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RESEARCH ARTICLE

Energy Efficient Trustworthy Target Tracking Scheme (3TS) Based on Clustering and Task Cycle Scheduling for Wireless Sensor Networks

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Abstract – One of the notable uses of Wireless Sensor Networks (WSN) is target detection and tracking. The primary objectives of a target tracking system are to improve target tracking precision and network longevity. This paper presents a Trustworthy Target Tracking Scheme (3TS) for WSN. The entire network region is divided into several grids of equal size, with each grid functioning as a cluster. All the grids include the same number of nodes. A Cluster Head (CH) node is selected for each grid based on the level of trust. The CH node determines the minimum number of active nodes per grid and regulates node activity. Together with the active nodes, the CH node identifies and tracks the target. In addition, the CH node informs the surrounding clusters that the target may cross. This concept enhances the accuracy of detection. Utilizing task cycle scheduling and a clustering approach, this work significantly increases the network's lifespan. The performance of the suggested work is justified in terms of detection accuracy, energy consumption, and network lifetime. The experimental findings demonstrate the effectiveness of the proposed method.

Index Terms – WSN, Target Detection, Target Tracking, Clustering, Task Cycle Scheduling, Energy Efficiency.

1. INTRODUCTION

Numerous sensor nodes comprise a Wireless Sensor Network (WSN), and the tasks of the sensor nodes vary depending on the application. Essentially, a sensor node can collect data from the surrounding environment, partially process the data, and transmit the information. Communication between the sensor nodes enables the process of information sharing. Typically, sensor nodes collect and transmit data to the Base Station (BS). In order to carry out these tasks, the sensor nodes must have a sufficient battery backup. WSN are typically deployed in remote locations where human participation is low. In such circumstances, battery replacement or recharging is impossible. Utilizing the available energy efficiently is therefore a major task for WSN. WSN has a broader range of applications, including environmental temperature monitoring, healthcare monitoring, battlefield sensing, weather monitoring, and target tracking [1-3]. Consequently, WSN involves numerous surveillance applications designed to track a target. The target may or may not be movable. Target tracking is based on the principle that the nodes must be constantly vigilant in order to detect the target's movement pattern. However, energy inefficiency comes into picture when the sensor nodes are always active for target tracking. This has a significant impact on the lifespan of the network, as sensor nodes that continuously detect targets demand more energy [4,5].

1.1. Problem Statement

A basic algorithm for tracking a target includes three key phases: target identification, mobility prediction, and communication. Initially, the sensor nodes must be able to detect the target using an algorithm for target detection. Target movement must be captured by following or tracking the detected target. Finally, the framed path must be communicated with some end terminal. Target tracking's primary obstacles include detection precision, energy efficiency, network structure, etc.

This study intends to propose a clustered target detection and tracking system based on the concept of trust and task cycle scheduling. Due to the inclusion of task cycle scheduling and cluster techniques, the suggested work conserves energy in a better way. The entire work is divided into four major phases, which are network area partitioning and cluster formation, Cluster Head (CH) node selection and recycling, and target tracking.

The objective of the network area partitioning phase is to divide the network area into multiple partitions. This concept

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reaps beneficial characteristics such as modularity, effective management and simplicity. The cluster formation phase tends to generate node clusters for every partition. This method of clustering is effective regardless of the rate of node mobility. As soon as the cluster is formed, the most suitable node must be selected to serve as the CH. This node has authority and control over its constituent nodes. The CH decides the node's task cycle and the sensors detect the target accordingly. Some of the noteworthy points of this work are as follows.

- The process of network partitioning helps in better management of the nodes and faster cluster formation is accomplished.
- The CH is selected on the basis of trust score, such that the reliability is enhanced.
- The trust score of the work is computed by considering the opinions of two sensor nodes, such that correctness of the trust score computation is ensured.
- Task scheduling helps in conserving energy of the sensor nodes by allowing the nodes to be in sleep state, during unnecessary periods.
- The target is detected with better accuracy rates, as the network is partitioned. Besides the movement of target is predicted and notified to the nearby CH nodes.

The remaining parts of this paper are organized in the following way. Section 2 studies the existing literature with respect to target detection and tracking. The proposed target detection and tracking system is described in section 3. The work efficiency of the proposed work is evaluated in section 4 and section 5 concludes the paper.

2. REVIEW OF LITERATURE

This section studies the recent existing literature with respect to target detection and tracking systems.

The authors of [6] proposed a dynamic clustering method that they referred to as EEAOC. In this method, the CH re-adjustment and cluster migration techniques were used to activate relevant clusters for continuous event monitoring by using a clustering scheme that involved two logical overlapping clusters. Within EEAOC, the cluster architecture is able to be altered based on the mobility of the target with a minimum amount of additional communication burden.

