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Recovery of Coordinator Device using Adoption Technique in ZigBee Network

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Abstract
ZigBee wireless standard known as the IEEE 802.15.4 standard, have very popular in recent years. This can be attributed to the fact that ZigBee networks consume low power, have long battery life and provide security management. Academic and networking industries have taken interest in ZigBee because of its applications. In this thesis, ZigBee wireless standard has been studied in detail. A ZigBee network has been created in two environments, one in case of no failure and other in case of failure. A technique (Parent Adoption Indicator) has been proposed to recover the failed network. In PAI technique the orphan end devices are adopted by other coordinator for the time till failed coordinator is recovered. The adoption is done in such a way that load is not increased beyond threshold which result in another failure. The thesis aims to recover the failed system in such a way that it can withstand the network performance.

Keywords
Opnet; Coordinator; Router; Load; Recovery

I. Introduction

ZigBee is a technological standard created for Control and Sensor Networks created by ZigBee alliance, an open association providing easy to use ZigBee standard. The origin of the name can be traced back in 1960s when Nobel Prize winner Karl von Frisch noticed the peculiar behavior of bees which can be said as the ZigBee principle. The domestic honeybee lives in a hive consisting of a queen, a few male drones and thousands of worker bees, each sharing vital information by continuous communication. This technique of sharing information regarding new found food sources is called ZigBee principle. On discovering a new found food source the bees dance in a zigzag pattern thus communicating it to other members. ZigBee is based on IEEE 802.15.4 standard, a global standard ensuring solid performance; that defines the physical and Medium Access Control layer. The operation is in an unlicensed band worldwide including 2.4 GHz global with a data rate of about 250Kbps, 915 MHz America with a data rate of about 40Kbps, 868MHz Europe with a data rate of about 20Kbps and 920MHz Japan bands.

A. ZigBee Nodes

The ZigBee standard has a capacity to address up to 65535 nodes in a single network. The nodes here are mainly of three types: The Coordinator, the Router and the End devices. The Coordinator allows other devices to connect to it thus forming the network. It initializes the network. In the network a coordinator can also provide service of security management. In some networks with star topology it also provides message routing service. In the network the router is attached to the coordinator which acts as a parent to it and allows end devices to connect to it thus acting as a parent to it or the end device can be termed as its child. It helps in relaying messages from one node to another. Since it connects large number of node in a system thus it acts as a network extender. The End devices in a network are the child that cannot allow other nodes to connect through them. These are present at the extreme ends of the network performing specific tasks of sensing or controlling.

II. ZigBee Topology

The ZigBee network can work on any of the three network topologies are the star topology, tree topology and mesh topology. In star topology the network consists of a central node, the coordinator, which is connected to rest of the nodes in the network. The messages in the network are thus relayed by the coordinator. Thus, if the coordinator fails then the network cannot work. The major disadvantage of this network is that there is no alternative route if the RF link fails due to some reason between the coordinator and the target device. Tree topology resembles a tree where a top node is present, here it is the coordinator. The coordinator is then connected to routers and end devices. The routers can be connected to more routers and end devices. Thus coordinator acts as parents where as router act as parent and child both but end devices can act only as a child. The parent can directly communicate only with its child and with its own parent whereas the child can do so only with its parent. When sending/ receiving a message it must travel the entire tree up and down. The disadvantage of this network is that there is no alternative route if the RF link fails. Mesh Topology is very similar to a tree topology in which some of the nodes down the tree are directly attached. As in a tree network, the coordinator is connected to routers and end devices. The routers can be allowed to connect to more routers and end devices. The major advantage of this topology is that alternative routes can be found.

