Reliability, Neighborhood Discovery and Active Node Selection in Wireless Sensor Networks

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ABSTRACT: *In the present computer world Wireless Sensor Networks are playing a major role in sensing environment, health care and embedded systems category. In WSNs sensors are the nodes which are deployed randomly and in a wide spread manner. Data can be transmitted to the controller by the sensors at periodic intervals. As the network is dynamic the number and behavior of nodes vary randomly and identifies the nodes which are active are selected and the nodes which are idle are neglected. In WSN, the topology of the network is dynamic, it is necessary to identify the neighbors in the proximity and coordinate data acquisition at the controller. In any network reliability is an important issue which deals with stability under mobility, low delay, more life time, optimal route and other optimizations.*

Keywords: WSN, Mobility, Reliability, Neighborhood Discovery, Optimization, Active Nodes

Received: 30 May 2017, Revised 5 July 2017, Accepted 17 July 2017

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1. Introduction

Wireless Sensor Networks encompasses a wide variety of sensors which cooperatively and cumulatively lead to control and monitoring of various applications like surveillance, tracking and detection, transportation, military and other applications. The sensors range from acceleration sensors, temperature sensors, pressure sensors, gas sensors, bio-medical sensors, water level detection sensors, web cameras, microphones, mobile phones and other sensors. These sensors are deployed in the field of acquisition zone which depends on the application context. The sensors properties include sensing, formatting, compressing, sending data and life time. This is done periodically by the sensors. The life time depends on the energy stored in the sensors. If the battery gets discharged it has to be recharged. Then the life time of the sensors comes up. It will interactively participate in communication after getting recharged.

Active Node Selection is one of the important issue in such domains. The sensors transmit data periodically. Many nodes transmit data at a time. These data are sent one by one. This is achieved by Time Division Multiple Access. The nodes interactively take turns to transmit data. This data is not always transmitted by all nodes. The nodes have predefined life time of processing. This is determined by the battery life time.So the nodes that do not actively participate in transmission becomes idle because of want of charge. It recharges then and continues. Neighborhood discovery is an important aspect in the WSN. For a particular node, it is intended to determine who the neighbor node is. This is because with the neighbor node only it has to negotiate to transmit data. The third issue is the reliability of WSN. The reliability is the probability that there occurs no node failure. The delay is reduced. The life time becomes high. All these things lead to high reliability. In this context these issues are discussed. The various protocols and algorithms are discussed.

2. Related Work

In [1], Joanna et al in 2002 has done a work on Negotiation based Protocols for Disseminating Information in Wireless Sensor Networks. Their method is not novel and has some drawbacks. Hence new methods are adapted. In [2], Eylem et al in 2006 has done an experiment on Mobility Based Communication in Wireless Sensor Networks. This is an existing technique. In [3], Yulong et al in 2016 has worked on Intercept Behavior Analysis of industrial Wireless Sensor Networks in the presence of eavesdropping attack which is again an existing technique. In [4], Wei et al in 2016 has worked on Optimized Node Selection for Compressive Sleeping Wireless Sensor Networks and their method is very old and hence we adapt to the new protocol discussed in this context.

In [5], Pouya et al in 2016 has worked on Scalable Video Streaming with Helper Nodes using Random Linear Network Coding. The linear coding technique is not to our context but referred to. In [6], Heng et al in 2016 has worked on Optimal Dos Attack Scheduling in Wireless Networked Control System and it deals with the security issue which may be adapted in future work and their control strategy is different and old. In [7], Dong et al in 2016 has done a research on Design and Evaluation of an Open Source Wireless Mesh Networking Module for Environmental Monitoring which is considered for reference but adapted in a novel way which is our original work. In [8], Haung et al proposed a new method of design and analysis of wireless mesh network for environment monitoring application. In [9], Dongyao et al., in 2016 has conducted research on Dynamic Cluster Head Selection Method for Wireless Sensor Network which has the context in current work but dealt differently.

