Optimizing Energy Efficiency in WSN Through A Novel Advanced Optimized Sleep-Scheduler (AOSS) Protocol

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Abstract

Currently, there has been a lot of focus on finding ways for minimizing the consumption of energy over "Wireless Sensor Networks (WSNs)" deployed for surveillance and management. More research and concrete initiatives are required to slow the velocity at which energy is being used up in these WSNs, which typically incorporate rechargeable batteries in the "Sensor Node (SN)". With a sequence of this research, we suggest a new protocol for WSN called "Advanced Optimized Sleep-Scheduler (AOSS)" that uses "Cluster Aggregation (CA)" for minimizing the consumption of energy. The "Time Division Multiple Access (TDMA)" acts as a wake-up scheduler of the "Medium Access Control (MAC)" layer been designed to provide the maximum system throughput and lower energy usage. Every SN merely awakens twice every timeframe, first to receive the input from a neighboring SN and again to transmit information to the "Base Station (BS)", to save power. As soon as the BS comes available, it would wait for the "SYN" signal and then, whether it receives the proper "ACK" in response, will begin transmitting information to the originator SN. In addition, the

"Probability Identification (PI)" with "Sleep-Scheduler (SS)" strategy for reducing SN energy consumption after awakening is deployed. The frequency of awoken SNs inside an active zone would be constrained to reach the goal of SNs having a lower probability and outside of communication range. In this case, the probabilities associated with the target's regime in many sorts of directions are used to choose which woken SN to select. The distance between an awoke SN, as well as the alerting SN, is used to calculate the size of the awakened areas. This allows for effective schedule allotment among states, which reduces unnecessary energy usage. The proposed integrated scheduling method also contributes to lowering the overall cost of energy. Furthermore, we minimize the frequency of woken SN to minimize power usage. We evaluate and compare the capabilities offered by the developed AOSS protocol with those of the current E-BEENISH, DOR, and PAHCR protocols inside WSN, taking into account performance measures including "Energy Efficiency", "Packet Delivery Ratio", "Throughput", and "Routing Overhead".

Keywords: WSN, Sleep Scheduling, Energy Efficiency, AOSS, E-BEENISH, DOR, PAHCR.

1. Introduction

Defense and military-oriented sectors are where WSN adoption first emerged throughout history. The inexpensive expenditure and high functionality of this communication standard make it useful in many contexts. Those WSNs may be utilized for a multitude of tasks which includes a practical volcanic alert device, surveillance of hostile areas, medical centers, and automated traffic administration processes [1]. It takes a combination of SNs with BSs to carry out the necessary tasks in these kinds of scenarios. Almost all purposes involving WSNs necessitate that they function independently for long periods [2].

WSNs' ability to function in hazardous conditions in terms of both infrastructure and network life constitutes one of their major benefits. In contrast, those sensory technologies obtain additional benefits from the implementation of hundreds of low-cost SNs, also including decreased SN expenditures, increased WSN reliability and accuracy, and then a wider sensory coverage [3].

In addition, power, storage, processing capacity, and communication throughput, which are all required for highly effective resource consumption, are often constrained by the cost and size of SNs. WSN performs a crucial part in life and energy, but the prospect of limited energy supplies is a major obstacle to WSN operations [4].

Batteries inside SNs have often been temporary and have a reduced capacity. In particular, after WSNs have been installed, it is typically impractical or impossible to replace or recharge those batteries linked with the SNs. This highlights the importance of these WSNs' potential to save energy [5].

The monitoring, computing, and transmitting of information together in WSN are the most energy-intensive operations. Conversely, an SN takes up approximately 90% of the total energy utilized in transmissions. Accordingly, designing and developing an energy-efficient routing mechanism is crucial for increasing the WSN's lifespan and enhancing its efficiency [6].

Clustering would be a crucial component of the network structure, particularly influencing WSN effectiveness across every context. When a WSN is clustered, the SNs are organized under smaller groups known as "Clusters", and within every Cluster would be a chosen leader known as a "Cluster Head (CH)". The WSNs are primarily responsible for transferring all incoming data, as well as the CHs within every WSN work together to form a cluster. After then, the CHs send streams of data for its BS. Constant data transmission inside a WSN employing multicast connectivity for reaching the BS drains most SNs' energy resources, thus decreasing the WSN's lifespan [7].

Energy-efficient protocols that take advantage of clustering's capabilities, aggregation of data or fusing, and CH selecting mechanisms could extend the operational life of a WSN. It is usual practice for experts to examine, adapt, and enhance LEACH, the most popular clustering-based energy-efficient distributive protocol, and evaluate the effectiveness of other clustering network protocols [8].

Numerous types of research have examined how energy-efficient routing could extend the life of WSNs. But creating an energy-efficient routing technique for WSNs is fundamentally an optimizing issue. Numerous meta-heuristic methods were developed to investigate WSN energy usage, and this research has provided academics with valuable guidance in aspects of energy efficiency [9].

Problem Statement: Researchers have been looking for ways to improve the present protocols because of their drawbacks in terms of energy usage and WSN lifespan. A major problem with such protocols is whether they employ probabilities as the primary factor in choosing which CHs to be using, therefore the criteria for choosing CHs also isn't uniformly distributed throughout the network. As a result, the chosen CHs could be clustered within a particular region of the network at specific times. As a result, it chooses CHs at randomness. The "Residual Energy (RE)" value of the chosen CH is disregarded. Equally a result, SNs having lower energy are as likely to be picked as CHs, while SNs having high RE are not [10].