III. What does ZigBee do?

ZigBee finds its application in almost everything around us. It has been designed for sensory and control networks. It can be used in home automation where it defines a set of devices in home automation like light switches, thermostats, window shades, heating units etc. It can be used for industrial plant monitoring where parameters like temperature, pressure etc are monitored. It finds application in medical field also. Patients receive better care at a reduced price by this technique. Patients can stay at their home and monitor vital statistics and send via internet to the concerned doctor who can adjust levels of medication. The elderly patients in home can be monitored by their family member sitting at home. They can be notified via a mobile call in case any anomaly occurs. This can also be used in hospitals reducing the staff to patient ratio. It can also be used in commercial lighting control. It finds major use in environmental and agricultural monitoring.

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IV. Literature Survey

Mihajlov B. and Bogdanoski M.. In the research the author has worked upon analysising the performance of ZigBee based wireless sensor networks [1]. The author concluded that the end to end for a tree topology almost 50% more than in comparison to any other topology.

Malek A.et al. The research was carried on improving the ZigBee AODV Mesh Routing Algorithm Topology. In this work an AODV mesh topology method was developed in order to create an efficient routing path so as to send and receive data from source to destination [2].

AL-Mukhtar M.M.A et al. In this research work the author diagnosed the failure in ZigBee based wireless sensor networks [3]. Here the author concluded that failure of the coordinator is most serious and affects the maximum in a ZigBee network than failure of router or end devices.

Attia S.B. et al. The author in this research paper worked on fault tolerance mechanism for ZigBee WSNs. The author concluded that the reactive mechanism and pro-active approach helps an orphan child link to a new parent faster [4].

Vats K. and Madaan D**.** In this research paper the author tried to evaluate Wireless Sensory Network performance during failure of coordinator using OPNET [5]. The author concluded that the performance of higher values of transmits power and CSD is better than low values.

Jurcıket P. et al. The author made a deep study on Simulation of energy efficient scheduling for IEEE 802.15.4 ZigBee network. The author concluded that the interdependence of various factors like reliability, energy consumption and timeliness make the network more complex [6].

Nourildean S.W. et al. The author made a deep study on various topologies on which ZigBee can work [7]. The author concluded that the failure can degrade the overall performance of the entire network.

Jasneet Singh Sandhu et al. The author analyzed the performance of mobility of coordinator and end devices for mesh and tree topologies in ZigBee [8]. The author concluded that the performance of tree topology is better than that of mesh topology.

Stevanovic D. and Vlajic N. The author worked on the analysis of performance of IEEE 802.15.4 in wireless sensory network by implementing various mobility strategies [9].

Kaur A. et al. The author made a research work on failure of Full Functional Devices and Reduced Functional Devices in ZigBee WSNs [10]. The author concluded that it is essential to assign star topology to one of the coordinator and another should not be tree or mesh

V. Proposed work

In this thesis two scenarios are designed. The first scenario has been designed in case of no failure. The second scenario shows that the coordinator has failed and hence the network has failed. The both scenarios are designed exactly same for the comparison purpose. The major difference in both scenarios is that, in scenario 1 there is no case of failure, but in scenario 2 the coordinator devices are failed and then recovered using the Parent Adoption Indicator Technique. In this method the coordinator acting as the parent for the end devices. In this scenario two coordinators are deployed, when one coordinator fails, the end devices join the other coordinator, which result in increasing its load and delay etc. The impact of joining the coordinator in computed on basis of simulation results.

VI. Results and discussion

There are two result panels saved along with the network model. Additionally, the network structure can best be viewed via the output report or the visualization functions.

A. Delay of both scenarios

Here figure 1 shows the graph for delay in blue colour for the normal scenario (no failure) and indicated by red colour in fault scenario (coordinator failure).The graph in blue shows that there is constant delay as there is no failure. The graph in red shows a sudden increase in delay when the first coordinator fails and it descends as the traffic is handled by the second coordinator. Similar happens when the second coordinator fails and its traffic is handled by the first coordinator.