In [10], Pushpendu in 2016 has done a work on Reliable and Efficient Data Acquisition in Wireless Sensor Networks in the Presence of Trans faulty Nodes which deals with reliability issues. But we incorporated our own protocol for reliability detection model. In [11], Ju et al in 2016 has done a work on Adaptive and Channel Aware Detection of Selective Forwarding Attacks in Wireless Sensor Networks which deals with security of WSN, This is referred but our own protocol is considered for discussion. In [12], Yuxin et al in 2016 has done a work on Active Trust: Secure and Trustable Routing in Wireless Sensor Networks where the routing protocol is discussed and the novel and new technique is adapted in our design in the current context. In [13], Zhen et al in 2016 has conducted a work on A Clustering-Tree Topology Control Based on the Energy Forecast for Heterogeneous Wireless Sensor Networks deals with clusters. The current work encompasses a random and dynamic distribution of sensors.

In [14], Mianxiong et al in 2016 has worked on Joint Optimization of Lifetime and Transport Delay under Reliability Constraint Wireless Sensor Networks. The current discussion deals in a different way the reliability problem which is a new one. In [15], Tong et al in 2016 has done a work on Code-Based Neighbor Discovery Protocols in Mobile Wireless Networks. The neighborhood discovery of proposed method attacks the problem with user generated packet structures and packet life time. Thus the existing techniques are thoroughly studied and their drawbacks are discussed. The proposed method eliminates these drawbacks and solves the problem of Active Node Selection, Neighborhood Discovery and Reliability Detection of WSN in a quite different and perfect manner.

3. Protocols for WSN

WSN is the important communication network in the computer science and engineering field. The WSNs network encompasses wide variety of sensors which may be deployed in random nature. The nodes gets self-organized and participates in communication. Sometimes the nodes move in the environment and negotiate in communication. In this work it is intended to discuss about these protocols anew.

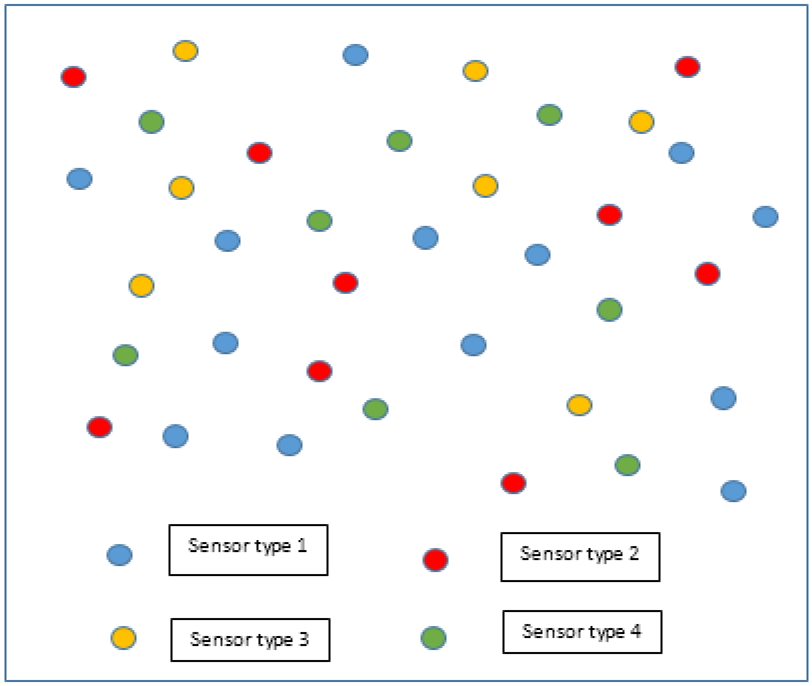

Figure 1. A typical WSN for a specific Application

3.1 Optimal Node Selection Protocol

Figure 1 shows the typical WSN.The sensor nodes get self-organized in the network and actively transmit wireless data to the controller. The number and nature of data received varies. The data is transmitted in the form of packets. These data packets are transmitted as such using the network transmission protocol to the controller. These nodes transmit data periodically. This period is designed by the protocol. Figure 2 below depicts the transmission of data in WSN and processing of data in WSN.

