Methods for Auto-Configurable Wireless Sensor Networks that Maximize Cell Survival Efficiency and Minimize Cell Merging

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Abstract— The efficiency of the network may be negatively impacted by the variable rate of power loss in the sensor nodes (SN), which are battery-powered devices. This is because the lifespan of the nodes directly impacts the lifetime of the wireless sensor network (WSN). In real-world systems, certain measures are usually implemented at each layer to increase the lifespan of the network. In this work, we examine the procedure for topology control in detail. In order to reorganize the network architecture effectively, the authors suggest a novel method that may be adjusted automatically. The suggested approach is implemented in clustered homogeneous cellular architecture and combines the cell merging and cell manager selection processes. The simulation results show that compared to the current auto-configurable technique, the suggested approach uses less power, which means the network lifespan is prolonged.

***Index Terms*— wireless sensor network, auto-configuring or self-configuring algorithms, cell merging, clustering**

I. Introduction

Sensor components, microelectronic systems, and the wireless network make up the three main parts of a WSN. The four main components of a device in a wireless sensor network—the power supply, the central processor unit, the data transmission unit, and the sensor component—make up an embedded system. Modern technology in microelectronics has allowed for the development of tiny, cheap sensors that use very little power. The foundational sensors of wireless sensor networks follow a predefined protocol; the issue becomes critical when the batteries used to power them cannot be recharged, leading to substantial power consumption during data processing during transmission and reception. Inconsistent energy consumption among nodes shortens the lifespan of the network and makes efficient operation very difficult, if not impossible, [1]. In the event of a failure, WSNs must be able to reconfigure themselves or repair themselves, and these procedures must be fine-tuned such that the fault may be recovered with little energy consumption. As a result, sensor networks should use efficient survival algorithms to keep the energy flowing and utilize it strategically. Thus, several algorithms and methodologies were able to develop WSN systems that were energy efficient. This paper's goal is to show how to implement energy-efficient algorithms for self-configuring WSN, which will let the network last longer with less power consumption compared to previous methods. This study focuses on the cell merging approach and the process of selecting cell managers. To keep things simple, the suggested approach is used in WSNs that are all the same.

The following is the outline of the paper: The current methods and techniques are described in depth in Section 2. Section 3 detailed the auto-configurable method and its expanded variant. We lay out our suggested method in Section 4. Section 5 showcases the outcomes of the simulation as well as assessments of performance. Section 6 serves as the paper's conclusion.

II. Related Works

The key to a wireless sensor network's longevity is its ability to communicate in an energy-efficient manner. Researchers are therefore primarily concerned with finding ways to manage energy more efficiently, increase the lifespan of networks, and improve energy efficiency in communication. In order to distribute the power consumption of the sensors evenly, the authors of [2] suggested a hierarchical optimization algorithm called Low-Energy Adaptive Clustering Hierarchy, or LEACH. This algorithm uses a periodic random rotation of cluster heads. A centralized controller is used to choose cluster heads in LEACH-C (Centralized), a variant of LEACH described in [3]. The non-automatic cluster head selection and the need to know the location of every sensor are the primary drawbacks of these methods. In [4], a deterministic cluster head selection approach is given as an extension of LEACH's stochastic algorithm. When compared to the original LEACH protocol, this approach does improve network lifespan; nevertheless, it does not address the issues that were previously present. In [5], the Ad hoc Network Design Algorithm (ANDA) was used to find the ideal cluster size and the optimal assignment of sensors to cluster heads. While this does increase the network's lifespan, it requires knowing in advance how many cluster heads there are, how many sensors there are, and where each sensor is located. In its Weighted Clustering algorithm (WCA) [6] evaluation, the authors take into account

