International Journal of Advances in Applied Sciences (IJAAS)
Vol. 7, No. 2, June 2018, pp. 135~142
ISSN: 2252-8814, DOI: 10.11591/ijaas.v7.i2.pp135-142

Building Fault Tolerance Within Wsn-A Topology Model

M. Sai Rama Krishna, Ch. Jnana Gayathri, K. Laxmi Pallavi Rao
Department of Electronics and Computer Engineering, K.L University, Vijayawada, India.

Article Info

Article history:

Received Dec 14, 2018
Revised Apr 21, 2018
Accepted May 17, 2018

Keyword:

Fault Tolerance
Topology
Wireless Sensor Network

ABSTRACT

Wireless Sensor network plays a crucial role which helps in visualizing, processing, and analyzing the information wirelessly. WSN is a network which consists of huge amount of sensor devices which are of low cost and low powered also known as sensor nodes. These type of networks are generally used in real time applications such as monitoring of environmental conditions, militaries, industries etc., .but the problem that exists in WSN is may be due to different failures such as node failure, link failure, sink failure, interference, power dissipation and collision. If these faults are unable to handle then the desired network criteria's may not be reached properly which results in inefficiency of the network. So, the main idea behind the investigation is to form a different networking topology which works in the event of failure

Corresponding Author:

M. Sai Rama Krishna,
Department of Electronics and Computer Engineering,
K.L University, Vijayawada, India.
Email: drmramakrishnaa@gmail.com

1. INTRODUCTION

Wireless Sensor Networks (WSNs) play a noteworthy part in present day innovation which acts as a bridge between the physical and virtual worlds. These sensors are small with restricted processing and computing resources which are inexpensive and helps in sensing, processing, and aggregating the information from the environment, based on the requirement they can transmit the sensed data. A Wireless Sensor Network is a self-designing network of little sensor nodes which helps in conveying among them utilizing radio signals, deployed in quantity to detect, monitor and understand the physical world. In general a network consists of huge components which are to be inter-conceded for remote sensing and transmitting information of data to the server which is located far away and receiving data from the server an depending on that the local environmental conditions will be controlled. WSN's even work in crucial environments which are subjected to different failures by several layers in a framework. Suppose if a node which should transmit data is in a failure condition then all the other nodes will be waiting for the data to get received. WSN must be free from faults. The network must be recovered from the fault as soon as possible when the fault occurs. A WSN can be made to be operating under normal conditions even when a fault occurs by implementing fault recovery techniques. Faults can happen within WSN involving many components of the network. Different fault tolerance techniques when introduced into the system make the WSN more reliable. Replication has been one of the major concepts that have been implemented over the time for making the WSN fault tolerant. The Quality of WSN may suffer due to the introduction of redundancy within the wireless networks. A typical wireless sensor network is shown in Figure 1.

WSN Node: A WSN node, otherwise called a bit. It is a node in a sensor system that is supplied for performing some handling, gathering actual data and speaking with other associated nodes in the system.

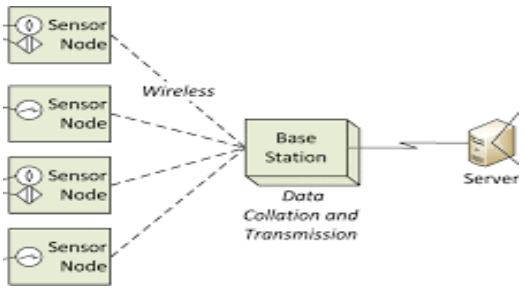

Figure 1. Typical WSN

Base station: The base station should perform computations; higher memory is required and is frequently associated with better continuity source than batteries. One can look at the base station as an area point to the WSN where the base station's fundamental target is to collect distinguished data strength nodes in WSN. The main role of base station is to transfer the received data from nodes to the server.