A typical WSN is deployed in the field area and it is sensed using the wireless transmission network like Zigbee. The Zigbee is connected at the receiving side and it transmits the data to the controller. The controller processes the data and takes decision. The decision is then incorporated in the output side. This is the basis of WSN. The active node selection protocol is explained in the algorithm stated below.

Figure 2. WSN transmission and processing

3.1.1 WSN_ActiveNode_Selection_Protocol

1. Select the application for the current context.

2. Determine the various wireless sensors for the deployment.

3. Choose the strategy for deployment like random spreading, spraying, dropping and so on.

4. Activate the various wireless sensors and assign node id to the sensors and allow to transmit data in a multiplexed way.

5. Receive the transmitted data at the controller end.

6. Store the big data in the specified database.

7. Determine the wireless node from which the data is received.

8. Is done by the node identifier pre-specified by the protocol.

9. Check if there are idle nodes by processing the node identifiers from which the data is received.

10. If any node is found idle allow the nodes to recharge using batteries.

11. Check if the nodes are alive again periodically and energize if found idle.

12. Repeat Steps 1 to 11 for active node selection protocol.

3.1.2 WSN Active Node Selection Model

A typical WSN encompasses a variety of sensors. The sensors are identified for the type and the facilities it offers. The sensors of the corresponding type are grouped and they are recorded. These sensors are deployed in a random manner. All the sensors are initially filled with full energy. They transmit the data sensed in the environment as they perceive. This is received at the controller center. Later the nodes become idle for want of energy. We identify such nodes using the WSN_ActiveNode_Selection _Protocol and this protocol helps in managing and controlling the WSN from the required perspective.

3.1.3 WSN Active Node Selection Mathematical Model

Let the number of category of sensors is m. The number of sensors in each category is l. The initial total energy empowered for each sensor is Einit. Energy consumed during transmission is

$$Econs = Einit - Etrans \qquad (1)$$

The initial Total Energy in the network is l * Einit. The Energy during transmission l * Econs. Energy loss due to transmission is

$$Eloss = Einit - Econs \qquad (2)$$

The condition for Node deactivation is Eloss < Ethresh where Ethresh is the threshold value of energy for the specified sensor. The condition of Active node selection is Eloss > Ethresh. If the node is deactivated then allow the node to recharge. The recharge time is

$$Time\ taken\ (Erecharge) >= Time\ taken\ (Einit) \qquad (3)$$

3.2 WSN Neighborhood Discovery

After all nodes become active the protocol explores the neighbor of the particular sensor in the network. In WSN the nodes have the capability to move in the current context.This depends on the nature and property of the WSN chosen. The application specific sensors are critical to the application chosen. These sensors interact amongst themselves for something or the other. Some sensors have common communication and data digitization circuits. In this context the neighborhood discovery is very important. The protocol for neighborhood discovery is dealt with here. Figure 3 shows the model for neighborhood discovery in the WSN.

3.2.1 WSN_Neighborhood_Discovery_Protocol

1. Formulate the WSN.

2. Select the sensors which are dependent and have commonalities.

3. Choose the strategy for deployment like random spreading, spraying, dropping and so on.

4. Assign the identifiers and identify the initial configuration in the WSN.

5. Allow to transmit in cooperation with each other.

6. Receive the transmitted data, store and process the data at the center.

7. Check for any WSN node mobility.

8. If there is node mobility the new network with different topology and architecture is formulated.

9. Any node arbitrarily transmits the are_u_my_neighbor packet to the nodes.

10. The nodes which receive this packet will respond with I_am_your_neighbor packet to the nodes from which it received the are_u_my_neighbor packet.