The authors of the article [7] developed a dynamic clustering technique known as EEDC for the continuous surveillance and monitoring of events and targets. In EEDC, the overlapping cluster structure was dynamically reconstructed to meet the shifting positions of targets, and possible CHs were selected via rough fuzzy C-means (RFCM) and a genetic algorithm. This was done in order to handle the shifting locations of the targets (GA). When compared to other clustering methods, EEDC has the potential to significantly reduce the amount of energy that is consumed by the system.

A dynamic chain-based sensor collaboration (DCBC) methodology was proposed for target tracking by the authors of [8]. This approach is a useful benchmark for various clustering algorithms. When compared to clustering, chain topologies are distinguished by a significantly higher number of nodes than are necessary and by transmission delays that are not acceptable. Because of this, the authors of DCBC decided to avoid recreating the chain structure and instead make dynamic changes to the topology of the network by removing and adding nodes. The results of the experiments showed that DCBC has the potential to reduce and even out the network's overall consumption of energy.

According to the research presented in reference [9], an energy-efficient adaptive clustering system (EEAC) for target tracking with an adaptable cluster size is proposed. The goal of this system is to achieve great tracking precision while maintaining a low overall energy consumption. In this study, a model for predicting the position of the target is presented, as well as descriptions of the development of adaptive clusters and the selection of CHs. It was observed that the EEAC used a noticeably lower amount of energy compared to other methods.

Bhagat came up with a tracking method in the paper [10] that made use of state prediction technologies and the Particle Swarm Optimizer (PSO). The goal of the method was to achieve coordination between nodes and continuous target tracking. The author applied state prediction technology to identify goal trajectories and PSO to optimize network topology during tracking in order to reduce overall expenditures. The results of the tests showed that the technology being offered possesses a high level of energy management capability and has the potential to effectively extend the lifetime of a network.

A strategy known as fault-tolerant sensor scheduling (FTSS) was presented in [11] with the intention of lowering the probability of losing a target during target tracking in WSNs. FTSS was used to create the fault-tolerant domain, and the binary Gray Wolf Optimizer (bGWO) was applied in order to activate the optimal tracking node set. Experiments showed that minimizing the possibility of target loss using FTSS not only increases tracking precision but also minimizes the additional energy consumption brought about by the recovery process. This reduction in energy consumption was brought about by the recovery process.

The enhanced LEACH-MTC algorithm, which is offered in [12] and is based on the LEACH protocol, can be found there. First, by employing the extended Kalman filter, often known as EKF, it is possible to forecast the target's future location.

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An elliptical monitoring region that is aligned with the target's movement was generated after the target's expected condition and the results of collaborative monitoring were combined. It has been discovered that LEACH-MTC can increase the number of nodes that survive and reduce the amount of energy used by the network.

A method for detecting space-moving targets is provided in [13], and it makes use of an approach known as Modified Keystone Transform Matched Filtering (MKTMF). Doppler ambiguity and aliasing make the detection of moving targets a very difficult problem to solve. As a result, the MKTMF approach is utilized in this work so that the validity of the work may be assessed. The focus of this work is on high speed targets. In the study that is reported in [14], which attempts to detect small targets on InfraRed (IR) pictures, a Weighted Three-Layered window Local Contrast Method (WTLLCM) is used. This method was developed by the authors. WTLLCM is a technique that is used to deal with the background clutter of IR images. During this technique, the images are filtered, and then the local contrast is measured. After that, the local contrast map is evaluated, and the targets are found.

A Double Dictionary based Non-linear Representation model for Target Detection (DDNRTD) is reported in [15]. This model is used for target detection. In this case, the spatial attribute is taken into consideration in order to differentiate the targets from the background. The Spectral Angle Distance (SAD) and sparse representation are both incorporated into the model for the generation of the dictionary. [16] Presents a model for the detection of targets that is based on the use of distributed sensor networks. This work makes use of the localization technique, the quality of correlation, and an algorithm called "multistatic range only track association."

In [17], an algorithm for detecting targets that takes into account the characteristics of the targets is provided. In the beginning, a space target model is used to determine the properties of the image, and operators are used to obtain the approximate center points of the targets. The local regions that are immediately next to these spots are extracted and given a normalized value. In order to detect the target, certain features, in addition to the information regarding its scale, are retrieved.

Using an improved version of the Glowworm Swarm Optimization (GSO) algorithm, the authors offer a method for the detection of multiple targets [18]. In this study, the GSO-Mutation (GSOM) algorithm as well as the GSO-Mutation Linearly Decreasing Weight are analyzed (GSOMLDW). On the basis of the hybrid filter algorithm, the multi-target tracking and detection scheme that is presented in reference [19] is described. When it comes to tracking the targets, the Kalman filter is used.

