International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Trustworthy Intra Cluster Management Scheme (TICMS) to Improve Lifetime of Wireless Sensor Networks

Mr. S. Suresh Babu*[1], Dr. N. Geethanjali[2]

Submitted: 05/09/2023 **Revised**: 13/12/2023 **Accepted**: 19/03/2024

Abstract: Wireless Sensor Networks (WSN) place a significant emphasis on energy efficiency because power consumption is the single most important factor in determining the overall lifespan of the network. There have been multiple suggestions made for potential strategies that could reduce the energy consumption of nodes. In this article, a intra cluster management scheme based on trust is provided and it is demonstrated that the method is also energy efficient. The success of the work is dependent on significant phases, which are the network area segregation phase, Cluster building phase includes cluster head node selection, computation of the trust degree & the control of the node's state and the routing phase. Taking into account the location coordinates allow for the formation of the cluster and the CH node selection. The CH node is responsible for calculating the trust level and maintaining control over the state of the other nodes in the network. The network lifetime is significantly improved, owing to the control over working nodes.The experimental results show that the proposed work is satisfactory with regard to the longevity of the network and energy efficiency.

Keywords: Wireless Sensor Networks, Energy Efficiency, Trust, Network Lifetime, Cluster

1. Introduction

Wireless Sensor Networks (WSN) uses several sensor nodes being distributed in different locations for attaining a specific goal. Nodes communicate and share sensed data to the Base Station (BS) frequently. Due to WSN's extensive application, sensor jobs can vary from simple to difficult. Yet, sensor nodes have energy, memory, and computational limitation and hence, resource efficiency is essential. Since energy efficiency determines WSN lifespan, it is the biggest challenge. Energy efficiency can be achieved in several ways and some prominent techniques are energy-efficient routing, sleep/wakeup schemes, data minimization, radio optimization and battery repletion [1,2].

This article tends to preserve energy through sleep/wakeup. Sleep/wakeup mechanism turns the radio off when needed to preserve sensor energy. Topology management, passive wakeup radios, and duty cycling enable sleep/wakeup [3,4]. Duty cycling techniques switch between idle listening and sleep, concerning the network operations. In spite of its energy-efficiency, it involves sleep latency. Additionally, duty cycling wastes energy on unnecessary wakeups. A passive entity performs passive wakeup scheduling and is energy-intensive. Intra cluster management controls network connectivity by limiting the working nodes. The application determines the minimum number of working nodes. This article aims to conserve energy by presenting Trustworthy Intra Cluster Management Scheme (TICMS) for WSN. Based on the geographic coordinates, the nodes are clustered for determining the CH. Then CH fixes the minimum number of working nodes based on trust, while setting the remaining nodes sleep which conserves energy and maximizes network lifetime. The following are some of the key points that are discussed throughout this article.

The sensors are grouped into clusters according to their geographical locations, and because of this, the mobility of the node has no bearing on the clustering process. Therefore, the WSN may either be movable or it may remain stationary. The selection of the CH takes into account the pattern of energy consumption of the nodes. The CH is responsible for controlling the number of working nodes and monitoring how the member nodes of the cluster behave. It results in an improvement to the network's security, as well as a significant reduction in the amount of energy consumed.as a result of the proposed algorithm's use of a clustering technique, the scalability and robustness of the solution, in addition to its energy consumption and latency, have been significantly reduced. The head of the cluster is paying attention to any inappropriate behavior. and as a result, it calculates the trust level of each of the nodes that make up the cluster. When the trust degree is lesser, the CH node will prevent the member node from communicating the proposed technique does not incur any memory overhead because the nodes are not required to keep any tables in their memory. The CH is the only node that is responsible for maintaining two tables, which record the latest routes and the trust degree of each member node. The remaining parts of the paper are structured as described below. The associated review of literature is discussed in Section 2. In section 3, both the proposed technique and the preliminary considerations are laid forth. The experimental

[1]Research Scholar, Computer Science & Technology,
Sri Krishnadevaraya University,
Ananthapuramu – 515 002, India.
[1]laksur.suresh@gmail.com
ORCID ID: 0009-0005-0734-6025
[2] Professor, Computer Science & Technology,
Sri Krishnadevaraya University,
Ananthapuramu – 515 002, India
** Corresponding Author Email: laksur.suresh@gmail.com*

findings are discussed in Section 4 and the concluding remarks are discussed in section 5.

2. Review of literature

In [5], a linear topology based WSN is presented to minimize packet drop. This work considers the node's stability of data queue and monitoring constraints. Stochastic optimization is performed concerning power allocation and routing. Lyapuvov drift plus penalty theorem is applied for obtaining the objective value and the packet drop rate is minimized. A Software Defined Networking (SDN) based WSN management system is presented in [6]. A Management Service Interface (MSI) is utilized to enable management entities.