11. The nodes waits for all such packets and after receiving all the replies it comes to know about the entire network.

12. Every node in the WSN executes this protocol and every node knows about every other node.

13. This emphasizes the neighborhood connectivity of every node and thus the protocol.

14. If there is node mobility then the steps 7-13 is executed.

3.2.2 Neighborhood Discovery Mathematical Model

Node identifier	Packet Reception	Start Time	Finish Time	Life Time	No_of_hops	Error bit	Data

Figure 3. Neighborhood discovery format in the packet

The number of category of sensors is m. The number of sensors in each category is l. Next_hop bit pattern will receive the id of next hop. Optimal route is if Next_hop <= Hopmin.

3.3 WSN Reliability Detection Model

In any network reliability is an important issue. Reliability is the probability that there should not be any node failure. If there occurs any node failure then the node is repaired and added to the network. The packet carries the start time and at the other end the finish time is marked. The total time for transmission is calculated by the protocol. The optimal mean time for transmission is encountered using this field. Every packet carries the packet life time. If the life time expires the packet is discarded. Optimal route is identified by the number of hops field. There should be minimum number of hops for transmission. The packet error field determines if the packet or data is lost or erroneous. Then the data is ignored and next packet is encountered. Thus the various parameters for reliability is encountered. Figure 4 below shows the packet reliability model in WSN.

Node identifier	Packet Reception	Start Time	Finish Time	Life Time	No_of_hops	Next hop	Error bit	Data

Figure 4. Packet Reliability Model

3.3.1 WSN_Reliability_Detection_Protocol

1. Formulate a WSN.

2. Initiate all sensors and allow the data transfer to the controller.

3. Set various fields in the reception side like packet reception bit, total time taken for transmission, Packet life time and number of hops that the packet has traversed, error packet or not in the Controller for each packet that is received.

4. The data are filled in the respective fields and control decision is taken on various Parameters.

5. If any packet is not received then the stability field is marked incorrect. If the transmission delay is more, then the congestion in the path is checked. If the number of hops is more than the route optimization decisions taken. If the received packet is error then next data is considered. The current packet is ignored.

6. This reliability checking is done for every packet and stability in the network is emphasized.

3.3.2 Reliability Detection Mathematical Model

The number of category of sensors is m. The number of sensors in each category is l. The Node id of each node is Node id. The start time of the transmission is Tstart. The finish time of the transmission is Tfinish. The total time for transmission is

$$Ttime\_consumed = Tfinish - Tstart \quad (4)$$

Life time of the packet is Tlife. Packet discard condition is Tlife > Texpiry. Number of hops is No_of_hops. Optimal path strategy is No_of_hops <= Nmin. Error bit is set then the packet is Perror.