Application server: Development and implementation of different applications which are related to real time applications needs the use of Wireless Sensor Networks (WSN). The unique feature of these applications is to use WSN to collect and process the information continuously

1.1. Characteristics of Wireless Senor Networks

WSN are characterized by many intricate issues which all have a bearing on its fault tolerance. Each of the characteristics must be taken into account and analyzed to understand the effect of the same on its behavior when any of the fault occurs. Some of the features that affect the fault tolerance behavior are as shown below:

a. Ability to adapt to hub disappointment
b. Some portability of hubs
c. Heterogeneity of hubs
d. Adaptability to huge size of sending
e. Ability to withstand severe environmental conditions
f. Ease of utilization
g. Cross-layer plan

1.2. The need for building fault tolerance within WSN Networks

WSN are being used for many critical and mission critical systems, failure of which may sometimes leads to disastrous situations and WSN lead to great losses in many forms. WSNs are being used for many purposes which aircraft management, Vegetation, whether forecasting, Traffic management and control etc. WSN are being used extensively for real life and real time data acquisition. The WSN networks are delicate as the networks are established using tiny and fragile devices and generally quite prone for failures. Therefore it is necessary that WSN are built considering the failures of the devices used for networking. It is necessary to build as much fault tolerance as possible into WSN so that the networks can be made to work as much reliably as possible.

1.3. Problem definition

There are various techniques exhibited in the realated work for increasing the fault tolerance of the WSN network and none of the strategies presented have presented verifiability of the fault tolerance levels of the WSN network. The problem is to discover the procedures, techniques and mechanisms utilizing which the WSN can be made to be fault tolerant and verifiable. In this paper two techniques have been proposed using which fault tolerance levels can be computed. The fault tolerance processed by both the methods provides for verifiability of the Reliability of the WSN networks.

2. RELATED WORK

WSN are small devices, low cost, limited memory, low power, and low power consumption devices. The main aim of the sensor networks is to provide reliability, maintainability, availability [1]. In general there will be faults which may occur due to various factors such as node fault, sink fault, network faults. Sushruta Mishra et, al., have expressed that WSN can be subjected to many faults and also provided an overview on various fault detection and recovery systems which helps in continuing the operation normally

in the event of some system component failures. The two methods used for fault recovery are Active replication in which all or many nodes perform same functionality. If any node fails then also receiver will get results from other nodes and the Passive replication involves Primary replica receiving all requests and process them accordingly. Samira [2] described about routing solutions for fault tolerant which includes re-transmission, in which the source node sends their data over an developed path, and if this path fails to forward the data then the source again retransmits those data through different path. The second technique is the data replication which sends different copies of the same data over multiple paths. Small scale sensor networks which comprises of huge amount of sensors deployed over a small area which is based on Energy and flow management in small scale WSN, Data management in small scale sensor networks and Coverage along with connectivity in small scale networks while considering the Large Scale wireless sensor networks (LS WSNs) which comprises of thousands of sensors are also based on various objectives of Energy and flow management. C AHilaet [3] have presented automatic path recovery and efficient routing algorithms to make the WSN fault tolerant. Fault tolerant multipath routing scheme for energy efficient wireless sensor network (FTMRS) is based on multipath data routing scheme in which one of the shortest path is used for main data routing and in the other two backup paths are used as alternative path for faulty network and to handle the overloaded traffic on main channel. Manasvi [4] explained that wireless devices are battery powered for maintaining protocols in an efficient manner. Flooding is a technique which continues until the destination node is reached which results in impulsion or overlap. When same region is sensed by two sensors and the sensed data is broadcasted at the same time, the neighbors will receive the duplicated packets which are overcome by gossiping. In gossiping when a packet is received, a sensor would select one of its neighbors randomly and send the packets to neighbor. This process continues until all sensors receive this packet but there is a delay problem if the no of nodes get increased. Ting Yuan [5] presented the securing of the data through introducing fault tolerance within WSN. The position of aggregating and forwarding the information is known as sink. A node can't be each a sink and a source due to the fact this will substantially dissipate the constrained power and security strength is a key management scheme, tamper-resistant hardware is still economically mistaken to be applied in low-fee sensor nodes, making node capture even more appealing to put into effect.