On the basis of compressive samples, an improved method of target detection and tracking is provided in reference [20]. For the purposes of target recognition and tracking, an Optimal Bayes Joint Decision and Estimation (JDE) architecture is utilized. A method for the detection and tracking of moving targets is presented in reference [21], which takes into account the context information. At the outset, the posterior probability of the target location is determined, and an estimate of the target's state is derived using the spatiotemporal information that is local to the area. The target detector looks through the frames to find the target, and the integrator works to pinpoint the best possible placement for the target. During this phase of the learning process, training samples are generated, and the detector is given an update. The summary of related works is tabulated in Table 1.

Table 1 Summary of Related Works

Routing Technique	Efficiency In Energy	Complexity	Scalability	Advantage	Disadvantage
EEAOC [6]	Lower	Better	Lower	Chooses CHs that have a lower mobility ratio	Use more energy to determine CH Node
EEDC [7]	Poor	Lower	Better	Utilize Scalability of network	Consume a lot of power ineffective speed of transmitting
RFCM [7]	Lower	Lower	Poor	Utilizing Remaining Power and Mobility to Choose CHs	Ignore the issue with the crucial networks

DCBC [8]	Poor	Lower	Better	Time complexity	Lead to Connection Failure
EEAC [9]	Poor	Poor	Lower	Distribute the energy usage	Limited Complexity
PSO [10]	Lower	Higher	Better	Network lifespan	Mobility to select CHs
FTSS [11]	Poor	Poor	Better	To extend Scalability	Limited Complexity
LEACH-MTC [12]	Lower	Poor	Higher	Not Demand knowledge of the world Networks	Use more energy to determine each SN
MKTMF [13]	Lower	Poor	Better	Analyzed the connection among neighbour Router	Low Complexity
WTLLCM [14]	Better	Poor	Higher	Enhance cluster stability improved energy	Techniques get more scalability
DDNRTD [15]	Moderate	Lower	Higher	Reduce data delay and packet loss	Don’t think about security issues
GSO [18]	Moderate	Lower	Moderate	Networks energy use is improved	Use more energy to determine Speed ratio
JDE [21]	Moderate	Lower	Moderate	Ensure network consumption is balanced while addressing the hot spot issues	Low Scalability

Motivated by these existing works, this paper presents an energy efficient target detection and tracking technique based on the processes of clustering and task cycle scheduling. The proposed target detection and tracking scheme is described as follows.

3. PROPOSED TARGET DETECTION AND TRACKING SYSTEM

The fundamental purpose of this study is to devise a target tracking technique for WSN that is accurate as well as efficient in terms of its use of energy. The goal can be accomplished by breaking the task down into its component steps, which include the development of network area partitions and clusters, the selection of CH nodes for recycling and reuse, and the tracking and detection of targets. The network area partitioning and cluster construction phases both adhere to the divide-and-conquer strategy, which makes it easier to administer and maintain the nodes in the network.

In addition to this, the fact that each grid is assigned the same weight contributes to an increase in the task's overall efficiency. Each grid serves as a cluster, and each grid has the same number of nodes distributed throughout it. Calculating the degree of trust held by the BS, results in the discovery of the CH node. The trust measurements, which include energy backup, packet delivery rate, and node loyalty, are what determine the degree of confidence in a network. The CH node will always be the node in the network that has the highest degree of confidence. The CH node is in charge of supervising the operations of the member nodes, which are the cluster nodes that remain when the CH node is removed. This CH node contributes to the process of locating and following the target. Because dependability and the accuracy

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of target detection are currently being prioritized, the most trustworthy node is selected for identifying and following the target. The model of the system is presented in the following manner.

3.1. System Model

For the purpose of locating a mobile target $\mathcal{M}_t$, this study sets up a large number of stationary sensor nodes across a broad area. The network space denoted by N_a is partitioned into a number of grids with a square format denoted by $N_a = \{N_1, N_2, \dots. N_x\}$. Every grid has the same amount of sensor nodes distributed throughout it.

Each grid is treated as its own cluster, and inside each cluster, a CH is assigned to monitor the individual nodes that make up the cluster. The Base Station (BS) travels to each grid at predetermined intervals and can be considered movable. Calculating a trust score is the first step in determining the CH. The CH is recycled at regular intervals so that we may save money and reduce our carbon footprint. Figure 1 illustrates the process through which the work is completed in its entirety.