4. Results and Analysis

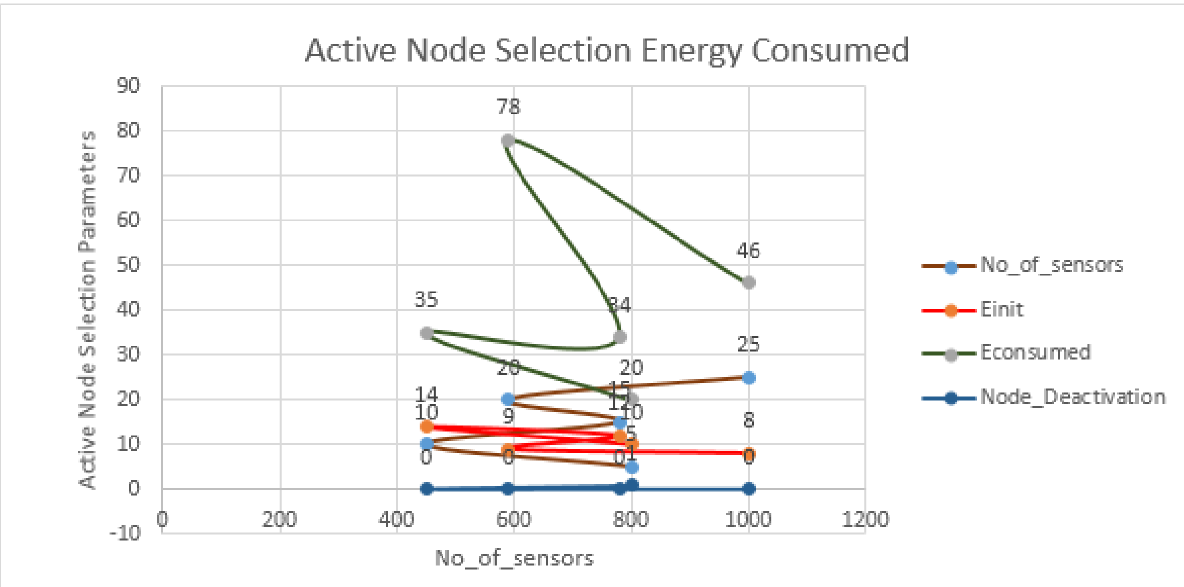

Figure 5. Active Node Selection Plot for Energy Consumed

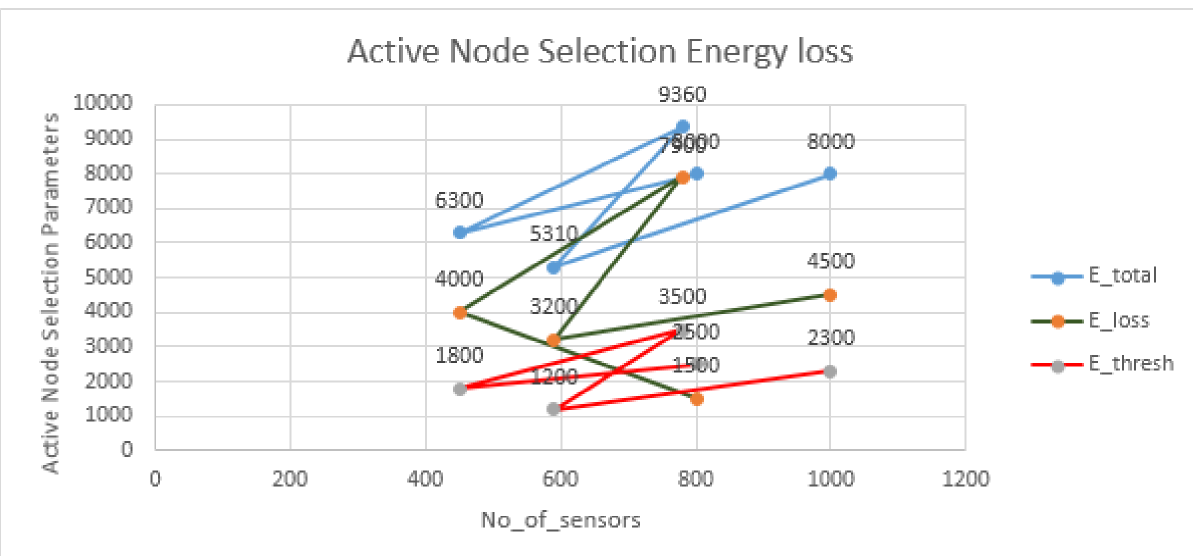

Figure 6. Active Node Selection Plot for Energy loss

The WSN is constructed using standard strategy using NetSIM package. The nodes are deployed and activated. The reception side is perfectly organized. The nodes start transmitting data packets. These packets are received, processed and control decisions are taken. The various parameters are recorded and analyzed. The resultant statistics are gathered plotted in the form of graph and analyzed. Figure 5 deals with the plot of Active node selection for Initial Energy, Consumed energy and Node Deactivation against number of sensors. It is observed that if the consumed energy is minimal then the node deactivation is not present in WSN. Figure 6 depicts the plot of total energy, energy loss and energy threshold against the number of sensors in the network. Energy loss is minimal for a high class WSN. Figure 7 displays the plot of neighborhood discovery protocol. It shows the graph of number of hops, minimum number of hops against the number of sensors. It determines the optimal route if the number of hops is less than the threshold value. Figure 8 depicts the plot of WSN Reliability analysis protocol parameters of some category. It mainly displays the total time consumed for the sensors deployed. Figure 9 shows the WSN Reliability