Topological ordering based distributed Time Division Multiple Access (TDMA) scheduling algorithm is presented for WSN in [7]. The topological ordering based scheme is employed for distributed scheduling for attaining TDMA scheduling without collision. In [8], linear topology based WSN is proposed for oil and gas industries. Different routing protocols are tested with linear topology in different packet sizes.

A topology control algorithm based on binary grey wolf optimization is presented in [9]. The active and inactive schedules of sensors are processed in binary format and the fitness function that could minimize the active nodes is employed. Different topology control algorithms for WSN are reviewed in [10]. In [11], an energy-efficient network topology obfuscation is presented. A ranking based route mutation is utilized for route obfuscation, which is based on overlapped routes, energy consumption, reliability of nodes and link costs.

In [12], the impacts of WSN strategies and topologies upon healthcare management and prognostics are discussed. Different coverage strategies are discussed in the literature and this work claims that these approaches are not neutral for prognostics. A trust management based hierarchical routing protocol is presented in [13]. This work is based on dynamic CH nodes, energy backup and node density. A topology control algorithm is presented for IOT based WSN applications in [14], which modifies the LEACH algorithm. This work can effectively manage the dynamic network such that the transmission range is changed instantly.

A fault tolerance scheme based on planar topology is proposed in [15], which can preserve coverage with a face structured topology. The objective of this work is to handle faults and to preserve the durability and reliability. In [16], topology discovery and data forwarding protocol is presented. In [17], an extended topology based cryptographic scheme is presented on the basis of lightweight cryptographic scheme. The considered aspects of cryptography are confidentiality and authentication. This work presents a hybrid cryptographic scheme namely topology authenticated key scheme, which utilizes topology authenticated keys.

In [18], a fuzzy analytical hierarchy process is presented for topology control is presented for WSN. The network topology is formed by considering energy backup, transmission power, node degree and depth. The weight vector is computed by a fuzzy judgment matrix and the network topology is constructed. A topology modification strategy is presented for WSN in [19]. This work considers different attacks by involving two operations such as high degree operation and degree associativity operation. All the nodes maintain the nodal degree and this leads to include scale-free properties.

In [20], a topological localization technique is presented. This work presents a clock pattern based sensor deployment and the CH node plays the role of CH and associate CH. A coverage and connectivity based technique to improve network lifetime is presented in [21].

This paper proposes an energy-efficient Trustworthy Intra Cluster Management Scheme (TICMS) inspired by these research works. Clustering saves energy in the suggested approach. Energy utility pattern selects CHs and the number of working nodes is adjusted to maximize energy conservation

3. Proposed Trustworthy Intra Cluster Management Scheme (TICMS) for WSN

The purpose of this part is to illustrate the general flow of the work as well as the operating strategy behind it.

3.1. Work Overview

The primary objective of this study is to present a trustworthy intra cluster management scheme, which preserves energy and as a result, extends the lifetime of the network. The nodes are grouped together into clusters, according to the regions in which they are located geographically. The area of the network is divided up into a number of grids in square shape. Because the coordinates of the nodes' locations are so important to the operation of the clustering process, the mobility of the nodes has no effect, whatsoever on the operation of the clustering process. The functioning characteristics of the suggested algorithm can be broken down into network area segregation, cluster building and routing phases.

Initial network grids are square in shape and the count of Cluster Member (CM) nodes vary through grids. Selecting a CH node to manage and regulate member nodes is the next step. Thus, selecting the CH node is critical. The CH node oversees CM nodes, making node misbehaviour easy to spot. The CH node regularly checks its CM nodes to block suspicious nodes. Clustering also improvesscalability, maintenance, and energy efficiency. The CH node controls states (sleep or work) of CM nodes. Every grid has a limited number of working nodes thus the rest of the nodes are maintained in sleep state. The working nodes are regenerated when their energy drops below the threshold or the timeperiod expires. Two nodes are allowed per grid and this idea results in energy conservation and networklongevity. The work's assumptions and all steps are detailed here.

- The network consists of a mobile base station, which is outfitted with a significant amount of backup power.
- The sensors in the network are permanently installed and do not move.
- Every node that is a member of the network is aware of the locational coordinates of its own position, and these nodes are clustered according to the position of their own locational coordinates.

- The network's nodes have the potential to take on either the function of the CH or the CM.
- A CM node has the ability to transmit the packet straight to the CH node.
- The data is transmitted to the BS from the CH node by way of the other CH nodes.
- Due to the fact that the nodes participating in this effort are not dynamic, the nodes are distributed consistently across all of the grids.
- The number of working nodes per grid is required to be a minimum of two at all times.