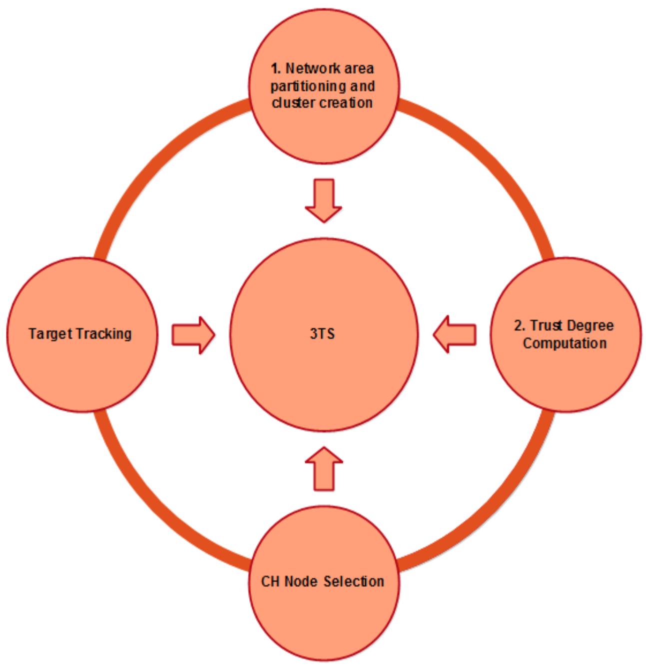

Figure 1 Overall Flow of the Work

In addition to this, the CH is recycled if the energy level of the node drops below a predetermined threshold. The CM can take on either an aggressive or a passive role depending on the situation. The nodes that are in the active state are participating in a task cycle, while the nodes that are in the passive state are conserving energy by not participating in any activities. In this study, two separate kinds of nodes known as worker and boundary line nodes are created. The worker nodes that are positioned inside the cluster and the border nodes that are located on the outside of the cluster's boundaries. The building of clusters is discussed in the subsequent sections.

3.2. Cluster Creation

The stationary sensor nodes spread across a large region are able to pick up on the mobile target $\mathcal{M}_t$ in a wide area. The network space denoted by N_a is partitioned into a number of grids with a square format denoted by $N_a = \{N_1, N_2, \dots. N_x\}$. Every grid has the same amount of sensor nodes distributed throughout it. Each grid is treated as its own cluster, and inside each cluster, a CH is assigned to monitor the individual nodes that make up the cluster. The Base Station (BS) travels to each grid at predetermined intervals and can be considered movable. The degree of trust is the input into the calculation that determines the CH. The CH is recycled at regular intervals so that we may save money and reduce our carbon footprint. In addition to this, the CH is recycled if the energy level of the node drops below a predetermined threshold. The cluster member may hold either the active or passive label, depending on the situation. The nodes that are in the active state are participating in a task cycle, while the nodes that are in the passive state are conserving energy by not participating in any activities. In this study, we focus on dissecting two separate kinds of nodes known as worker and boundary line nodes. The worker nodes are positioned inside the cluster and the border nodes that are located on the outside of the cluster's boundaries.

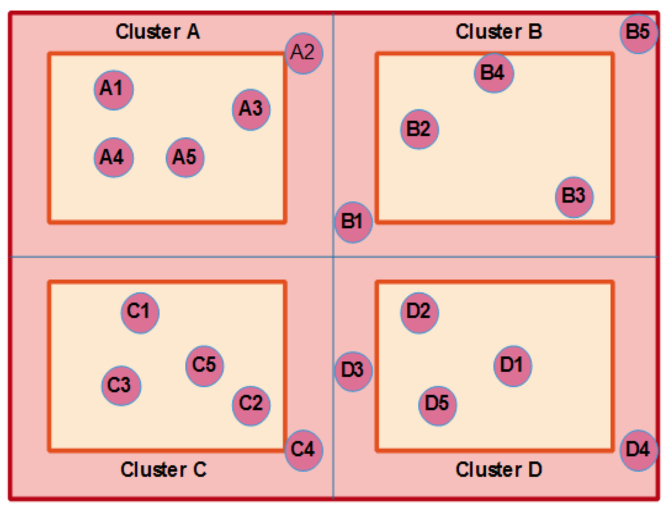

Figure 2 Cluster Creation

The nodes in the Figure 2 that are surrounded by red lines are known as worker nodes, while the nodes that are located outside of the red box are known as borderline nodes. The cluster that is formed by the nodes contained within each grid is denoted by the notation $N_n = \{C_1, C_2, \dots. C_n\}$. The many benefits that are brought to the suggested work by implementing this recommendation are outlined below: The nodes of a grid are taken into consideration when constructing clusters; as a result, clusters can be produced with either mobile or immobile nodes. The technique for clustering is unaffected by the movement of the nodes to new locations. In addition, the overhead that is normally associated with cluster formation is removed. Because the clusters are formed in a streak rather than individually, the energy of the node is not lost in the process. The nodes that are present in each cluster are denoted by the notation $C_n = \{nc_1, nc_2, \ldots . nc_n\}$. The network area is partitioned in this way, and the clusters are constructed in an efficient manner. The process for selecting CH nodes for the cluster according on trust degree computation is going to be presented in the following section.

3.2.1. Trust Index Computation

The trust index of the node is computed using three simple yet potent trust criteria, including battery backup, packet forwarding rate, and loyalty. These trust measures are easily calculable and can effectively determine the nature of the node. The specifics of the trust metrics are provided below.