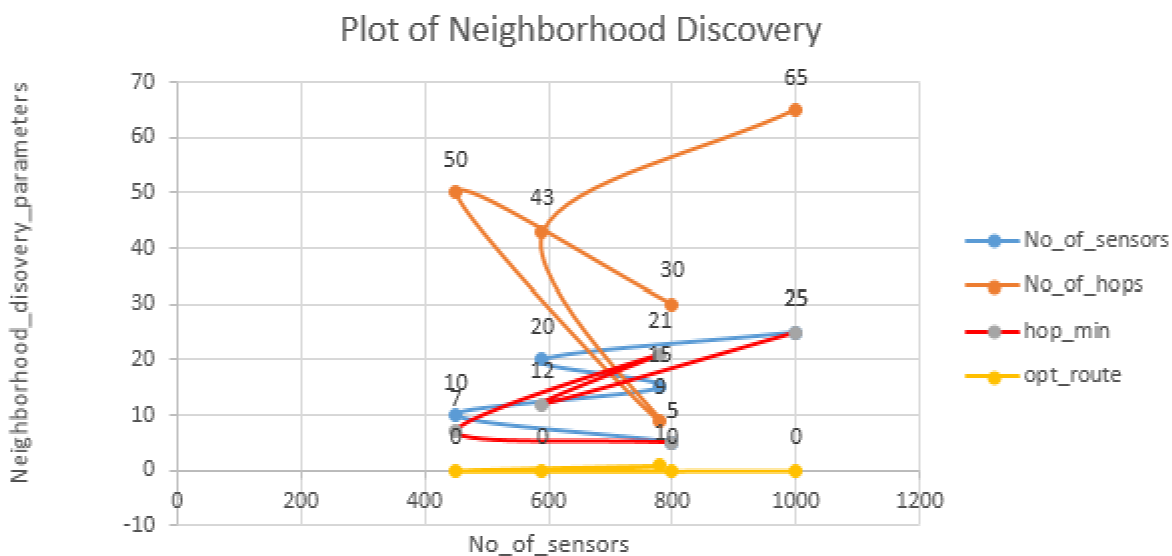

Figure 7. Neighborhood Discovery Plot

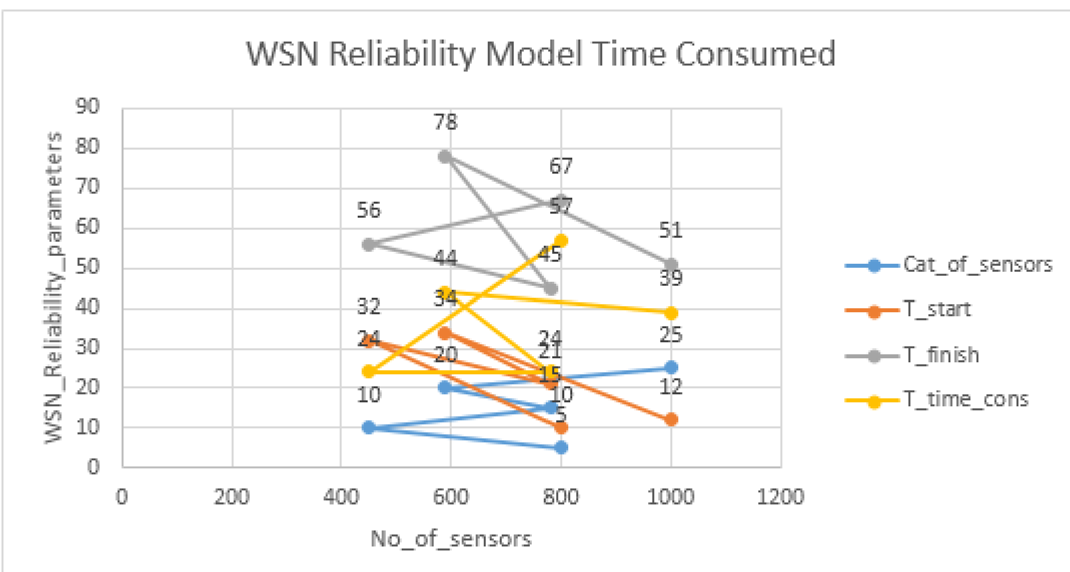

Figure 8. Plot of WSN Reliability Analysis for Time Consumption

protocol on the optimal route based on the hops. It determines whether the packet has been successfully received or discarded due to expiration time. Thus the behavior of various models like Active Node Selection Model, Neighborhood Discovery Model and WSN Reliability Detection Model is clearly discussed.

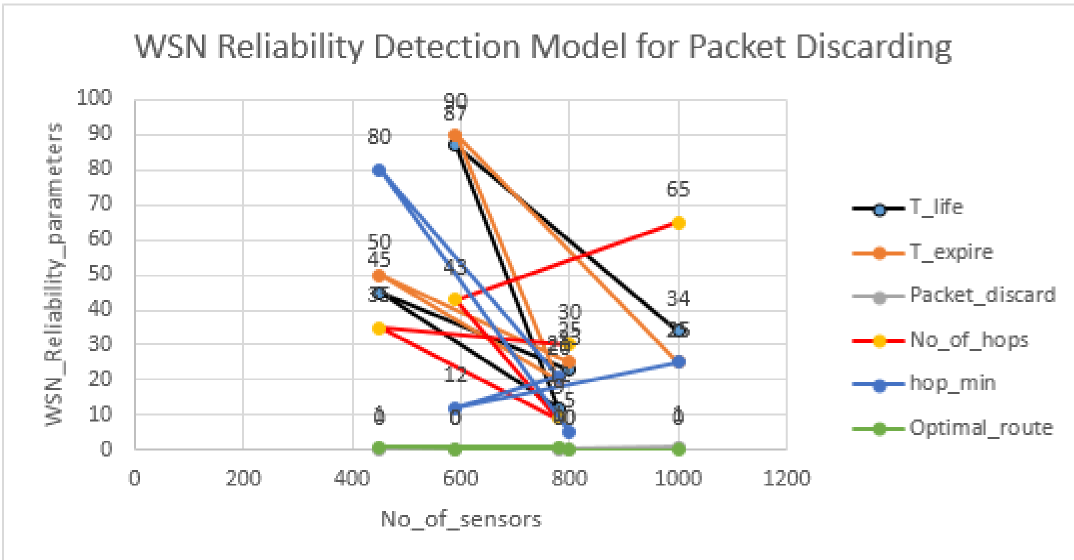

Figure 9. Plot of WSN Reliability Analysis for Packet Discarding

5. Conclusion

Wireless Sensor Network is a classical network which is gaining world class popularity because of its increased usage in various fields. In such networks the node activation plays a major role. The active node selection is an important issue to be discussed and hence in this context it is discussed that the active nodes are polled for energy content. If the energy expires it becomes inactive and has to re-charge for becoming active.The next issue is the neighborhood discovery which is very important in the mobility based sensor network. The neighbors play a major role in active node participation of packet transmission. By means of neighborhood detection, an optimal route is explored. The next issue that is considered for discussion in the current context is the reliability detection model. The analysis implies that the sensors total time taken for data transmission is the difference of finish time and start time. These time depends on the number and nature of sensors. The life time of the packets are recorded and packet discarding is correlated with the life time. An analysis is done on this. On an average rate packet discarding is reduced. Thus the discussion yields better performance and suggestions for improvement in the performance of a typical WSN.

