International Journal of Engineering Research
Volume No.3, Issue No.12, pp :812-816

ISSN:2319-6890)(online),2347-5013(print)
01 Dec. 2014

# Topology Aware Auto-configuration In Wireless Sensor Network

**Muhammad Zeshan Alam[1], Muhammad Baseer Ur RehmanSheikh[2] ,Arooba Zeshan[3]**
1 [1]School of Engineering, Design and Technology,University of Bradford, Bradford, UK
[2]Department of Computing, Engineering and Technology.University of Sunderland, UK
[3]Department of Electrical Engineering,CIIT,Islamabad, Pakistan
zeshusher@hotmail.com

***Abstract Wireless sensor network consists of a number of energy constrained sensors which are densely deployed in large geographical area. We consider dynamic configuration of wireless sensor networks, where certain functions can be automatically assigned to nodes at any time of network operations, based on the parameters such as remaining energy and topology changes. In order to achieve the topological controlled network reconfiguration the received signal strength indication value along with battery level of nodes were used which indicate any changes in the network layout and remaining energy of the nodes. Based on these two parameters new tasks were then assigned to the nodes. The algorithm's performance was tested in different situations and the results displayed over the graphical user interface showed that the algorithm's performed in the expected manner. The algorithm provides the best platform to evaluate different topology based energy efficiency techniques as the algorithm accommodates changes in the topology of the network.***

***Keywords- Wireless Sensor Networks, Auto configuration, topology control algorithm***

## 1 Introduction

Wireless sensor networks (WSNs) consist of a huge number of small, battery powered sensing devices (nodes) which communicate with each other through a wireless medium [1]. WSNs have applications in broad range of areas including environmental monitoring, industrial monitoring, military, healthcare and security [2]. WSNs are often deployed in physically tough environments because of which networks face several changes in their physical topology and some nodes get displaced or removed from the network coverage area, in such scenarios the prior configuration fails to keep the network operational and at this point human intervention is needed to reestablish the network. As mentioned earlier, approaching such zones could be challenging and costly which ends up in causing undesirable delay in network reestablishment. Our algorithm enables the network to reconfigure dynamically and successfully keep the network operating. In our algorithm the network configuration is performed in two steps; the first step is network formation which is automatically carried out by simply placing motes in area under consideration. The second step is dynamic reconfiguration in which the network automatically reconfigures itself if any change occurs in its physical topology or any intrinsic parameter, such as changes in battery level, without affecting the operation of the network.

The reconfiguration technique is based on two major parameters, RSSI value and the battery level of the nodes. All tasks assigned to the network elements are based on these two parameters. These two parameters are constantly monitored by the base station; any changes in these two parameters could result in the assignment of different role to that particular node.

The network is also capable to detect presence of any new node in its coverage area and assign role to the new node based on the previously mentioned parameters. Similarly absence of any node is also accommodated by the network sometimes through dynamic reconfiguration in a particular level or in some cases the entire sub network area is reconfigured.

This paper is organized as follows. In Section 2, related work is presented. In section 3, an overview of the network architecture is given. In section 4 and 5, network topology and network formation are discussed respectively. Topological aware dynamic reconfiguration algorithm is discussed in section 6 and is results are given in section 7. In section 8, conclusions are drawn.

## 2 Related Work

Dynamic self-configuration in WSN has been a major research area of the recent past. Several other approaches for dynamic configuration already exist in the literature. Few of the main approaches include coverage [3] and aggregator placement [4].

Guo et al. [5] designed self-configurable role assignment strategy in WSN. They proposed that WSN sensor nodes could compete for the set of independent roles but their strategy lacked scheduling and energy consumption.

An autonomous task scheduling technique in WSN established on reinforcement learning algorithm proposed by Shah et al [6] where they cater for fixed network topology. However, they did not consider cooperation between neighboring nodes in their work.

Subramanian and Kat's [7] self-configuration algorithm consisted of four phases which were discovery phase, organizational phase, maintenance phase and self re organization phase.

Chevally et al in [8] proposed the cluster based network formation. The cluster head election was based on the energy level and processing capability of the node. Slijeocevic and Potkonjak [9] proposed a heuristic that organized the network in which mutually exclusive sensor nodes that completely covered the area under consideration.

