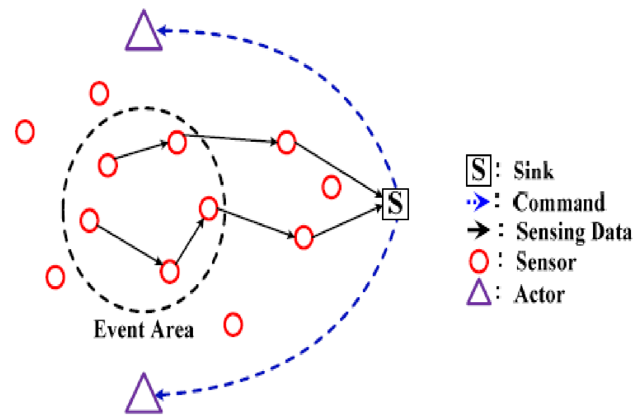

Fig.1. Semi-Automated Architecture of WSN

Sensors gather the sensing data and perform the suitable action in automated architecture .Node takes decisions to perform the action from sensing data directly as shown in Fig. 2. So sensors could save energy without forwarding the data to sink. The latency of performing actions could be minimized and prolonging the network lifetime is main concern of the automated architecture of WSAN [2]. In the this paper, the automated architecture in WSAN is taken into account.

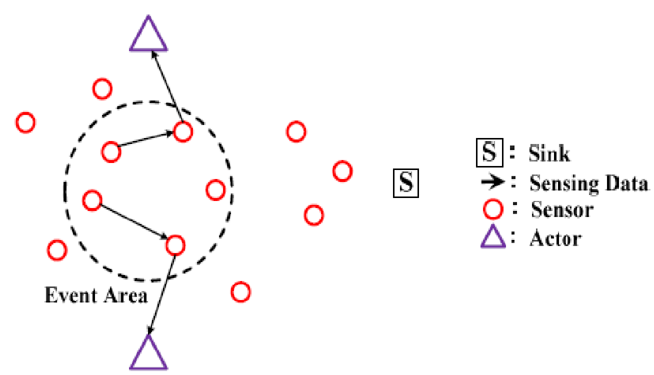

Fig.2. Automated Architecture

Fault tolerance mechanism is a main research issue in WSAN because sensor and communication link are easy to fail in the unreceptive or ruthless communication surroundings. There are many mechanisms to solve these issues in WSAN and are planned and taken into action. Some research focuses on the link fault without considering the fault in sensing the data. In this case, actor node may perform error actions because of receiving error sensing data from the sensors, due to which the sensing ability is failure but the communication ability is working. To solve this issue, Five Number Summary method for fault tolerance (FNSMFT) is analysed in this paper. In FNSMFT, it uses the attribute of different data to sift the correct data by five number summary method. Therefore, in FNSMFT, node could perform the correct actions after receiving the correct sensing data.

II. Related Work

Fault-tolerant permit a system to continue its operation, maybe at a reduced level, instead than failing entirely, when some of the parts are failed in system. Fault tolerance is the important part of the WSAN due to limited energy and communication link failure. There are many mechanisms to solve these issues in WSAN and are planned and taken into action. Some depth studies emphasis on the link fault without considering the fault in sensing the data. Because of this, sensors may send the error data to actor node and node may perform the incorrect computation. In this way, the sensing function may fail, but the communication function may work properly.

Average fault tolerant mechanism is proposed (AFTM) [6] to solve this problem. In AFTM, it defines r as a threshold value of failure, D_{avg} as an average data value and D_i, is the sensed data value of sensor i. AFTM denotes sensing data as Byzantine Fault [18], whereas the absolute difference between real data and the sensing data will be greater than r. This type of sensor is also taken as the fail sensor in AFTM.

In AFTM, firstly the actor node calculates the average data value D_{avg} using the all sensed data of sensor node. Then the comparison will be performed by actor node between the average data value D_{avg} and sensed data value D_i of sensor i. If the difference between them will be greater than r then i will be considered as a fail sensor and sensed data value D_i will be fail. At last, the appropriate actions will be performed by filtering the correct sensing data.