3. EXISTING WIRELESS SENSOR NETWORKS

A Wireless Sensor network is mainly used for continuous monitoring and processing the information, in general there are so many existing WSN in which one of the applications is detailed in Figure 2 which sprinkling of water and pesticide for turmeric plantation depending on the range of humidity existence. After sensor sensing the existing humidity value then it initializes the sprinkling of water if it is below the predefined. The entire data including date, time, humidity range, latitude and longitude, water pumped are sent using base stations via internet to the main server. The data will be analyzed and if any specific instructions required will be sent to the formers through SMS messages and the entire data received will be stored at the main server. Connectivity of the main server and the base station is achieved through a cable connection or using a combination of Wi-Fi/Cellular interface.

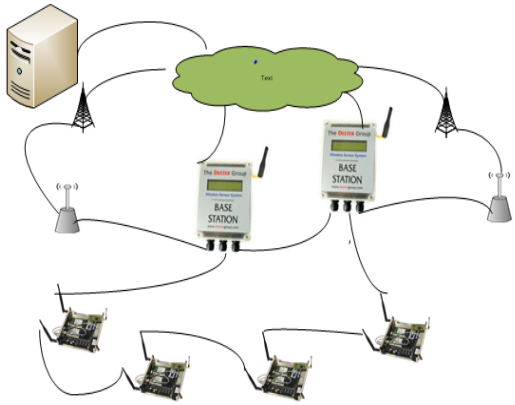

Figure 2. Existing WSN

3.1. Tree Topology

The investigation presented in this paper shows how the reliability of a WSN can be enhanced based on networking topology. To start with Fault tree for the existing WSN is developed and overall fault rate is computed. The fault tree diagram for the existing WSN is shown in Figure 3.

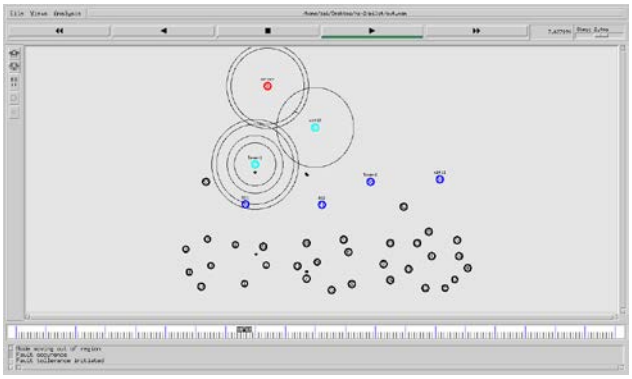

Figure 3. Tree topology in NS2

By developing these type of tree topology will result in high packet loss, low throughput, high delay etc., so in order to avoid these type of faults while transferring data we are opting another topology known as butterfly topology which is having multiple number of inputs and outputs which will help in transferring information in any path.

4. IMPLEMENTING BUTTER-FLY TOPOLOGY WITHIN WIRELESS NETWORKS

It is possible that the failure rate of the network can be reduced by implementing different topologies than the tree topology used for the sample WSN. Multi-stage networks are commonly used to connect a set of inputs to a set of outputs; the concept as such is similar to cloud computing. The connectivity is established through links between computing and switching systems. These networks use 2 X 2 switches. Each switch takes two inputs and produces 2 outputs via different connections (Straight, cross, upper broadcast and the lower broadcast. A butter fly network is a multi-stage networks. Number of stages used depends on the kind of connectivity required.

A butterfly topology which uses 4 stage networks has been considered and the same is fitted into a WSN network. A switch box in stage "I" is connected with the links that are at a distance of 2^i apart. The 4 X 4 butterfly network is achieved through two 2 X 2 networks.

The probability that one of the paths exists for connecting to a WSN node can be computed as

$$A_c = 2^{k\,\rho l}\,\Phi(k) \quad (1)$$

where k = Number of stages, ρ = probability that a node fails and Φ(k) is the probability that that a switch box in the stage K can fail. Φ(k) can be computed using the equation (2).

$$\Phi(k) = 1 - (\,1 - \rho_l\,\Phi(k-1)^2 \quad (2)$$

The butterfly network connected for fitting the sample WSN has been shown in Figure 4. The butter fly network has been established using 4 X 4 network containing 4 stages. The 4 X 4 network has become necessary due to the availability of 8 elementary levels of inputs and 4 different types of outputs required to make the network reliable and available.