3.2.1.1. Energy Backup ($\mathcal{E}$)

Since energy is the primary source of life for the sensor node, measuring its availability is one of the most important and vital trust metrics. It is impossible for a node to function properly in the network if it does not have an enough energy backup, and as a result, the performance of the network may decrease. As was said earlier, the value 1 is assigned to a node that has a complete energy backup, while the value 0 is assigned to a node that does not have any energy. As a result, the numbers for the energy backup can be anywhere from 0 to 1.

3.2.1.2. Packet Forwarding Rate ($\boldsymbol{\mathcal{P}}$)

By inspecting the flow of packets, the PFR is able to determine the characteristics of the node in question. Every normal node is obligated to send forth any and all packets that are destined for transmission. Nevertheless, there are situations in which hostile nodes do not respect the role of routing, which results in a huge conundrum. When a node indicates that it is interested in the process of packet forwarding, that node might be considered reliable. Because of this, it is always best to choose a route that has a large number of nodes that can be relied upon.

In order to compute the PDR, both the packet input and the packet outflow must be taken into account. Let's use the abbreviations by $\mathcal{IF}$ and $\mathcal{OF}$ to refer to the inflow and outflow, as given in equations (1) and (2), respectively. The following criterion is met by the normal node in the network.

$$\mathcal{IF} = \mathcal{OF} \quad (1)$$

It is clear that a node is not interested in forwarding packets if the node's packet outflow is less than half of the number of packets it takes in, or even slightly less. This is shown by the subsequent condition.

$$\mathcal{IF} = \frac{\mathcal{OF}}{2} \quad (2)$$

If the $\mathcal{OF}$ rate is lower than half of the $\mathcal{IF}$ rate, then the node is completely unreliable and should not be included in the network because it cannot meet the requirements for participation. When these different sorts of nodes are taken into consideration throughout the process, risk-free and secure data routing can be achieved. As a consequence of this, the PFR is an extra essential trust metric of a node that might potentially improve the route's dependability.

3.2.1.3. Node Loyalty ($\mathcal{N}$)

Node loyalty is an additional significant trust indicator, and it involves analyzing the initial behavior of the node when it was transmitting data. A malicious node, for example, will carry out a variety of unwanted tasks in order to snoop on other nodes on the network or break the network's security. Changing or deleting the sent packets is the method used to achieve this goal. These node behaviors are computed by a process that involves continuously monitoring the activity of the node. A node that has a loyalty rating of 1 is deemed to be completely loyal and does not engage in any behavior that is judged to be undesirable. As a consequence of this, the following trust index is derived using these three trust measurements, as shown in eqn. (3).

$$\mathbb{T} = \frac{\mathcal{E}+\mathcal{P}+\mathcal{N}}{3} \quad (3)$$

By this way, the trust score is computed and is utilized as the fitness value for the choice of CH node. The tasks performed by CH node are presented as follows.

3.2.2. Tasks Performed by CH node

The CH nodes impose the constraint that, when three active nodes exist, two nodes play the role of worker and a single node operates as a borderline node respectively. In addition, the CH node will disable the node if the trust score of the node drops below the threshold of 0.3. The trust degree threshold of 0.3 is determined via trial and error. The following list provides an explanation of some important CH node duties.

- The CH node is in charge of preserving the state of the node, which can either be active or passive depending on the context.
- The CH node determines if the node is in an active or passive state and assigns itself accordingly.

- If the trust degree of the nodes drops below the threshold for trust degree, the CH node is obligated to block the node.
- As soon as it identifies a moving target, the CH node will send an alarm to all of the member nodes.
- The CH node sends a packet to the BS that contains the timestamp and the location of the moving target. In addition, the packet includes a timestamp.
- In order to guarantee precise target tracking, the CH nodes send an alert out to the surrounding clusters every time a target is discovered.

Immediate recycling of the CH node is required in order to prevent an excessively low level of available energy at the node. Every two minutes, the CH node will undergo a regeneration process. However, if the node's energy drops below 0.3 within two minutes, it will be recycled immediately. This will happen automatically. At the outset, all of the network nodes have full power, and the energy value is denoted by the number 1. The overall flow of the work is presented in algorithm 1.

```
Input : Sensor Nodes
Output : Target Detection
BEGIN
//Cluster Creation
 Partition the network space into grids N_a;
 Deploy nodes;
 Compute 𝕋 by eqn.(3);
//CH Activities
 Declare worker and borderline nodes;
 Check 𝕋;
 If (𝕋 > 0.3)
   Disable node;
 Alarm member nodes when target detection;
 Update BS with TS and target's location;
 Alert the surrounding clusters;
 Check ℰ;
 If (ℰ_thr > 0.5) Recycle CH;
 Else
   Renew borderline and worker nodes;
END
```

Algorithm 1 Proposed Target Detection Algorithm

3.2.3. Target Detection and Tracking

The CH node's principal function is to identify the target and then follow it through the other member nodes in the network. In order to keep the flow of energy as efficient as possible, the CH node chooses three nodes from each cluster. The third of the three active nodes has to be the border node, while the other two active nodes have to be worker nodes. Since the bordering node is situated near the edge of the grid, it is possible that the target will either go through it or get very close to it as it makes its way across the map. The worker nodes and the border nodes are renewed after every two minutes. However, in the event that the total amount of energy carried by the active nodes drops below the energy threshold, the nodes will be recycled instantly.