For Example, 10.5 ^oC, 15.1 ^oC, 15.0 ^oC, 15.3 ^oC, 14.7 ^oC are sensed by sensor nodes 1, 2, 3, 4, and 5 in an event area. Let the value of r is 2 ^oC and the real ambient temperature is 15 ^oC. In this case actor node calculates the D_{avg} as 14.12 ^oC and compares it with other sensing data. After the computation done from actor node, $|D_{avg} - D1| - r$, $|D_{avg} - D2| - r$, $|D_{avg} - D3| - r$, $|D_{avg} - D4| - r$, and $|D_{avg} - D5| - r$ are 3.62 ^oC , 0.98 ^oC, 0.88 ^oC , 1.18 ^oC, 0.58 ^oC respectively. Now we can see that, 3.62 ^oC is large than r. In this case, sensor 3 will be considered as fail sensor and its sensing data will be discarded. Now, the actor node could compute the average temperature value as 15.025 ^oC from sensor 2, 3, 4, and 5, and make the proper actions.

Conversely, if the data sensed by sensor 3 is 0 ^oC instead of 10.5 ^oC. The actor node computes the D_{avg} as 12.02 ^oC and compares it with other sensing data. After the computation by actor node, $|D_{avg} - D1| - r$, $|D_{avg} - D2| - r$, $|D_{avg} - D3| - r$, $|D_{avg} - D4| - r$, and $|D_{avg} - D5| - r$ are 12.02 ^oC, 3.08 ^oC, 2.98 ^oC, 3.38 ^oC and 2.68 ^oC respectively. Here, mostly values are greater than r. Therefore, mostly sensors will be considered as the fail sensor and their sensing data will be discarded. But we know that, only sensor 3 is fail. To solve this problem, Five Number Summary method for fault tolerance (FNSMFT) can be used.

III. Five Number Summary Method for Fault Tolerance

There is an important issue while designing a fault tolerance which is efficient, in wireless sensor network and wireless sensor and actor network, where sensors and communication link are prone to failure in hostile and harsh environment. However, some research emphasis on the link fault without considering the fault in sensing the data. To solve this problem, average fault tolerant mechanism was proposed (AFTM). However, average fault tolerant mechanism is not able to select the right sensing data.

To solve the above problem, Five Number Summary method for fault tolerance (FNSMFT) may be used. In FNSMFT, it will select the right sensing data and the sensors that perform correctly. Because of this, the actor node will perform the suitable actions.

3.1 Five Number summary Method

In five number summary method, firstly data will be sorted in a ascending order. For example, if the total number of data is n, then the n/4 will be the first part of data, n/2 will be the second part of data, and 3*n/4 will be the third part of data. Let us suppose the first part; second part and the third part will be represented by Q_1, M and Q_3. Maximum and Minimum data will be denoted by Max and Min. The relation of Q_1, M, Q_3, Max and Min are defined as the five-number summary as show in Fig. 3.

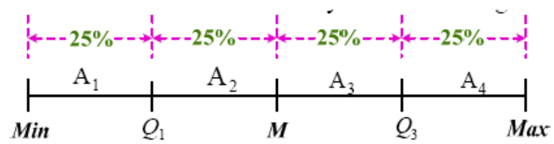

Fig.3. Q_1, M, Q_3, Max and Min in Five-Number Summary method

3.2 Process of Five Number Summary Method

Firstly, we will collect the sensing data and sort it in ascending order. Then we calculate Q_1, M, Q_3, Max and Min. If Max-Min < r, then we store the value of min and max in C_{min} and C_{max} respectively, which are temporary variables. If Max-Min !< r , then we check the difference between the parts which is less then r/2 until unless we get C_{min} and C_{max}. For getting this we sift the partition. And then correction will be made by actor node for sensing and computing the correct data and sensor node respectively.

IV. Conclusion

Fault tolerance mechanism is a main research issue in WSAN because sensor and communication link are easy to fail in the unreceptive or ruthless communication surroundings. There are many mechanisms to solve these issues in WSAN and are planned and taken into action. Some research focuses on the link fault without considering the fault in sensing the data. In this case, actor node may perform error actions because of receiving error sensing data from the sensors, due to which the sensing ability is failure but the communication ability is working.

To solve this problem, Five Number Summary method for fault tolerance (FNSMFT) can be used. We divide the sensing

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data into four parts in FNSMFT. Then, we modify the region for selecting the right data from the discrete data. Therefore, the actor nodes can carry out the suitable actions in FNSMFT. FNSMFT has the better detection rate of correct data.

In the future, we propose an intrusion tolerance method combined with FNSMFT to give the proper security. INtrusion-tolerant routing protocol for wireless SEnsor NetworkS (INSENS) construct the tree structured routing, securely and efficiently for wireless sensor and actor networks (WSANs). INSENS is able to tolerate the damage caused by an intruder.

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