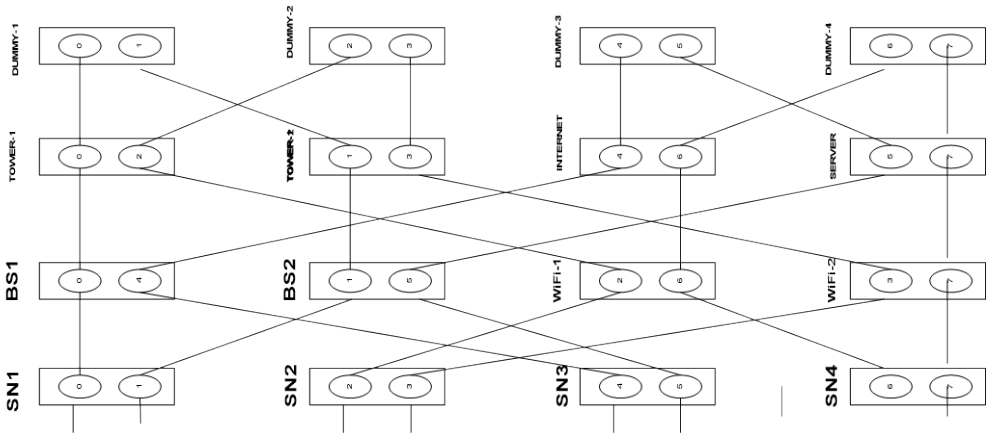

Figure 4. Sample butterfly network

Using the equation (1) and equation (2) the probability of success that at least one path exists from input point to an output has been computed as 0.81.

From the Figure 5 it can be seen that 6 extra switches have been included into WSN network to make more fault free.

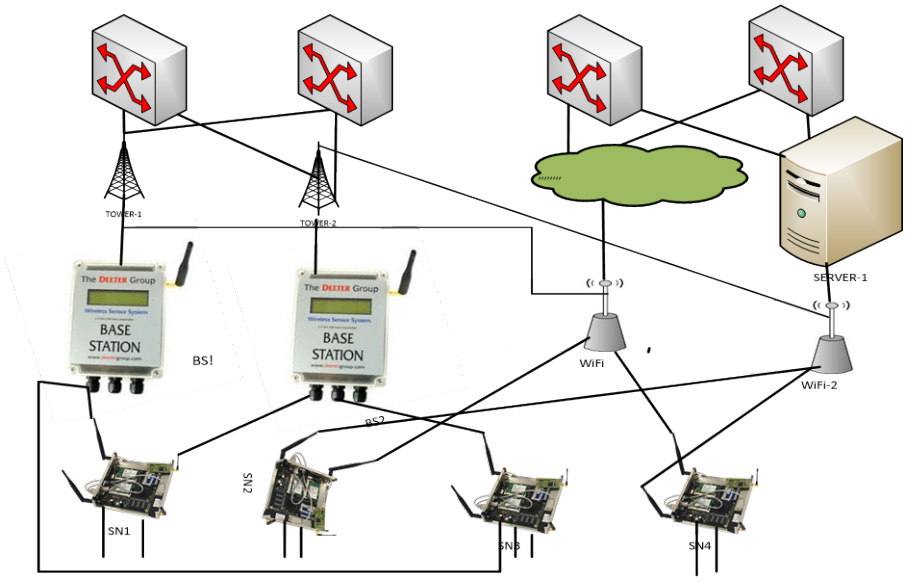

Figure 5. Modified WSN network-Butterfly topology-Hierarchical model

We developed a butterfly network in NS2 where we are obtaining High throughput, delay in transferring packet is less and packet delivery ratio is high which is shown in Figure 6.