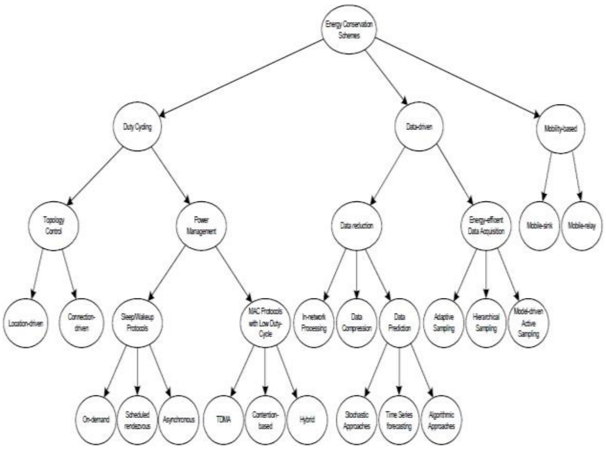


Figure 1. Classification of power savings approaches in WSN [24]

III. certain factors to consider while selecting clusters, including mobility, battery life, transmission power, and the amount of nearby nodes. This approach limits the number of sensors in a cluster so that the cluster heads can manage the load without compromising the network's performance. These clustering techniques are only suitable for smaller networks since they rely on synchronous clocking to exchange data across sensor nodes [9]. J. Zhu and S. Papavassiliou offered an analytical approach to estimate and assess the network lifespan in [11], while M. Bhardwaj and A. P. Chandrakasan obtained upper limits on the lifetime of sensor networks in [10]. The issue of optimizing the lifespan of a static network is addressed in [12], which offers a globally optimum solution using a graph theoretic method. A decentralized approach was used by the authors in [7, 8] to cluster an ad hoc sensor network. Based on the number of neighbors and a randomized timer, each sensor decides whether to join a nearby cluster or construct a separate cluster with itself as the leader. It also monitors communication among its adjacent clusters. Various techniques and methodologies for optimizing the selection of cluster heads or cell managers were suggested in [13–23]. Nonetheless, as shown in Figure 1, these algorithms and methodologies made use of some intricate ways for interacting with and keeping tabs on nearby clusters. In light of these prior works, we develop a new strategy to improve cell survival time in the event of a cell management failure and an algorithm to merge cells or clusters in a way that minimizes energy consumption for self-configuring WSNs.

IV. Section IV. Optimizers with Extended Capabilities In the previous part, we expanded the current auto-configuring algorithm by adding a new cell manager selection process. Then, in the next section, we created a new algorithm by merging the two processes. When the cell manager's remaining energy drops below 20%, it will select a node from its energy list—which it updates periodically using messages sent by member nodes—that has an energy level equal to or greater than 50% of its remaining battery energy and appoint it as the new cell manager. In the event that the cell manager fails, our technique for self-organizing WSNs uses less energy (Fig. 2).

V. Cell merging activity will occur if no node is located with a remaining battery energy of 50% or more to assume the role of cell manager. Cluster survival strategies like cell merging or cluster merging need a lot of energy. In Fig. 3, a scenario is provided to help comprehend the cell merging process. Out of the nine cells or clusters, cell 5's header is unavailable and cannot carry out its usual functions. Therefore, a new cell header must be joined by members.

VI. Here are the steps to complete the cell merging process:

VII. The "Join_in" message is sent to the sensor nodes in the event cell by the nearby cell managers.

VIII. All of the sensor nodes in the event cell get the "Join_in" message from nearby cells, which notifies the available cell managers.

IX. By comparing the surrounding cell manager's remaining energy and minimal hop count, the sensor nodes in the event cell choose the right neighboring cell to join. Once the nodes have accepted a cell manager, they will respond with an acknowledge message to the chosen manager.

X. Now we may examine the application of these procedures to our case. Things that will occur are as follows:

XI. It has been known to all nodes in the event cell (e.g., cell 5) that the cell manager is unavailable. Their surrounding cells' "Join_in" signals are what they're waiting for.

XII. Managers of nearby cells begin sending out "Join_in" signals and patiently await responses from the event cell's nodes.