The dynamic reconfiguration technique proposed in this paper differs from the discussed techniques in a manner that the network is divided in to sub network areas (SNAs) which enabled us to apply different topologies in each sub network area to evaluate the effect of different physical topologies on energy consumption of the network by just placing nodesin many different ways. Our dynamic configuration technique also provides an easier way to debug network problems because each SNA is totally independent of the other SNA so the problem can easily be isolated and resolved.

## 2 Network Architecture

The entire coverage area of the network consists of several adjacent sub network areas (SNA). Each SNA has a definite width (horizontal area of coverage) and set of levels which extend vertically down in a similar manner as in our ERRT algorithm [10]. Each level in SNA consists of a five nodes one of which acts a router while other act as end devices. Fig. 1 presents network architecture.

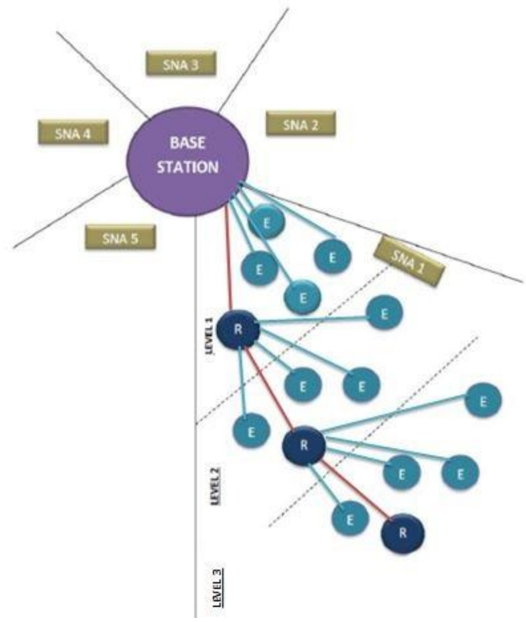


Figure 1: Network Architecture

### 3.1 Network Element Roles

Three specific tasks are assigned to nodes for the purpose of gathering and forwarding sensor data to graphical user interface that allowed interpretation of the attained data.

### 3.2 Base Station

There is only one base station (BS) in the network which is fixed and could not be replaced by any other node at run time. The base station is responsible for network initiation and it enables the first router of every SNA. It also receives data from routers and end devices in its coverage area (CA), and forwards the received data to the system attached to it where the data is displayed in meaningful manner.

### 3.3 Router

There are several routers in a network and every node in the network is capable of becoming a router at run time except the node acting as base station. The router is responsible for enabling a router of higher level and collecting data from the router as well as from the end devices of the higher level, and passing that data to a lower level router.

### 3.4 End Device

End devices are the maximum number of devices that exist in a network. Every node in a network is capable of becoming end device except the node that is working as a base station. Its role is to sense the environment and send data regarding the environment to the router of previous level.

## 4 Network Topology

Network topology described in this paper is a combination of *tree topology* and *star topology*. A very simple form of tree topology based on the hierarchy of nodes is used for data flow from router of the highest level to base station which passes through all routers of the levels in between them; fig. 1 shows a clear flow path among the routers.

Normally in tree topology two or more branches generate from the parent node but in this case only single branch extends from a router.

In star topology every node is connected to a central hub and the hub acts as a server while the peripherals act as clients. In this design, the end devices of level are connected to the router of previous level and all the traffic that traverse through the network passes through the routers hence it is a perfect example of star topology among the end devices and router which can be seen in fig. 1.

## 5 Network Formations

The initial setup of the network consists of following basic steps.

### 5.1 First Level Setup

1. Initially the base station broadcasts its ID to all the nodes in its range and waits till the response arrives.
2. All the nodes which receive the BS ID respond to the BS with their own ID and battery level status.

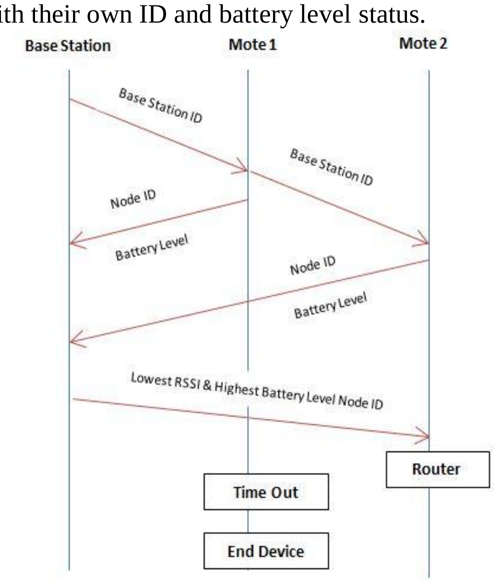


Figure 2: First Level Role Assignment

3. On receiving the IDs, BS measure the RSSI value of the received packet and determines the node with lowest RSSI value.
4. Once the node with the lowest RSSI value is determined, its battery level is also checked against the minimum threshold and if the value is also greater than the threshold the BS sends a message containing its role, which is to act as router, to that particular node.
5. The remaining nodes wait for the given duration of time and then become the end devices.