At the outset, the CH node stays active throughout all grids together with the other nodes that are active. Since the target is moving about, it is not difficult for the CH node to locate it. When a moving object comes into close proximity to a cluster, three nodes two worker nodes and one boundary node immediately begin tracking the target. The network region is being subdivided into grids, and the midpoint of each boundary is being recorded as u, v along the x and y axes. By using this measurement, active nodes determine the distance that exists between themselves and the target. After that, the distance that has been computed is sent to the CH node by all three of the nodes. The name of the packet that has been forwarded is tt_pkt, and it includes both the distance and the date. The BS receives a report from the CH node after it has validated the tt_pkt and selected the packet with the most recent information. In addition to this, it sends a notification to the neighboring cluster to ensure that the desired precision in target detection is attained. The concept is depicted in figure 3.

Figure 3 shows that after the cluster P4 finds the target, the active nodes compute the distance between themselves and the target and then send the tt_pkt along with the timestamp to the CH node. This happens after the active nodes have computed the distance between themselves and the target. As a result, the CH node is given three tt_pkts, from which it chooses the most recent one to send to the BS in order to report its status. In addition to this, the neighboring CH nodes of clusters P3, Q3, and Q4 are notified when the target is expected to arrive at their location.

The target moves into Q4 as expected, and then it moves into Q3. The CH nodes of clusters P2, Q2, R2, R3, and R4 are notified when this scenario occurs, and the target travels through R2. At this point, the CH nodes that correspond to Q1, R1, S1, S2, and S3 are active. As a result, the objective may be followed without any difficulty from the beginning all the way through to the end. The most recent information regarding the target is communicated to the BS whenever it departs a cluster that it was part of.

This idea results in an improvement to the detection accuracy, as well as a significant reduction in the amount of energy

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consumed. Only the surrounding clusters are notified when the CH node sends out an alert. It makes perfect sense that the CH nodes of the clusters, which the target is unable to access, do not receive an alert because of this. This concept reduces the tracking area while also conserving energy. By conserving energy in this way, the lifespan of the network is extended to its full potential.

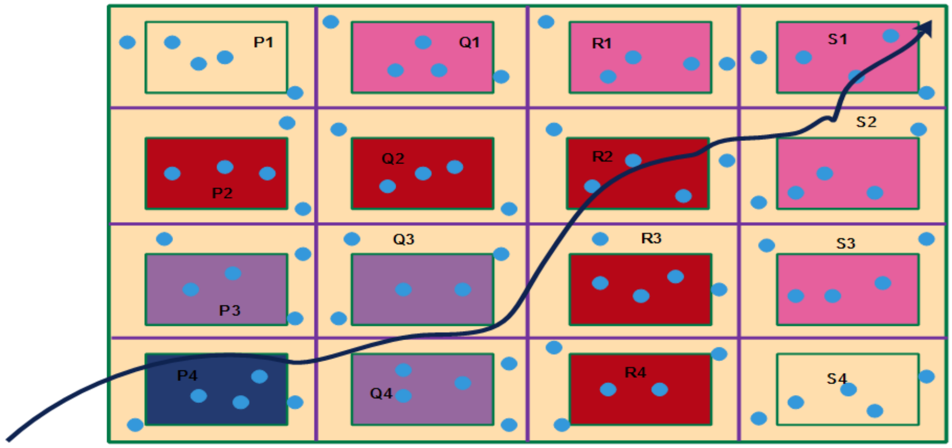

Figure 3 Target Travels

4. PERFORMANCE ANALYSIS

The experimental setup of 100×100 square meters is utilized in order to evaluate the practicability of the proposed work. This network space has been partitioned into numerous grids that are each 10 square meters in size. In order to test how well the proposed strategy works, the number of nodes that are deployed can range anywhere from 100 to 500, and the number of nodes that are actively working can be anywhere from three to ten. At the beginning, each of the nodes receives an initial supply of energy equal to sixty joules. The PPSS [13] and PSO [10] are used as benchmarks against which the energy consumption, network lifetime, and tracking accuracy of the proposed Trustworthy Target Tracking Scheme (3TS) are assessed and compared. The packet delivery and average latency rates are shown in the following figures 4 and 5 respectively. Table 2 shows the simulation settings.