3.2 Network area Segregation Phase

The primary objective of this stage is to subdivide the total network area into grids of comparable dimensions. The formation of a cluster by the nodes that are located in a specific geographicarea is the aspect of this method that is particularly remarkable. A further essential aspect is that there is no predetermined limit to the number of nodes that can be contained inside a grid. There is no set limit to the number of nodes that can be contained within a grid; nevertheless, the bare minimum is two nodes per grid. As a result, there may be an excess of nodes in some clusters, while other clusters mayhave a shortage of nodes. This study, in an effort to address this problem, distributes the nodes among the grids in a consistent manner. Every single one of these works' grids has a predetermined number ofnodes placed into it. Because the process of clustering is dependent on the coordinates of the locationsof the nodes, the mobility of the nodes does not impact the cluster process. The nodes may have a highdegree of mobility or may have no mobility at all. Nevertheless, the immobile nodes are used in this paper, and the mobile Base Station (BS) is the only component. The network space is partitioned into many grids, each of which has the same size as the others. The sensors are dispersed uniformly over each and every grid.

3.3 Cluster Building

The establishment of the cluster of nodes concerning the geographical coordinates removes any complexity that may have been present in the cluster formation process. The selection of the ideal CH node, on the other hand, can be difficult. The reason for the need of CH recycling is that the power of a single node will be depleted. As a result, it is essential to reuse the CH node according to a set of predetermined standards. The CH node is recycled as a result of this work by making the time threshold or the energy threshold the recycling criterion. In this phase of cluster development, there are three sub- phases involved, and those are the phases of selecting the CH node, operations of CH as well as the node status management. Sample illustration of clustering is depicted in figure 1. The following sub-sections will provide a description of each of the sub-phases.

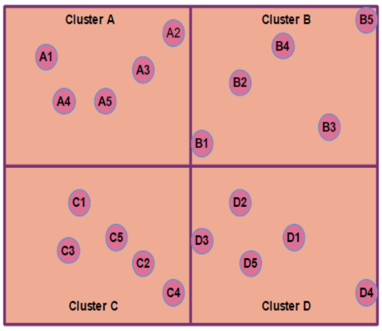

Fig.1. Sample illustration of clustering

3.3.1 CH Node Selection Process

In this work, the node cluster has already been built by taking into account the location coordinates. The selection of the CH node is an extremely important task, due to the fact that the CH node needs to be able to oversee all of the CM nodes. The CH node is chosen by this work by taking into consideration the energy consumption pattern of the other nodes. When the behavior of the nodes is watched for a particular amount of time, only then will it be possible to frame the pattern of energy use. Therefore, at the beginning, the behavior pattern of each of the nodes is scrutinized for a period oftime denoted by t_i

$Strt\_msg$ includes the distinctive identity of the node, as well as the available energy $avl\_$ is passed around by each and every one of the nodes that are part of the network. The $Strt\_msg$ is sent out to all of the nodes in the grid. As a result, a great number of nodes obtain $Strt\_msg$ from the nodes in close proximity. When a node receives $Strt\_msg$, the signal power is used to calculate the distance between the receiving node and the node that transmitted the message. It is possible to calculate the node's typical pattern of energy using

$$erg_{crate}(i) = \frac{cons_{erg\ (i)}}{avl\_erg(i)} \quad (1)$$

$erg_{crate}(i)$ represents the rate of energy consumption by the ith node, $cons_{erg(i)}$ indicates the amount of energy used by the ith node and $avl\_erg(i)$ indicates the amount of energy that is accessible. The following equation can be used to calculate the amount of time necessary to broadcast the $cnmsg$, which is what makes up the node's unique identifier.

$$btime_t(i) = erg_{crate}(i).\,rand \quad (2)$$

$rand$ is the random number generator, and its values range from 0.5 to 1. The $rand$ is designed to prevent the $cnmsg$ from being sent at the same time as other messages, which will in turn reduce the number of collisions that occur. In addition to this, there is a considerable decrease in the amount of energy that is consumed. The smallest energy consuming nodes have a shorter period of time during which they must wait to receive $cnmsg$ than other nodes. Because there is such a small waiting period, it makes perfect reason that the minimal energy using nodes have a low likelihood of receiving $cnmsg$. The fundamental concept that underpins this statement is that the node that uses the least amount of energy should serve as the CH node.

Every node in the network anticipates to receive $cnmsg$ for $btimet$. In connection with this, there are two possible outcomes. The first case involves the nodes that are successful in receiving

$cnmsg$, and the second scenario involves the nodes that are unsuccessful in doing so. After it has been given the $cnmsg$, the node will determine the distance that separates itself from the node that supplied the $cnmsg$. If the node does not receive $cnmsg$, it indicates that it is interested in taking on the position of the CH node in the event that it occurs again. Because the $cnmsg$ is being passed around within certain grids and the $rand$ function is being utilized, this method of circulating the message does not involve any kind of collision.