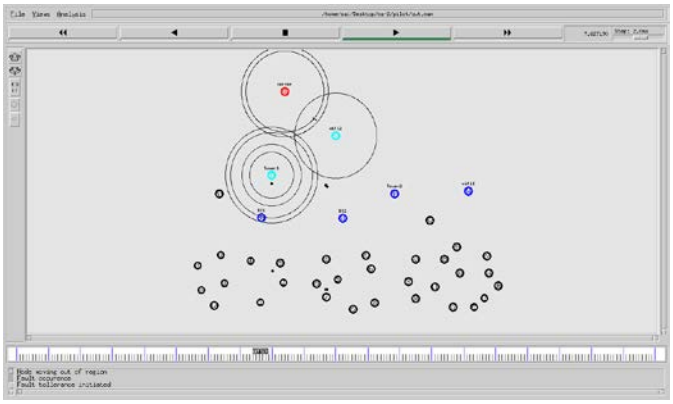

Figure 6. Butterfly network in NS2

5. SOFTWARE PLATFORM

5.1. Network simulator2 (NS2)

The scenario of assay of the system in the digital era is primly based on the simulation, the simulation which exemplifies the system design model illustrates the system functioning and its accompanying output. Simulation exhibits the comprehensive way of designing the system and the way its operating desired to its objective which facilitates the user with the concept of learn by doing. The accomplishment of the simulation is analogous to a child behaviour. The approach to the simulation is the way of intercommunications between many entities and which depicts in the desired outcome.

5.2. Importance of NS2

There are prevalent Varian's in the era of network simulators and in which some of the sequel are ns-1, ns-2, ns-3. The network simulator has their own significance in all aspects of domains, but in the era of teaching and research it is predominant and all of the versions are employed as prime simulators for the computer technology. In the networking domain the Network simulators is a diverse simulator exhibiting a significant outcome.

5.3. NS2 Installations and Setup

a. Install Ubuntu 12.04
b. Download NS-2.35 (http://sourceforge.net/projects/nsnam/files/allinone/ns-allinone-2.35/ns-allinone-2.35.tar.gz/download)
c. Unzip or untar it to any folder (recommended is /home/loginname) using the following commands one by one
   sudo apt-get update
d. Using cd command go into appropriate folder, where the .gz file exists, and then execute below commands
   tar zxvf ns-allinone-2.35.tar.gz
   sudo apt-get install build-essential autoconf automake libxmu-dev
   cd ns-allinone-2.35
   ./install
e. Once installed the PATH information will be provided to you. So dont close the terminal after installation complete, because you dont get path again.)

You will see some configuration in some last lines of completed installation as shown below.

Please put /home/Vertexsoft/Desktop/NS-Installation/ns-allinone- 2.35/bin:/home/Vertexsoft/Desktop/NS-Installation/ns-allinone-2.35/tcl8.5.10/unix:/home/Vertexsoft/Desktop/NS-Installation/ns-allinone-2.35/tk8.5.10/unix

5.4 Developing a Networking topology in NS2

Using the existing application specific WSN and separately considering the modified hierarchy method named butterfly approach, the following results are obtained which adopt the features of both technologies individually to produce efficient results as shown below. The nodes in this simulation results are same as above mentioned approaches and the remaining are considered as sensor nodes for effective functioning.

The data from nodes to server is reached by adopting the shortest, so that effective time in performing the computation is maintained. But in simulation, there will not be any sign of failure of virtual nodes. But in practical approach, there may be chance of occurrence of any failure .to verify the functioning of proposed method a fault condition is introduced at time 4minutes near tower.at this situation, the data packets move by selecting another approach leaving the failure tower node.

6. SIMULATION RESULTS

The butterfly method is the best approach witch delivers appreciate results when compared to pilot network in case of any model. The following Figure 7 specifies the end to end delay in Ns2 simulation region indicating time on x-axis and delay on y-axis.

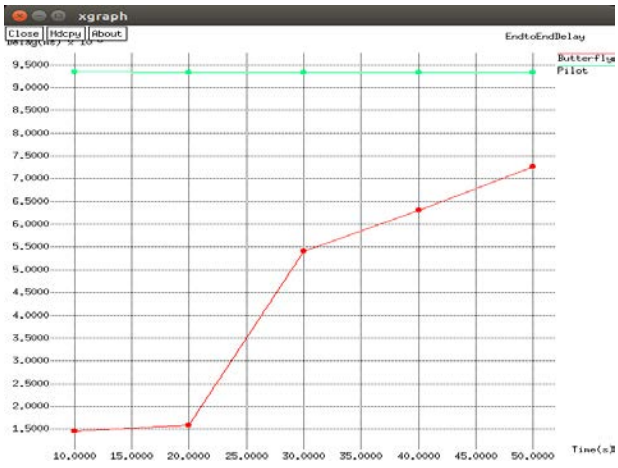

Figure 7. End to end delay

The throughput is essential parameter which specifies the performance of any model. If the throughput of any approach is high, then it is more efficient approach. The average throughput obtained by using butterfly approach is very high unlike pilot approach is given in Figure 8