XIII. In response to "Join_in" signals, a predetermined node verifies its membership in the event cell. The system will rebroadcast the packet with a modified hop count if this is not the case.

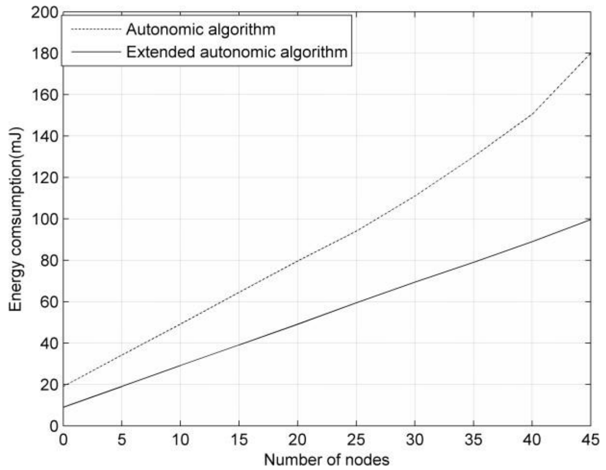


Figure 2. Comparison between the autonomic and existing algorithmsof self-configuring WSN

Upon receiving the "Join_in" message, a node in the event cell (say, cell 5) collects the following information about the cell manager: cell_id, node_id, the number of communication hops, and the source cell manager's remaining battery energy.

In order to decrease unnecessary message transmission in the network, the node discards the packet when it gets the "join_in" message from the same cell manager twice.

Considering the highest residual energy and smallest hop count towards the source cell managers, the node in the event cell chooses the correct cell manager if it gets the "join_in" signals from several cells (i.e., cells 1, 2, 3, 4, 6, 7, 8, and 9). Therefore, it chooses cell 2 (blue arrows in Fig. 3) that has the fewest hops and enough remaining energy to merge with.

XIV. PROPOSED ALGORITHM

XV. A novel strategy for improving cell survival time and energy efficiency during cell merging is presented in this research. When the cell manager's remaining energy drops below a certain threshold (less than or equal to 20% of its battery life), the extended auto-configuring algorithm will choose the next node on the energy list—a list that is periodically updated based on messages sent by member nodes—to appoint as the new cell manager. To be designated as cell manager, a member node's leftover battery energy must be at least 50%. As shown in Figure 3, cell merging activity will occur if no node is available to assume the role of cell manager in that cell with remaining battery energy equal to or more than 50%. In the event that the present cell manager fails, our suggested approach takes into account an extra criterion for choosing a replacement, which is detailed below:

XVI. 1. Look for a node that is a member and has an energy level of 50% or above.

XVII. 2) If you don't see any nodes with an energy level of 25% or more, try to find a member node with that level of energy.