This work has the goal of choosing the node that is most suited to serve as the CH node, and itis not recommended to keep the same node serving in that capacity for an extended period of time. As a result, it is essential to recycle the CH node according to a set of predetermined standards. The CH node is recycled by the proposed method, which accomplishes this by taking into account two distinct determining factors: the CH node's current amount of available energy and the time slot's impending termination. The required amount of energy is always 0.6, and the allotted amount of time is always two minutes. In the event that the energy threshold drops below the energy threshold, the CH node willsound a warning bell, and the BS will select a new CH node. In the second scenario, the available energy level of the CH node is checked for each time slot, and the BS recycles it, if necessary.The use of this concept saves more energy and will properly manage the communication overhead. In addition to this, the node that uses the least amount of energy is chosen to be the CH node.The performance of the CH node should be higher than that of the CM nodes because, its primary function is to control the nodes that make up the network. This is the reason why the selection of the CH node is given a great deal of careful consideration. The CH node is in charge of determining the state of the CM nodes and is also responsible for computing the trust degree of the nodes that it is composed of. In the following paragraph, the functionality of the CH node is discussed in more detail.

3.3.2 Operations of the CH node

The primary functions of the CH node are to compute the degree of trust held by its CM nodes and to manage the state of those nodes, in order to conserve as much energy. When computing the trust degree of the CM nodes, it is necessary to take important trust metrics into consideration. These metrics include the Packet Forwarding Ratio (PFR) and the Energy Backup (EB). The Bayes' theorem , which was developed by the Rev. Thomas Bayes, is utilized in the process of computing the trust rate.The computation of the trust degree and the state management by the CH node are both presented in the following subsections.

3.3.3 Trust Degree Computation

Following the completion of the process of selecting the CH node, the computation of trust degrees and the maintenance of the state of the CM nodes are two of the most important responsibilities that have been given to the CH node. The computation of the trust degree is required so that the behavior of the nodes can be monitored and the malicious nodes can be identified. When calculating the trust degree of the nodes, it is necessary to take the PFR and EB of the nodes into consideration, because these are two crucial trust metrics. PFR is taken into consideration, since this measure demonstrates the level of cooperation exhibited by the node in the process of packet forwarding. The EB is taken into consideration since meeting this criteria is essential for any node to do the activities that have been delegated to it. In addition to this, the node will not be able to serve its role for an extended period of time if the EB is low. Taking into account the assertion that was just made, these two metrics are selected, and the trust degree is derived using Bayes' theorem, as will be shown henceforth.

$$P\ (td|pfr, e_b) = \frac{P\ (pfr|td, e_b) * P\ (td|e_b)}{P\ (pfr|\ e_b)} \tag{3}$$

The posterior probability is denoted by the symbol $\mathrm{P\ (td|pfr, e_b)}$ in eqn. (3). The prior probability is denoted by $\mathrm{P\ (pfr|td, e_b)} *$ $\mathrm{P\ (td|e_b)}$ is the likelihood and it provides the probability of trust degree for the energy backup. $\mathrm{P\ (pfr|\ e_b)}$ is the normalization factor. $\mathrm{P\ (pfr|td)}$ is the likelihood function of $\mathrm{P\ (pfr|td, e_b)}$.Equation 4 represents the probability of trust degree.

$$P\ (td|pfr, e_b) = \frac{P\ (pfr|td) * p\ (td|e_b)}{p\ (pfr|\ e_b)} \tag{4}$$

$P\ (pfr|td)$ is computed by Bayes' theorem as follows

$$P\ (pfr|td) = \frac{P\ (td|pfr) * p\ (pfr)}{p\ (td)} \tag{5}$$

On applying Equation (5) in (4), Equation (6) is obtained

$$P\ (td|pfr, e_b) = \frac{P\ (td|pfr) * p\ (td|e_b) * P(pfr)}{p\ (pfr|\ e_b) * p\ (td)} \tag{6}$$

After elimination of normalizing factor, Equation 7 is presented.

$$P\ (td|pfr, e_b) = P\ (td|pfr) * P\ (td|P(td|e_b)) \tag{7}$$

By applying this Bayes' theorem, the highest possible level of trust that can be determined is 1. If the in-ratio of packets is the same as the out-ratio of packet and, if the node is operating at full power, then the trust rate is 1. There is a possibility that the trust degree will drop to 0, if the packet delivery ratio and the energy backup are not adequate. The trust degree of the nodes is computed and kept in the CH node using this method. Additionally, the trust degree that has been computed is reported to the BS.Due to the immobility of the nodes, the trust degree does not need to be computed very frequently. In addition to this, there are only few nodes specified to be in an active state. It results in a better reduction of computational and memory overhead. The working nodes in the network are chosen bythe CH node, and their selection is informed by the computed trust degree. The technique for selecting working nodes is going to be discussed in the following section