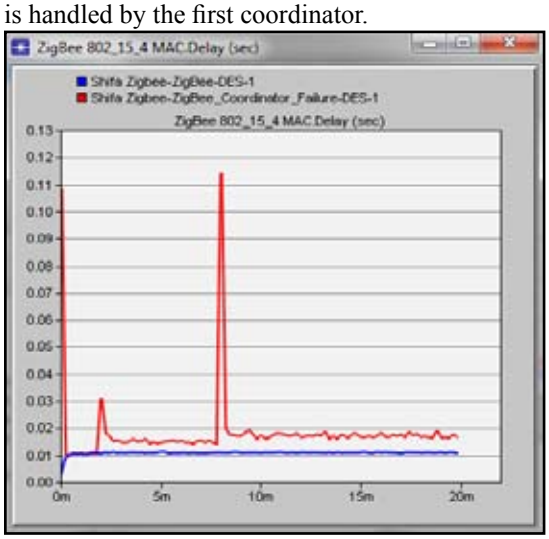

Fig 1: Delay of both scenarios

B. MAC load per PAN for both the scenarios

The following graph that is, figures 2 show the load per PAN for both the scenarios. The blue and green coloured lines show coordinator 1(PAN 1) and coordinator 2 (PAN 2) respectively for scenario with no failure whereas the red and sky blue colour indicates the coordinator 1(PAN1) and coordinator 2(PAN 2) respectively for scenario with coordinator failure. The graph tells us that in normal scenario the load is handled by their respective coordinators whereas in fault scenario whenever a coordinator fails the load is shifted to the other coordinator. A few minutes into simulation the traffic gets associated with PAN 2.

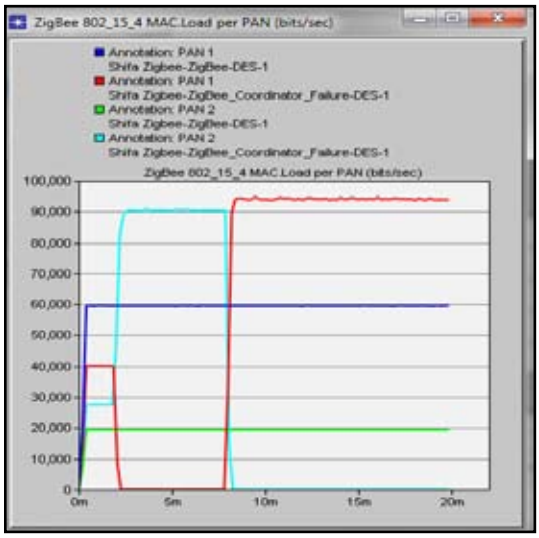

Fig 2: MAC delay per PAN for both scenarios

C. Throughput of both the scenarios

Figure 3 shows throughput for normal and fault scenario. The blue line indicates the graph for normal scenario and the red coloured for fault scenario. The normal scenario has a constant throughput. The fault scenarios throughput falls as the first coordinator (PAN 1) fails but using the purposed technique not only the problem is rectified but network throughput increases much more than the normal scenario.

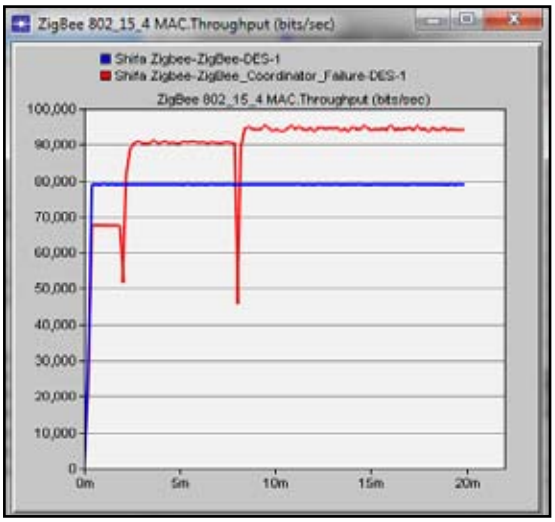

Fig 3: Throughput of both the scenarios

D. End to end delay

The blue and green coloured lines shows results for coordinator 1(PAN 1) and coordinator 2 (PAN 2) respectively for scenario with no failure whereas the red and sky blue colour indicates results for the coordinator 1(PAN1) and coordinator 2(PAN 2) respectively for scenario with coordinator failure in figure 4. The red colour broken graph shows that the coordinator 1 has failed and when it is rectified the graph can be seen again. Similar can be seen for coordinator 2.