### 5.2 Second Level Setup

1. The router broadcast its ID to all the nodes in the higher level and waits till the response arrives.
2. The nodes on receiving the previous level routers ID transmit a message to the router containing their ID and battery level.

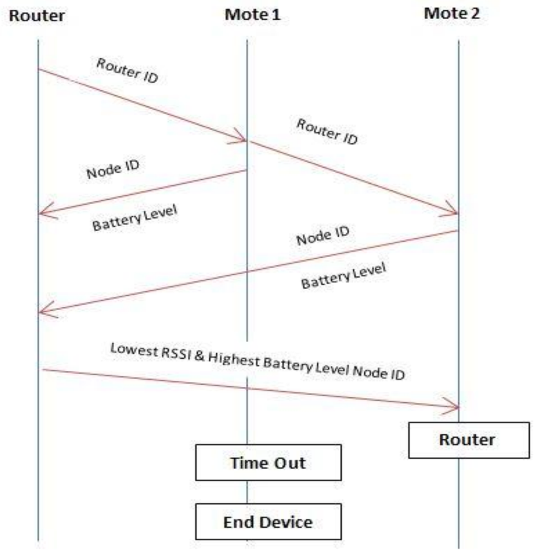


Figure 3: Second Level Role Assignment

3. The router determines the lowest RSSI value among the message received from different nodes and then checks their battery level against the threshold value.
4. Router sends a message to the node with the lowest RSSI value and battery level greater than threshold value to become a router.
5. The remaining nodes wait for the given duration of time and then become end devices.

It is very important that only one node in a level becomes router, therefore it is necessary for the router to keep record of all nodes that contested for the role of router and their IDs must be passed to the higher level routers so that they should not be selected as router for higher level.

This pattern is followed till the entire number of nodes in an SNA gets connected to the BS via intermediate routers. The same procedure is followed in all the SNAs to connect the entire nodes in the network to the BS.

## 6 Topology Aware Dynamic Configuration

Although most of WSN applications have already adopted dynamic configuration in their network design but there still is a greater need for WSN to develop the ability to reconfigure, especially in non-rechargeable environment [11].

In this paper, dynamic configuration is achieved in a manner to support any change in the physical topology of the network which has a great impact on the network's power consumption.

1- RSSI value
2- Battery level

The RSSI value indicates the strength of the received signal and it decreases with the increase in distance between the sender and receiver. Battery level on the other hand is the indication of the remaining battery life to support the mote's operation.

After the network setup phase, the BS and the routers keep broadcasting their ID after regular intervals.

If any mote is brought in to the coverage area of a BS or a router, it receives the ID of base station or router. The node then sends its RSSI value to that router or base station. This is compared with rest of the nodes in that level and then depending on that value the role of router or end device is assigned to that mote.

Similarly if a node is removed from the network, the base station is informed about the missing node and it's ID, level number and SNA number are displayed on the GUI so that the node could be replaced. If the node that is being removed was acting as a router then another node from that level automatically becomes router to maintain the network's connectivity at all times.

The base station also keeps in account the battery level of the router to avoid dis-connectivity in the network. If the battery level of any router goes below certain threshold value then that router becomes an end device and the end device with second lowest RSSI in that level became a new router. This change is also detected in the higher levels so the router in each higher level also changes depending upon the coverage area of the lower level router.

This dynamic configuration supports different changes in the physical topology of the network. It enables the network to expand its coverage area at any time just by bringing more nodes in the network without any prior configuration of the network elements. The network can expand in two dimensions, with the increase in the number of SNAs by bringing more nodes in the coverage area of the BS and with the increase in number of levels in an SNA by bringing more nodes in the coverage area of the highest level router.

The dynamic configuration achieved in this paper provides a network where different topologically controlled clustering algorithm for energy efficiency can be applied and evaluated.