XVIII. 3). Initiate the modified cell merging method if no such node is detected.

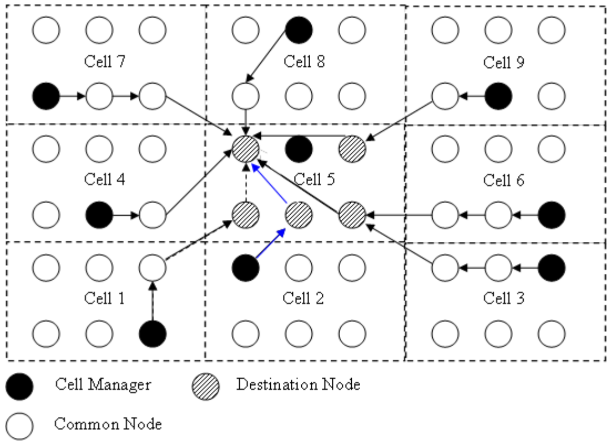


Figure 3. Clustering or cell merging process

The second criterion is being considered in order to increase the cell's operating lifespan. This extra time to live allows for other healing processes, such as physical replacement, maintenance, etc. We suggest an energy-saving tweak to the cell merging procedure for the third requirement. All of the event cell's nodes and the group's cell managers must exchange messages during cell merging, which is a very energy-intensive procedure. The number of available nodes and the remaining energy level of cell members are two pieces of information that cell managers often communicate with their group managers. The group manager generates a topology map and obtains an overview of the group's state after collecting and aggregating update messages from the cell managers. As a result, the group manager may adapt to group events and changes by taking appropriate action, such as changing cell formation. In the event that the cell manager fails, the virtual cell's border nodes might combine to form a larger cell. Modifications to the cell merging approach are suggested in the algorithm that will result in reduced energy use. The following are the suggested procedures for cell merging:

1) When a cell manager notices that another cell manager isn't available to take over, they should notify their group manager and designate a border node to act as a liaison between the two cells.

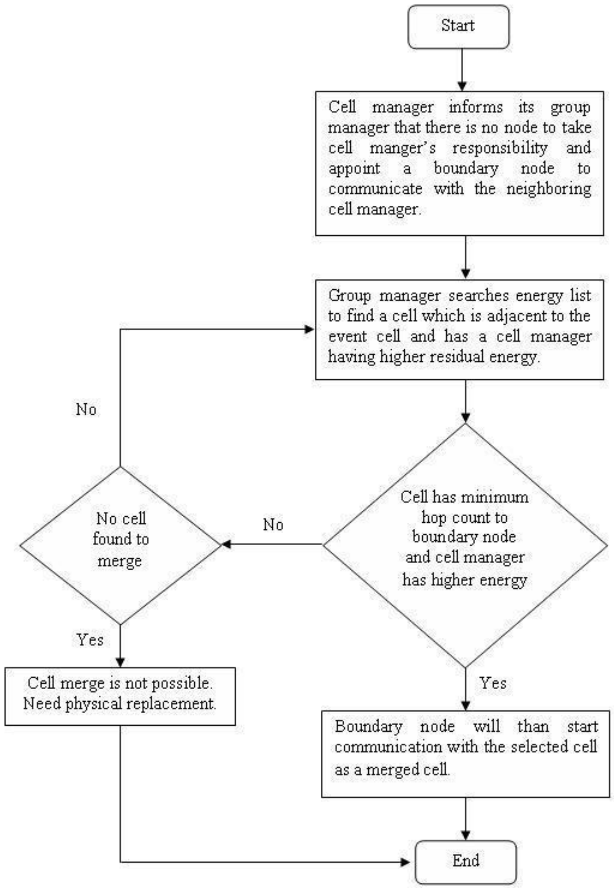
2) The group manager will verify the energy state of each cell manager by reviewing the energy list. One unique identifier is assigned to each cell. To locate a cell with a minimal hop count—that is, a cell that is next to the event cell—and a cell manager with a higher and adequate residual energy, the group manager will search the energy list by cell id. The next step is for the group manager to tell the cell manager to send a "Join_in" message to the event cell.

3) Once the designated border node and the chosen cell are combined, they will begin communicating as one cell.

Figures 4 and 5 show the detailed flow diagrams of the two methods that were suggested.

XIX. PEFORMANCE EVALUATION

The suggested algorithm's performance is assessed with the help of the network simulator NS2 [25, 26], as shown in Figures 6 and 7. From ten to three hundred, the number of sensor nodes might vary. Starting with an energy of 2000 mJ, each sensor is presumed to work. When a cell manager's remaining battery power starts to run low, the current auto-configuring algorithm searches for a node with an energy level that is at least 50% higher. We shall appoint this node as the new cell manager if it exists. In the absence of such a node, the energy-intensive conventional cell merging operation will be invoked.