References

[1] Joanna, K., Wendi, H., Hari, B. (2002). Negotiation based Protocols for Disseminating Information in Wireless Sensor Networks, *Wireless Networks*. 8, p. 169-185

[2] Eylem, E., Yaoyao, G., Doruk, B. (2006). Mobility Based Communication in Wireless Sensor Networks. *IEEE Communications Magazine*. p. 56-62.

[3] Yulong, Z., Gongpu, W. (2016). Intercept Behavior Analysis of industrial Wireless Sensor Networks in the presence of eavesdropping attack. *IEEE Transactions on Industrial Informatics*, 12 (2) 780-787.

[4] Wei, C., Ian, J. W. (2016). Optimized Node Selection for Compressive Sleeping Wireless Sensor Networks. *IEEE Transactions on Vehicular Technology*, 65 (2) 827-836.

[5] Pouya, O., Jie, W., Abdallah, K., Ness, B. S. (2016). Scalable Video Streaming with Helper Nodes using Random Linear Network Coding. *IEEE/ACM Transactions on Networking*, 24 (3), p. 1574-1587.

[6] Heng, Z., Peng, C., Ling, S., Jiming, C. (2016). Optimal Dos Attack Scheduling in Wireless Networked Control System. *IEEE*

Transactions on Control Systems Technology. 24 (3) 843-852.

[7] Dong, H. S., Saurabh, B., Wang, C. C. (2016). Toward Optimal Distributed Monitoring of Multi-Channel Wireless Networks. IEEE Transactions on Mobile Computing, 15 (7) 1826-1838.

[8] Huang, C. L., Hsiao, H. L. (2016). Design and Evaluation of an Open Source Wireless Mesh Networking Module for Environmental Monitoring. *IEEE Sensors Journal*, 16 (7) 2162-2171.

[9] Dongyao, J., Huaihua, Z., Shengxiong, Z., Po, H. (2016). Dynamic Cluster Head Selection Method for Wireless Sensor Network. *IEEE Sensors Journal*, 16 (8) 2746-2754.

[10] Pushpendu, K., Sudip, M. (2016). Reliable and Efficient Data Acquisition in Wireless Sensor Networks in the Presence of Trans faulty Nodes. *IEEE Transactions on Network and Service Management*. 13 (1) 99-112.

[11] Ju, R., Yaoxue, Z., Kuan, Z., Xuemin, S. (2016). Adaptive and Channel-Aware Detection of Selective Forwarding Attacks in Wireless Sensor Networks. *IEEE Transactions on Wireless Communications*, 15 (5) 3718-3731.

[12] Yuxin, L., Mianxiong, D., Kaoru, O., Anfeng, L. (2016). Active Trust: Secure and Trustable Routing in Wireless Sensor Networks. *IEEE Transactions on Information Forensics and Security*. 11 (9) 2013-2027.

[13] Zhen, H., Rui, W., Xile, L. (2016). A Clustering-Tree Topology Control Based on the Energy Forecast for heterogeneous Wireless Sensor Networks. *IEEE/CAA Journal of Automatica Sinica*, 3 (1) 68-77.

[14] Mianxiong, D., Kaoru, O., Anfeng, L., Minyi, G. (2016). Joint Optimization of Lifetime and Transport Delay Under Reliability Constraint Wireless Sensor Networks. *IEEE Transactions on Parallel and Distributed Systems*, 27 (1) 225-236.

[15] Tong, M., Fan, W., Guihai, C. (2016). Code-Based Neighbor Discovery Protocols in Mobile Wireless Networks. IEEE/ACM Transactions on Networking, 24 (2) 806-819.