## 6 Results

To evaluate the performance of the dynamic reconfiguration a total of fifty mica 2 motes were used and graphical user interface was designed. The GUI displays the number of SNAs in the network, number or routers in an SNA, the nodes connected through this router and the battery level of the router. This dynamic configuration technique is tested in different scenarios to analyze its performance.

1- A node is brought in to the network coverage area of router their ID and battery level is displayed under that router's connectivity; similarly if the node is removed from the network then its ID is displayed along with a warning message to replace that node.


Figure 4 (a): Performance Analysis Scenerio 1

ISSN:2319-6890)(online),2347-5013(print)
01 Dec. 2014


Figure 4 (b): Performance Analysis Scenario 2

As shown in Fig. 4 (a) node having ID ‘3’ is brought into the coverage area of the router 1 so it is shown under router 1 connectivity and similarly in Fig. 4 (b) node 6 is removed from router 2 so it is shown as missing node.

2- If a router is removed from the network an end device in that level becomes the router and the nodes that were connected to the removed router connects with the new router the old routers ID are displayed as missing.


Figure 5 (a): Performance Analysis Scenario 1


Figure 5 (b): Performance Analysis Scenario 2

Fig. 5 (b) shows that the router having ID 33 is removed from SNA 4 so it is automatically replaced by an end device having ID 35 thus the nodes previously connected to router 33 are now connected to router 35 and router having ID 33 is displayed missing.

3- If the physical position of the end devices is swapped with a router in the network. The GUI displays the change such that the previous end device ID appears in front of the router which implies that the node with this ID is new router, and the previous router ID appears as the end device connected to the new router signifying that the previous router is the new end device which is connected to the network through new router.


Figure 6(a): Performance analysis scenario 1


Figure 6 (b): Performance Analysis Scenario 2

The node having ID 22 is swapped with router having ID 24 which can clearly be seen in the figures above.

## 6 Conclusion

In this paper dynamic reconfiguration technique is presented. This algorithm enables the network to setup and operate all by itself without any human intervention. Our evaluation shows that the algorithm achieved the desired behavior and has detected all sorts of changes in the physical topology of the network, reassigned the roles to the network elements based on these changes, kept the nods remaining battery level in consideration during all these changes yet maintained the network connectivity all times and kept the network functional. The novelty of the algorithm is that the network is divided in to sub network areas so different topology based clustering algorithms can be applied in each SNA to compare their performance and to easily debug any problem in the network.

## REFERENCES

i. *Rabaey, R.S.a.J., "Energy aware routing for low energy adhoc sensor networks". 2002.*

ii. *Ababneh, N., Viglas, A. ; Labiod, H. ; Boukhatem, N., ECTC: "Energy Efficient Topology Sciences", Hawaii, HI, USA, 2000; pp 1–10.*

iii. *S. Slijepcevic and M. Potkonjak.Power efficient organization of wireless sensor networks. In ICC'01, Helsinki, Finland, Jun e 2001.*

iv. *B. Bonfils and P. Bonnet. Adaptive and decentralized operator placement for in-network query processing. In IPSN'04, Berkeley, USA, April 2003.*

v. *W. Guo, N. Xiong, H.-C.Chao, S. Hussain, and G. Chen, "Design and Analysis of Self Adapted Task Scheduling Strategies in WSN," Sensors, vol. 11, pp. 6533–6554, 2011.*

vi. *K. Shah and M. Kumar, "Distributed Independent Reinforcement Learning (DIRL) Approach to Resource Management in Wireless Sensor Networks," in Proceedings of IEEE Mobile Adhoc and Sensor Systems, 2007.*

vii. *L. Subramanian and R. H. Katz.An architecture for building self-configurable systems. In IEEE/ACM Workshop on Mobile Ad Hoc Networking and Computing (MobiHOC 2000), Boston, August 2000.*

viii. *C. Chevallay, R. E. Van Dyck, and T. A. Hall.Self-organization Protocols for Wireless Sensor Networks.In Thirty Sixth Conference on Information Sciences and Systems, March 2002.*

ix. *S. Slijepcevic and M. Potkonjak. Power Efficient Organization of Wireless Sensor Networks. In IEEE International Conference on Communications (ICC'01), Helsinki, Finland, pages 472–476, June 2001.*

x. *M ZeshanAlam, Yongqiang Cheng and AroobaZeshan "An Energy Efficient Cluster Based Routing Algorithm" IJERT Vol. 3 Issue 3*

xi. *Dhar, S., Energy Aware Topology Control Protocols For Wireless Sensor Networks. December 2005.*