Start
Cell manager informs its group manager that there is no node to take cell manger's responsibility and appoint a boundary node to communicate with the neighboring cell manager.
Group manager searches energy list to find a cell which is adjacent to the event cell and has a cell manager having higher residual energy.
Cell has minimum hop count to boundary node and cell manager has higher energy
No
No cell found to merge
No
Yes
Cell merge is not possible. Need physical replacement.
Yes
Boundary node will than start communication with the selected cell as a merged cell.
End

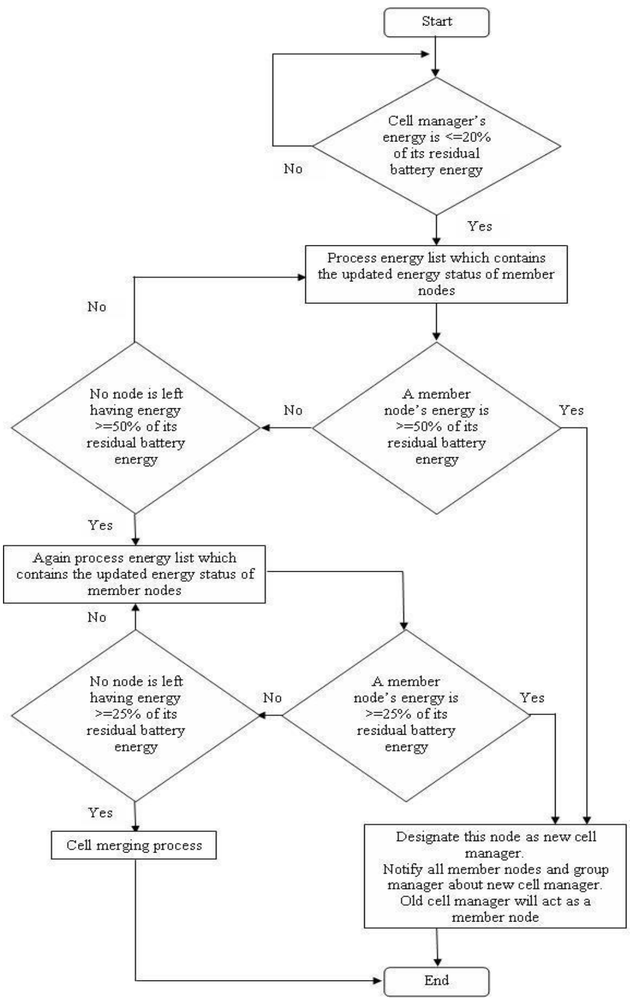

Start
Cell manager's energy is <=20% of its residual battery energy
No
Yes
Process energy list which contains the updated energy status of member nodes
No
No node is left having energy >=50% of its residual battery energy
No
A member node's energy is >=50% of its residual battery energy
Yes
Yes
Again process energy list which contains the updated energy status of member nodes
No
No node is left having energy >=25% of its residual battery energy
No
A member node's energy is >=25% of its residual battery energy
Yes
Yes
Cell merging process
Designate this node as new cell manager. Notify all member nodes and group manager about new cell manager. Old cell manager will act as a member node
End

Figure. 4. Flow chart for cell manager selection

When a cell manager's remaining battery power starts to run low, the suggested method searches for a node with an energy level that is at least 50% higher. The new cell manager will be assigned if such a node exists. If that node isn't located, the cell manager will continue searching until it finds one with an energy level that's at least 25% higher than its remaining battery power. The new cell manager will be assigned if such a node exists. Our suggested method will initiate the cell merging procedure if no such node is detected.