3.3.4. Node state management

The CH node evaluates the degree to which each of the CM nodes can be trusted before making a determination about the state of the CM nodes. The maximum number of working nodes has been capped at two at all times. After the trust degree has been computed, that value, together with the trust degrees of all of the nodes that make up the CH node, is saved in the CH node.The two nodes with the highest rankings are chosen to be the working nodes for a given time slot. When the energy backup of the nodes drops below the threshold or when the time window has run out, the working nodes are recycled. In the event that the time slot runs out while the energy backup continues to have a higher total than the energy threshold, the same node has the potential to enter working mode. In the event, if both of the working nodes have an energy level that is lower than the energy threshold, the CH node calculates the trust degree and then chooses both of the working nodes once more. On the other hand, the nodes that were already working properly after the first round are not chosen for the second. The various scenarios are discussed in the following paragraphs.

Case 1: Recycle both working nodes

The first sample presents the situation in which the total amount of energy held by both of the nodes that are working drops below the energy threshold either before or after the allotted amount of time has elapsed. In this scenario, the CH node is responsible for calculating the trust degree of the CM nodes, and the nodes that rank highest are the ones that are chosen to serve as working nodes.

Case 2: Recycle single working node

In this scenario, the energy of just one of the two working nodes falls below the threshold for acceptable levels of energy loss. It is possible to release the node's stored energy either while the time slot is still active or after it has ended. As a result, there is just one working node that needs to be chosen.In this scenario, the CH node does a check on the local memory and selects the node with the highest rank as the one that will do the actual work.

Case 3: Recycle no working node

In this particular instance, the scenario in which the recycling process of working nodes is not necessary. It makes perfect sense that the working nodes have an energy level that is significantly greater than the energy thresholds, and as a result, the same working nodes will continue to run during the following time period as well. The working nodes can then be selected using this method. It has been discovered that a greater amount of energy is conserved as the CH node schedules the working nodes based on the degree of trust that is held in the network. The safety of the process as a whole is ensured by the selection of the nodes that will function based on their trust score. This is due to the fact that any nodes that are found to be engaging in malicious activities are instantly disabled and reported to the BS.

3.4. Routing

As stated earlier, the CM nodes can communicate the CH node alone and the CH node alone can reach the BS either directly or through other CH nodes. The BS is mobile and will reach every grid at regular time interval. Based on the location of the BS, the packet transfer is made. Here, two cases are considered and they are Immediate Data Transfer (IDT) and Delay-tolerable Data Transfer (DDT), which are explained below.

3.4.1 IDT

Suppose when IDT is required, then the location of BS is tracked by the CH. The BS can easily be tracked by the CH node, though it is mobile. Whenever the BS reaches a cluster, the working nodesact immediately. As the network area is separated into grids, the midpoint of the boundary is noted as u, v along x and y axis. With this measurement, the active nodes measure the distance between themselves and the BS. The computed distance is then forwarded to the CH node by all the working nodes. The forwarded packet is named as tt_pkt consists of the distance and the timestamp. The CH node verifies the tt_pkt and picks the packet with recent information to track BS. This concept is illustrated in the figure 2.

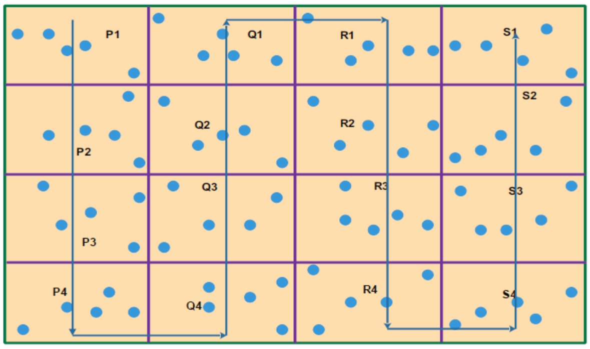

Fig.2. Illustration of BS arrival

Thus, the BS is tracked from the beginning till the end without any hassles. Whenever the BS leaves a cluster, the recent update about the BS is reported to the CH. This improves the detection accuracy and the energy consumption is considerably reduced.

3.4.2. DDT

DDT does not require instant data transfer and hence, the CH collects data from the CM nodes and waits till the arrival of BS. Once the BS reaches the cluster, the CH forwards all the data to the BS. This way of categorized data transfer helps in conserving energy and improves the Quality of Service as well.

4. Results and Discussion

The performance of the proposed work is tested against the existing works GWO based [9], hierarchical routing [13] and hybrid algorithm [4] in terms of energy consumption and network lifetime. In addition to this, the functionality of the proposed work is evaluated by adjusting the number of nodes in each grid as well as the total number of nodes. The proposed work calls for an experimental area that is a square with dimensions of 1000 meters on each side, and each sensor grid covers an area that is 10 meters on a side. The longevity of the network may be determined by varying the total number of nodes from 300 to 2000, with the number of working nodes being changed to 2, 5, and 10 respectively.