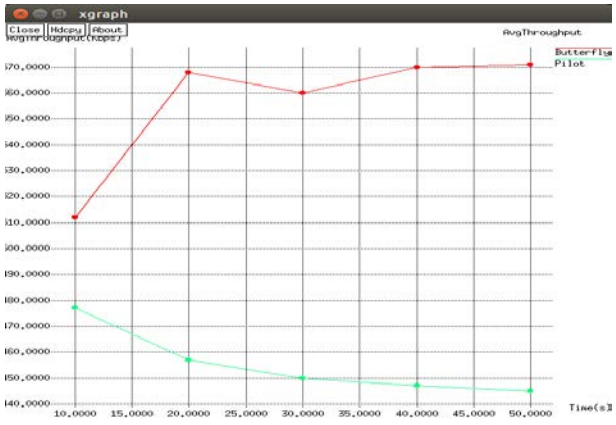

Figure 8. Average throughput

The packet delivery rate indicates the functioning of a method. If the delivery rate is very high, it indicates the poor packet loss. The following Figure 9. indicates the packet delivery rate adopted by butterfly technique is very high when compared to previous pilot approaches.

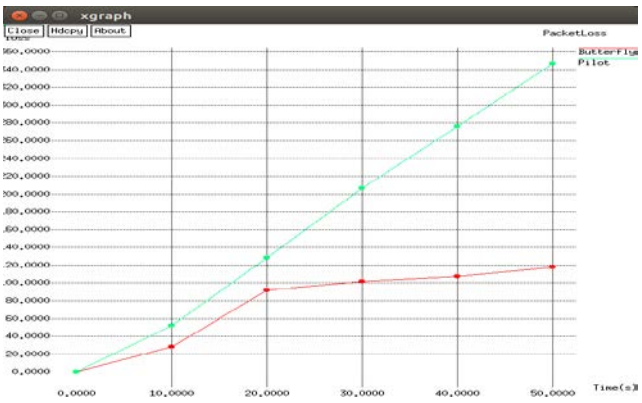

Figure 9. Packet loss

The maximum numbers of packets are delivered in butterfly topology and minimum packets are delivered in pilot sensor networks. The following displays the packet delivery ration in Figure 10.

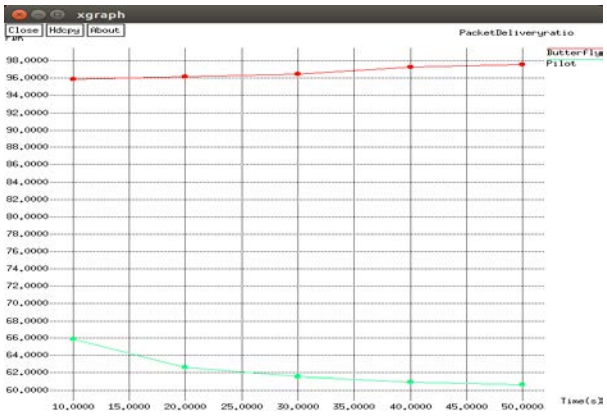

Figure 10. Packet delivery Ratio

7. CONCLUSION

Fault tolerance within a WSN can be enhanced by way of adding redundancy at network level requiring networking gadgets such as switches, bridges and gateways. The devices within the network when connected using the butterfly like topology will enhance the reliability of WSN networks. Fault tolerance as such can be included by way of creating as many paths as possible from a WSN node. In the case of butterfly topology 3 paths are created from each of the node as 2X2 switches are used to switch the output from one device to other.

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