Table 2 Simulation Settings

Parameters	Values
Area	$100 \times 100m^2$
Nodes	500
Worker Nodes	3 - 10
Initial energy	60J
Simulation platform	NS2

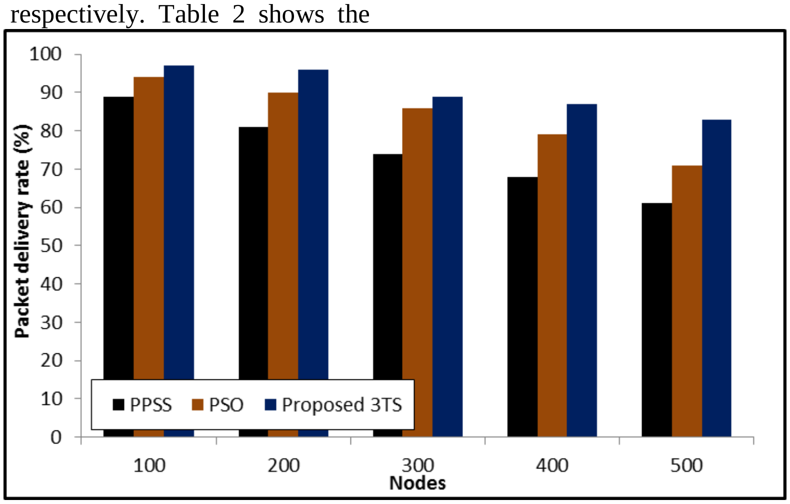

Figure 4 Packet Delivery Rate Analysis

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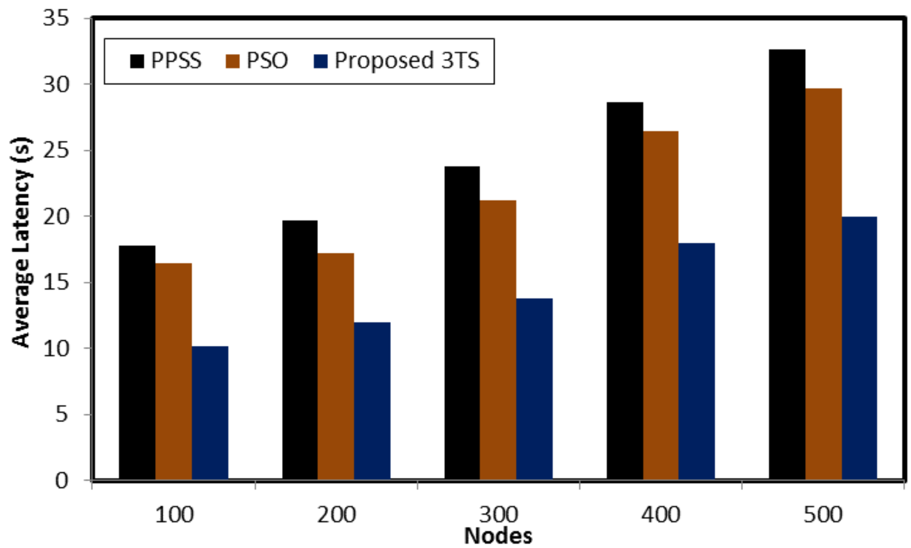

Figure 5 Average Latency Analysis

Figures 4 and 5 represent the average packet delivery and latency rates, where the former determines the communication ability of the sensors and the latter measures the time consumption of the packets to reach the destination. The experimental results show that the proposed work attains better packet delivery rates with reasonable delay. The main reason behind this is the effective partitioning of network area and incorporation of node clusters with different node functionalities.

4.1. Average Energy Consumption Analysis

Because energy consumption has such a big impact on the lifetime of a network, an efficient system for tracking targets needs to use less power than other systems. The average amount of energy that is consumed by the suggested approach is analyzed and compared to the energy consumption of existing procedures. Figure 6 displays the experimental results of an energy consumption analysis.

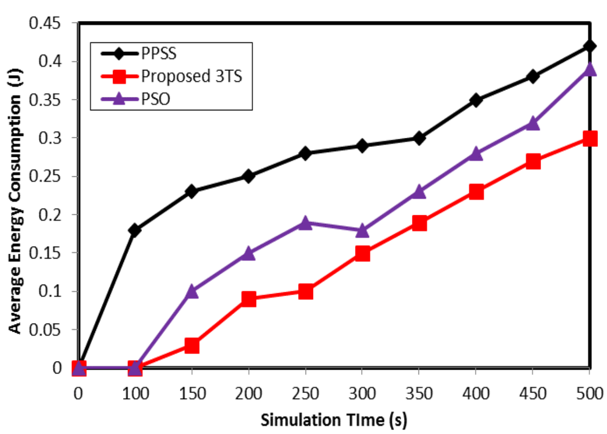

Figure 6 Energy Consumption Analysis

It has been demonstrated that the suggested method uses a cluster-based strategy and schedules the job cycles of the nodes, which results in an extremely low amount of energy consumption. Each grid can have a maximum of three active nodes, two of which must be worker nodes, while the remaining one must be a border node. In spite of the fact that it schedules nodes, the PPSS has a higher energy consumption rate. This is as a result of the fact that it makes use of a bigger number of awakened nodes, which results in an increased demand of energy. PSO does not schedule nodes for anticipating the movement of the target, which is a process that requires significantly more energy.