4.1 Network lifetime w.r.t working nodes

It is necessary to differentiate the count of working nodes in order to investigate the influence that working nodes have over the course of the network's existence. It has been discovered that the lifetime of the network decreases as the number of nodes that are actively working increases. The experimental analysis is carried out with regard to the length of time spent simulating in comparison to the total number of nodes. The findings of the experiment are depicted in figure 3, which can be found below.

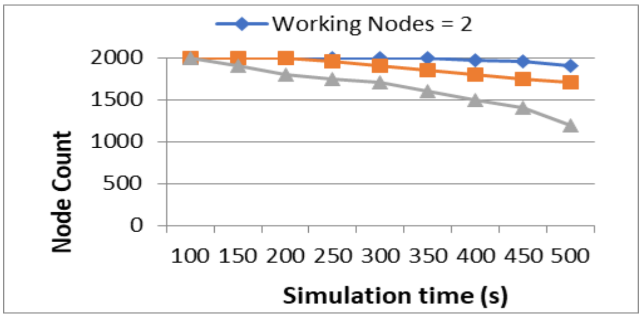

Fig.3. Network lifetime analysis w.r.t working nodes

When looking at the results of the experiments, it is easy to see that the lifetime of the network gets shorter as the number of working nodes is higher. When the number of nodes in the network that are working is capped at 10, the lifetime of the network drops dramatically.

4.2 Network lifetime w.r.t nodes/grid

In order to test how long the network will remain operational, the number of nodes that are being deployed is changed. The number of nodes in each grid is increased or decreased anywhere from 5 to 20, and the lifetime of the network is analyzed. Experiments have shown that if the number of nodes is raised while maintaining the same level of functionality across the network, then the longevity of the network is increased. On the other hand, the longevity of the network is impacted whenever the number of functioning nodes in the network is raised. The outcomes of the experiments are depicted in figure 4

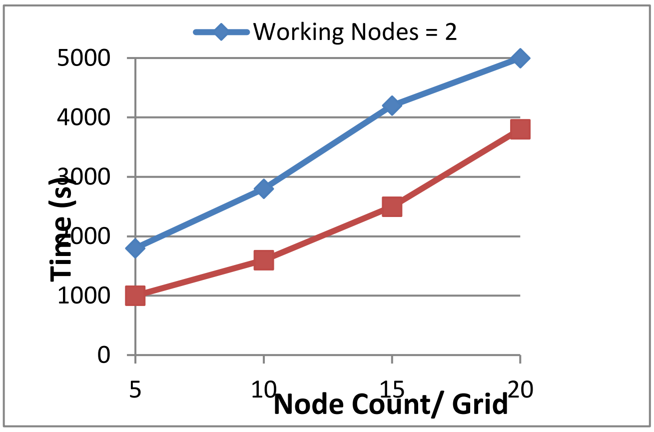

Fig.4. Network lifetime analysis w.r.t nodes/grid

In this investigation, the number of nodes that make up each grid is changed, and the lifetime of the network is measured. According to the findings of the study, the lifetime of the network is extended when the number of nodes in each grid is increased while the number of working nodes is kept to a maximum of 2.

4.3 Packet Delivery Rate (PDR) and Average Latency (AL) Analysis

PDR and AL rates are considered important for any routing algorithm. The PDR of the proposed work is compared against the existing approaches and found to be superior to the existing techniques. The main reason is the categorization of data transfer, which ensures data delivery

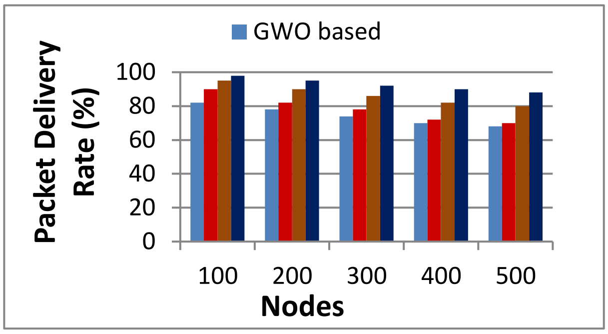

Fig.5. PDR analysis

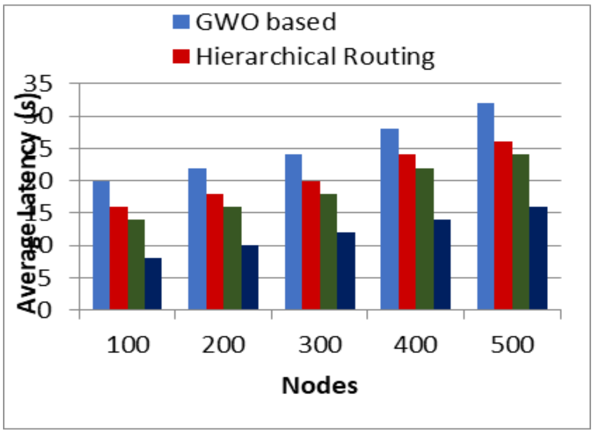

Fig.6. Average Latency Rate Analysis

Hence, the proposed work shows better PDR in reduced AL, when compared to the existing techniques. The following section shows the energy consumption analysis.