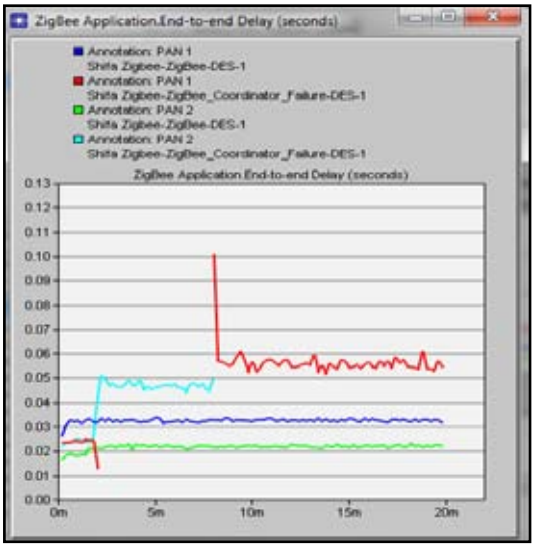

Fig 4: End to End delay

E. Traffic sent in bits/sec

The following figure, figure 5 shows the traffic sent per PAN in bits/sec. The blue and green coloured lines shows results for coordinator 1(PAN 1) and coordinator 2 (PAN 2) respectively for scenario with no failure whereas the red and sky blue colour indicates the results for coordinator 1(PAN1) and coordinator 1(PAN 2) respectively for scenario with coordinator failure. This figure shows that (fault scenario) in case of coordinator failure the entire traffic is shifted to a single coordinator and thus the traffic sent by it suddenly shoots up.

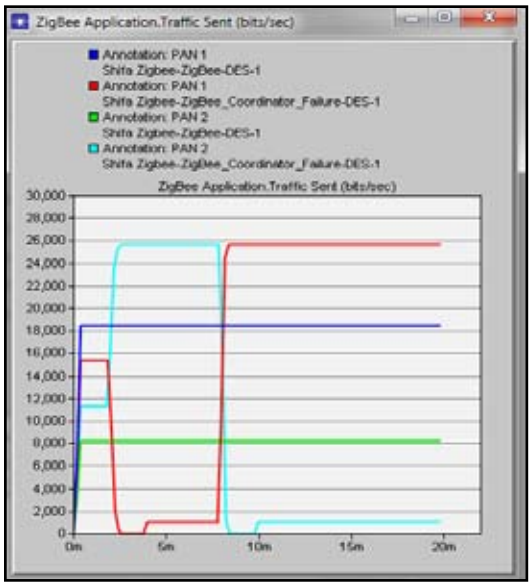

Fig 5: Traffic sent in bits/sec

VII. Conclusion

In the proposed approach, two scenarios are designed for ZigBee network routing. In scenario 1, there is no case of failure whereas in scenario 2, there is case of coordinator failure in the network. The failed device affects the network performance which is not desirable. The PAI (Parent Adoption Indicator) technique is used in research which focuses to recover the failed device to overcome the effect of failure and to withstand the network performance. In PAI technique the orphan end devices are adopted by other coordinator for the time till failed coordinator is recovered. The adoption is done in such a way that load is not increased beyond threshold which result in another failure. The energy factor is also considered in this research work, as energy of node highly affects the transmission range of node. So, in this work an optimal value of energy is used to enhance the range of communication of various nodes. Some of the important conclusions that were drawn are:

- The simulation study had shown that our proposed network out performed in comparison with ZigBee no failure whereas it had been expected that the performance of ZigBee network in case of no failure is better than in case of failure.
- The throughput of the system increased when the proposed technique that is the Parent Adoption Indicator was applied to recover the network.

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