4.2. Network Lifetime Analysis with Regard to Active Nodes

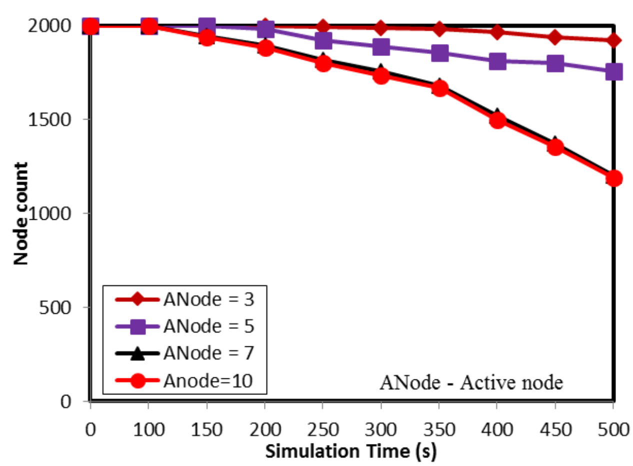

Figure 7 Network Lifetime Analysis by Varying Active Nodes

It is possible to determine the lifetime of the proposed

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approach (3TS) by varying the number of active nodes from 2 to 5, 7 to 10, respectively. It has been observed that the nodes with the fewest number of active connections have the longest longevity. On the other hand, the lifespan of the network is shortened when greater number of active nodes is fixed. The results of the experiment are displayed in figure 7.

The results of the experiments indicate that a significant influence on the longevity of the network can be attributed to the total number of active nodes. When there are three active nodes, there are a total of 1928 living nodes. When there are more nodes that are active in a network, there are less nodes that are still alive. When the number of active nodes is set to 10, the total number of active nodes is lowered to 1186 at the 500th second.

4.3. Target Detection Accuracy

Any target tracking system should first and foremost be designed to detect targets with a reasonable degree of precision in order to fulfill its primary objective. Any target tracking system will have accomplished its mission successfully when the target can be followed without error. The accuracy of the work's detection is evaluated by experimenting with different levels of target motion. In this section, the detection accuracy of the proposed approach is compared to that of other methods that already exist, and figure 8 presents the results of the experiments.

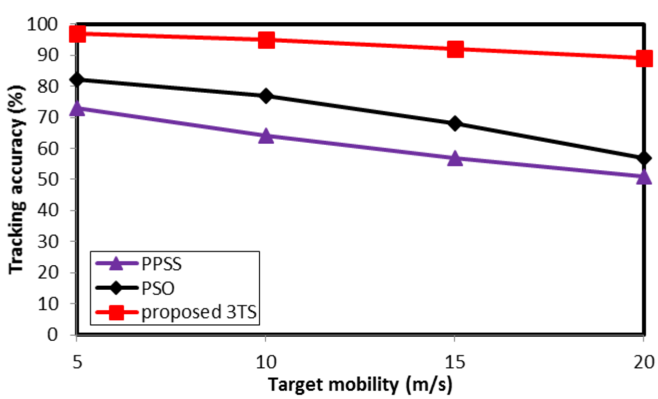

Figure 8 Tracking Accuracy Analysis

The results of the experimental study reveal that the suggested strategy has a tracking accuracy that is noticeably higher than that of comparable tactics. The PPSS has a poor performance since it is unable to determine the curved trajectory of the target. PSO is a better option than PPSS, but not as good as 3TS. The effectiveness of the 3TS is not affected by the target's mobility in any way. The reason for this is because the CH node alerts the clusters that are surrounding it to the possibility that the target would cross. In addition to this, network area partitioning is a crucial factor for enhanced tracking accuracy because it encompasses the entire area. This makes network area partitioning a significant aspect for increased tracking accuracy. Therefore, the suggested strategy is successful in accomplishing its primary aim, which was to improve the precision of target tracking and network lifetime.

5. CONCLUSIONS

This study describes a Trustworthy Target Tracking Scheme (3TS) for Wireless Sensor Networks. The process is subdivided into three primary steps, including network area segmentation and cluster formation, CH node selection and recycling, and target detection and tracking. During the initial phase, the entire network area is divided into grids of equal size, and clusters are constructed. The CH node of each cluster is determined by the degree of trust. The active nodes track the targets and transmit the tt_pkt to the CH node. Along with the timestamp, the tt_pkt contains the distance between the target and the relevant node. The CH node chooses the most recent tt_pkt and notifies the BS. In addition, the CH node warns neighboring clusters to ensure that no targets are overlooked. In the future, this work can be improved by employing optimal methods to choose the active nodes.

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