4.4 Energy Consumption Analysis

Energy consumption is the most important analysis for any algorithm, as it decides the lifetime of the network. The energy consumption of the proposed approach is evaluated against GWO based [9], hierarchical routing [13] and hybrid algorithm [4]. The energy consumption analysis of the proposed work is shown in figure 7.

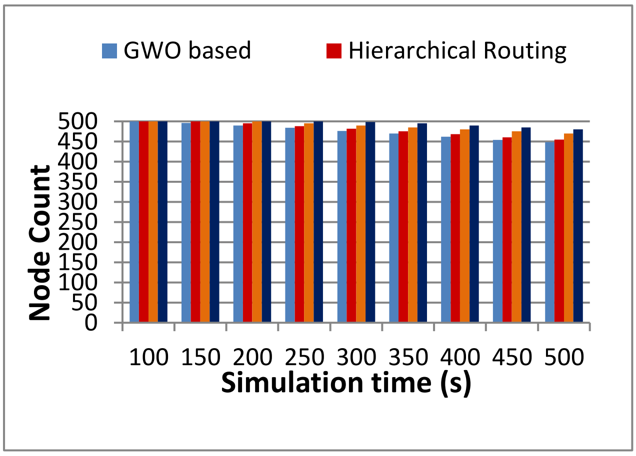

Fig.7. Energy consumption Analysis

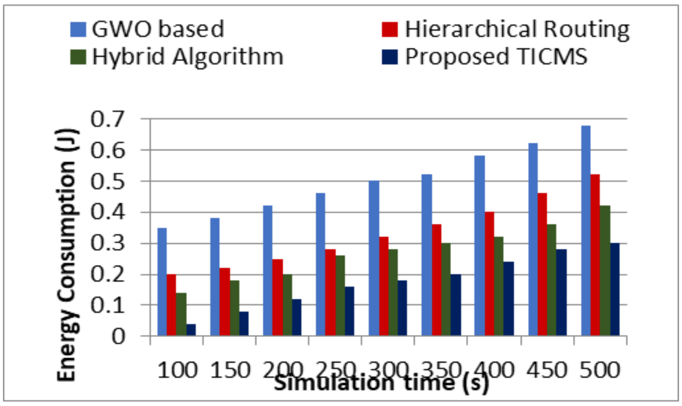

Fig.8. Network Lifetime Analysis

When compared to the techniques, the proposed work consumes minima energy and is evident through the experimental results. This result was achieved by the proposed work as a direct consequence of its control over the count of working nodes per grid. In addition to this, there is no additional overhead involved in the clustering process of the proposed work, because the clusters are constructed in accordance with the geographical coordinates.

4.5. Network Lifetime Analysis

The network lifetime analysis is made with respect to the simulation time. The proposed work is able to manage the status of the node and only permits a certain number of nodes to be in a working state at any given time. Because of this, the longevity of the network is increased. The findings of the experiment are depicted in figure 8 which can be found below.

The implementation of the cluster and trust concepts into the proposed work makes it abundantly clear that the system will have a low impact on the environment in terms of energy consumption. In addition to this, the CH node is responsible for scheduling and controlling the duty cycles of all of the sensor nodes. Because there are fewer nodes that are actively working, the lifetime of the network is significantly increased, and as a result, the goal of the task has been completed successfully.

5. Conclusion

This article presents a Trustworthy Intra Cluster Management Scheme (TICMS), which is cluster-based, trustworthy, and efficient in its use of energy. Because of the presence of an effective cluster formation and trust concept, the proposed work has been demonstrated to be energy-efficient. The network space is partitioned into grids of comparable dimensions, and the nodes are set up over all of the grids. After determining the location ordinates, the cluster is then constructed with that information in mind, and the CH node is chosen. The computation of the trust degree and the management of the state of the nodes are the primary responsibilities of the CH node. The entire procedure does not entail a significant amount of memory or communication overhead, and it does not use a significant amount of energy. The experiment demonstrates that the proposed work is effective. In future, it is possible that the security pattern can be implemented.

6. References

[1] Ijemaru, G. K., Ang, K. L. M., & Seng, J. K. (2022). Wireless power transfer and energy harvesting in distributed sensor networks: Survey, opportunities, and challenges. International journal of distributed sensor networks, 18(3), 15501477211067740.