Figure. 5. Flow chart for cell merging procedure

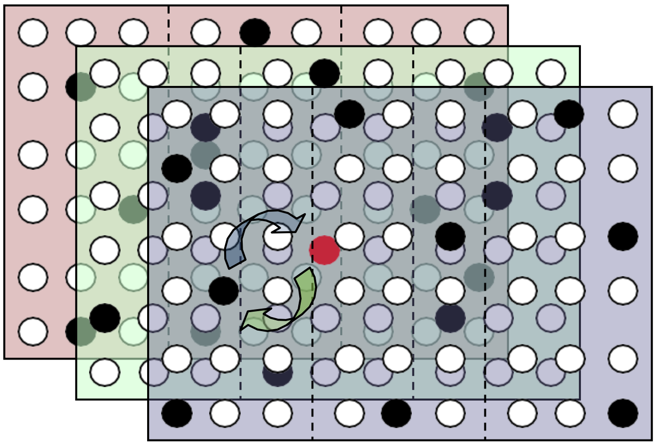


Figure 6. Example of cell merging using proposed scheme. Group manager selects a cell from blue plane to merge with the non-functionalcell (red) in the green plane.

During the cell merging process, the performance graph is constructed by comparing the energy consumption of the current and suggested algorithms.

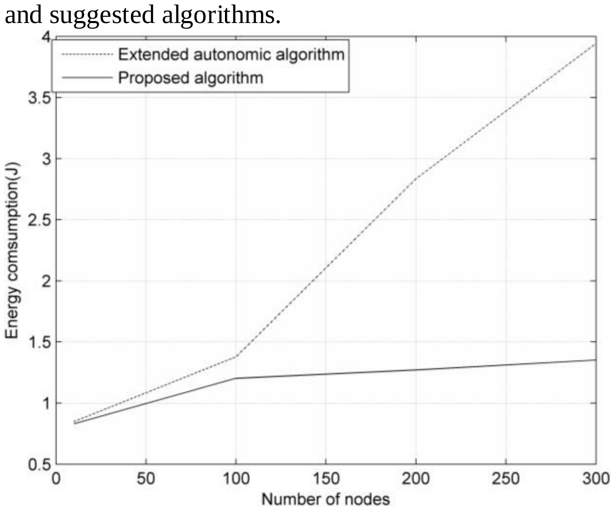


Figure 7. Comparison of existing and the proposed algorithm of self-configuring WSN for cell merging process

XX. CONCLUSION

By combining with nearby cells, the primary goal of cell merging is to increase the number of sensor nodes inside a cell, therefore dividing up the cell manager's duty. The cell merging mechanism is activated to merge adjacent cells when the remaining battery energy of a cell manager or cell head drops below a certain level. This leads to a longer lifespan for the network. Using the current auto-configuring algorithm as a foundation, this research proposes energy-efficient algorithm modifications for wireless sensor networks. Finding an appropriate sensor node to act as a cell manager and merging cells to restructure the topology effectively are two ways the suggested approach may increase the cell survival time.

REFERENCES

[1] "Optimal geometrical sink location estimation for two-tiered wireless sensor networks" (IET Wireless Sensor Systems, 2011, vol. 1, no. 2, pp.74-84), written by B. Paul and M. A. Matin.

[2] 2. "Energy efficient communication protocol for wireless microsensor networks" by W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan was published in the January 2000 issue of the Proceedings of the IEEE HICSS.

[3] In their 2002 article "An application specific protocol architecture for wireless microsensor network," W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan discuss this topic in the IEEE Transaction on Wireless Communications.

[4] Adaptive clustering hierarchies with low energy consumption and deterministic cluster head selection were discussed in a paper by M.J. Handy, M. Haase, and D. Timmermann published in 2002 at the 4th International Workshop on Mobile and Wireless Communications Network (pp. 9-11).

[5] [5] "Energy efficient design of wireless ad hoc networks," in Proceedings of European Wireless, February 2002, by C.F. Chiasserini, I. Chlamtac, P. Monti, and A. Nucci.

[6] (6) "WCA: A weighted clustering algorithm for mobile ad hoc networks" by M. Chatterjee, S. K. Das, and D. Turgut was published in 2002 in the Journal of Cluster Computing, Special edition on Mobile Ad hoc Networking, No. 5, pages 193-204.

[7] "Automatic decentralized clustering for wireless sensor networks," published in EURASIP by C.Y. Wen and W. A. Sethares, [7]

[8] Accessed from pages 686 to 697 of the Journal on Wireless Communications and Networking, Volume 2005, Issue 5.

[9] "Adaptive Decentralized Re-Clustering for Wireless Sensor Networks" (paper presented at the 2006 IEEE International Conference on Systems, Man, and Cybernetics) by C. Y. Wen and W. A. Sethares was published in October 2006 in Taipei, Taiwan.

[10] Lundelius, J., and Lynch, N. (2018). "Clock synchronization bounds, upper and lower," Information and Control, Vol. 62, 1984.

[11] [11] In "Bounding the lifetime of sensor networks via optimal role assignments," M. Bhardwaj and A. P. Chandrakasan discuss the topic in the 2002 IEEE INFOCOM conference (vol. 3, pp. 1587–1596).

[12] In their article "On the energy-efficient organization and the lifetime of multi-hop sensor networks" published in the IEEE Communications Letters in November 2003, J. Zhu and S. Papavassiliou discuss the topic in length.

[13] In their 2003 presentation at the IEEE International Conference on Communications (ICC) in Anchorage, Alaska, I. Kang and R. Poovendran discussed ways to increase the static lifespan of wireless broadcast ad hoc networks.

[14] [14] "Sensor networks: An overview" (Technical Report CA 95616) by A. Bharathidasan and V. Anand.

[15] [15] "A survey on sensor networks" in IEEE Communication Magazine, pages 102–114, by I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, 2002.

[16] 16 F. Lewis, "Wireless Sensor Networks," Wiley-InterScience, Smart Environments: Technology, Protocols and Applications.

[17] Referenced in [17] "Network Management in Wireless Sensor Networks" by W. L. Lee, A. Datta, and R. Cardell-Oliver, published by American Scientific Publishers in the Handbook of Mobile Ad Hoc and Pervasive Communications.

[18] The paper "An architecture for building self-configurable systems" was presented at the 2000 IEEE/ACM Workshop on Mobile Ad Hoc Networking and Computing by L. Subramanian and R. H. Katz. The paper can be found on pages 63–73.

[19] "Load-Balanced Clustering in Wireless Sensor Networks," in Proceedings of the International Conference on Communication (ICC 2003), Anchorage, AK, written by G. Gupta and M. Younis.

[20] The authors of the article "Autonomic self-organization architecture for wireless sensor communications" (J. L. Chen, H. F. Lu, and C. A. Lee, 2017) discuss this topic in the International Journal of Network Management, specifically on pages 197–208.

[21] The authors of the article "Energy-efficient cluster-based scheme for failure management in sensor networks" (G. Venkataraman, S. Emmanuel, and S. Thambipillai, 2016, pp. 528-537 in the IET Communications volume 2) have done great work in this area.

[22] [22] "A self-managing fault management mechanism for wireless sensor networks" (IJWMN, Vol.2, No.4, pp.184–197), by M. Asim, H. Mokhtar, and M. Merabti.

[23] [23] "A Self-Configurable Architecture for Wireless Sensor Networks" (E-systems Engineering, 2010), pp.76–81, by M.Asim, M. Yu, H.Mokhtar, and M. Merabbti.

[24] [24] "A cellular approach to fault detection and recovery in wireless sensor networks" (Pages 352–357) presented by M. Asim, H. Mokhtar, and M. Merabti at the 2009 SENSORCOMM conference in Greece.

[25] [25] The"Energy Conservation in Wireless Sensor Networks: a Survey" (May 2009), Journal Ad Hoc Networks, volume 7, number 3, G. Anastasi, M. Conti, M. Di Francesco, and A. Passarella.

[26] [26]Web address: http://isi.edu/nsnam/ns/ [27] The Network Simulator - NS -2http://www.isi.edu/nsnam/xgraph/ is the URL for XGraph.