[2] El Khediri, S. (2022). Wireless sensor networks: A survey, categorization, main issues, and future orientations for clustering protocols. Computing, 104(8), 1775-1837.

[3] Dogra, R., Rani, S., Babbar, H., & Krah, D. (2022). Energy-efficient routing protocol for next-generation application in the internet of things and wireless sensor networks. Wireless Communications and Mobile Computing, 2022.

[4] Kumar, A., Webber, J. L., Haq, M. A., Gola, K. K., Singh, P., Karupusamy, S., & Alazzam, M. B. (2022). Optimal cluster head selection for energy efficient wireless sensor network using hybrid competitive swarm optimization and harmony search algorithm. Sustainable Energy Technologies and Assessments, 52, 102243.

[5] Nobar, S. K., Mansourkiaie, F., & Ahmed, M. H. (2020). Packet dropping minimization in energy harvesting-based wireless sensor network with linear topology. IEEE Access, 8, 38682-38691.

[6] Ndiaye, M., Abu-Mahfouz, A. M., & Hancke, G. P. (2019). SDNMM—A generic SDN-based modular management system for wireless sensor networks. IEEE Systems Journal, 14(2), 2347-2357.

[7] Nguyen, T. T., Kim, T., & Kim, T. (2020). A distributed TDMA scheduling algorithm using topological ordering for wireless sensor networks. IEEE Access, 8, 145316-145331.

[8] Lee, M. Y., Azman, A. S., Subramaniam, S. K., & Feroz, F. S. (2020, March). Performance analysis of linear topology wireless sensor network in oil and gas industry. In IOP Conference Series: Materials Science and Engineering (Vol. 765, No. 1, p. 012070). IOP Publishing.

[9] Ghorpade, S. N., Zennaro, M., & Chaudhari, B. S. (2019). Binary grey wolf optimisation-based topology control for WSNs. IET Wireless Sensor Systems, 9(6), 333-339.

[10] Singla, P., & Munjal, A. (2020). Topology control algorithms for wireless sensor networks: A review. Wireless Personal Communications, 113, 2363-2385.

[11] Bin-Yahya, M., & Shen, X. (2022). Secure and energy-efficient network topology obfuscation for software-defined WSNs. IEEE Internet of Things Journal.

[12] Farhat, A., Guyeux, C., Makhoul, A., Jaber, A., Tawil, R., & Hijazi, A. (2019). Impacts of wireless sensor networks strategies and topologies on prognostics and health management. Journal of Intelligent Manufacturing, 30, 2129-2155.

[13] Fang, W., Zhang, W., Yang, W., Li, Z., Gao, W., & Yang, Y. (2021). Trust management-based and energy efficient hierarchical routing protocol in wireless sensor networks. Digital Communications and Networks, 7(4), 470-478.

[14] Nguyen, T. N., Ho, C. V., & Le, T. T. (2019, October). A topology control algorithm in wireless sensor

networks for IoT-based applications. In 2019 International Symposium on Electrical and Electronics Engineering (ISEE) (pp. 141-145). IEEE.

[15] Al Aghbari, Z., Pravija Raj, P. V., & Khedr, A. M. (2023). A robust fault-tolerance scheme with coverage preservation for planar topology based wsn. Wireless Personal Communications, 129(3), 2011-2036.

[16] Asakipaam, S. A., Kponyo, J. J., Agyemang, J. O., & Appiah-Twum, F. (2020). Design of a minimal overhead control traffic topology discovery and data forwarding protocol for software-defined wireless sensor networks. International Journal of Communication Networks and Information Security, 12(3), 450-458.

[17] Tiberti, W., Caruso, F., Pomante, L., Pugliese, M., Santic, M., & Santucci, F. (2020). Development of an extended topology-based lightweight cryptographic scheme for IEEE 802.15. 4 wireless sensor networks. International Journal of Distributed Sensor Networks, 16(10), 1550147720951673.

[18] Huang, Y., Tang, B., Deng, L., & Zhao, C. (2020). Fuzzy analytic hierarchy process-based balanced topology control of wireless sensor networks for machine vibration monitoring. IEEE Sensors Journal, 20(15), 8256-8264.

[19] Hu, S., & Li, G. (2020). TMSE: A topology modification strategy to enhance the robustness of scale-free wireless sensor networks. Computer Communications, 157, 53-63.

[20] Mohapatra, H., Rath, A. K., Lenka, R. K., Nayak, R. K., & Tripathy, R. (2021). Topological localization approach for efficient energy management of WSN. Evolutionary intelligence, 1-11.

[21] Serper, E. Z., & Altın-Kayhan, A. (2022). Coverage and connectivity based lifetime maximization with topology update for WSN in smart grid applications. Computer Networks, 209, 108940.