Disadvantages:

- Most current techniques for choosing CHs ignore the importance of physical proximity. The larger the CH and BS proximity, the greater the energy needed to transmit data between them. As a result, it can't handle the traffic of huge WSNs.
- Since these protocols presume that almost all SNs could interact with one another and thus it could access the BS regardless of its location, the energy usage increases whenever the BS was placed farther away.
- It's important to note that the BS plays no role in choosing the CH. The RE decreases since a lot of energy gets consumed whereas if CH is distant from the BS.

Paper Contribution: Based on these findings, we propose an energy-efficient novel protocol for WSN named AOSS. The following is the AOSS operating principle:

- After waking up, the source SN sends the destination SN a signal called "Synchronization (SYN)", that includes the source's and destination's addresses as well as the "Time Slot (TS)" needed to communicate data, and again it waits for the destination SN to transmit back an "Acknowledgment (ACK)" signal.
- After some period of inactivity known as "State Switch Time (SW)", a sleeping SN will become active and begin listening for the SYN signal. The data transmission process begins once the source SN receives the proper ACK signal.
- Doing this requires every SN to determine its own received weight and would then organize the outcomes in decreasing order.

- Then, the TS is initially allocated to the SN within every cluster that has the most weight, and then the process is repeated for the other SN inside the cluster.
- By designating again a subset of the SNs inside the waking zone as awakened SNs, the actual population of awakened SNs could be lowered much farther.
- Awakened SN could be reduced significantly by picking one according to a probability correlated with the direction of movement.

Advantages:

- Since certain SN wake up more than once throughout a predefined time frame, the conventional scheduling algorithms are incapable of decreasing the energy consumption of every SN.
- By grouping the tasks of several SNs into one coordinated schedule, the proposed AOSS protocol could minimize the amount of energy.

Paper Organization: Most recent research on WSN energy-efficient methods is covered in Section 2, Section 3 provides brief descriptions of the methodologies used in the development of each proposed and existing protocol, Section 4 compares and contrasts the obtained results using these protocols, and Section 5 concludes the article with an outlook on possible future research directions.

2. Related Works

In [11] the authors created a "Cluster-based Two-Level Routing System". They improved packet delivery and reduced energy usage in the proposed technique by clustering, selecting "Backup CH (BCH)" and "Supporting CH (SCH)", and dividing each cluster into four pieces. Two stages comprise the technique. The initial phase entails selecting CHs and BCHs, as well as grouping SNs. Each cluster is divided into four regions to facilitate intra-cluster routing, with SNs either directly communicating with CH or via the most appropriate SN in their region. CHs are tiered according to their proximity to the BS to simplify inter-cluster routing. Considering the RE plus proximity towards the BS, the originating CH selects its subsequent hop from the upper layer of CHs.

In [12] the authors present a "PSO-based energy-efficient Clustering" technique for WSNs. Routing SNs in a WSN is a difficult and complex problem. It is crucial for the network's stability and long-term viability. The "LEACH Protocol" determines the longevity of a WSN by correlating SN's energy consumption. Clustering was designed to decrease intra-cluster distance while increasing WSN energy usage.

To accomplish their aims of lowering energy usage and increasing the lifespan of WSNs, the authors of [13] used AI techniques like "Firefly Algorithm (FA)" and also the "Fuzzy Logic (FL)" to complete the task. FA and FL have been implemented in Stages 1 and 2, correspondingly, of the three-stage procedure. The WSN gets clustered using FA, as well as the pathways connecting CHs both the "Primary Path" as well as the "Backup Path" are discovered using FL. In regular operation, information is transmitted to the BS through the "Primary Path", while the "Backup Path" is activated only in the event of a "Primary Path" breakdown. The final stage is meant to keep the WSN running by beginning the process of route identification over again if a path fails.

In [14] the authors propose a "Fuzzy C-Means Energy-Efficient Hierarchical Clustering and Routing (FCM-EHCR)" that is reliant on the cluster and grid centroid, the remaining SN energy, and the respective "Euclidean Distances (ED)". By utilizing a dynamic grid, energy-efficient routing, and cluster construction, this system optimizes energy use. The fitness values of the SNs were used to assess if they could serve as the CH. The packet routing techniques of all of the CHs are dictated by their ED from one another and also by their RE. Additionally, they looked at power usage and discovered their developed method works effectively, produces more cluster formations, has a longer WSN lifetime, and provides better coverage.

In [15] the authors proposed a strategy for lowering the power usage and extending the WSN's lifespan in both heterogeneous and homogeneous environments. The authors demonstrated an efficient grouping and selection technique for CHs using "Cuckoo" and "Krill Herd". In terms of living SNs, they compared the proposed protocols to current protocols such as "Energy Swarm Optimization-Low Energy efficient hierarchical Clustering and Routing (ESO-LEACH)", "Hybrid Harmony Search Algorithm Particle Swarm Optimization (HSAPSO)", and "Genetic Algorithm based Energy-Efficient Clustering Hierarchy (GAECH)". Additionally, they assessed the efficacy of the recommended regimens.

3. Methodologies

Figure 1 represents the proposed AOSS architecture. In this proposed AOSS protocol, AOSS with CA is used. To achieve this, an efficient allocation of TS in a different state is done to avoid wastage of energy consumption. Even more, the combined use of PI and SS contributes to lower overall energy consumption. Energy efficiency is enhanced by decreasing the frequency of awakened SN. The proposed AOSS protocol was detailed in Section 3.3.

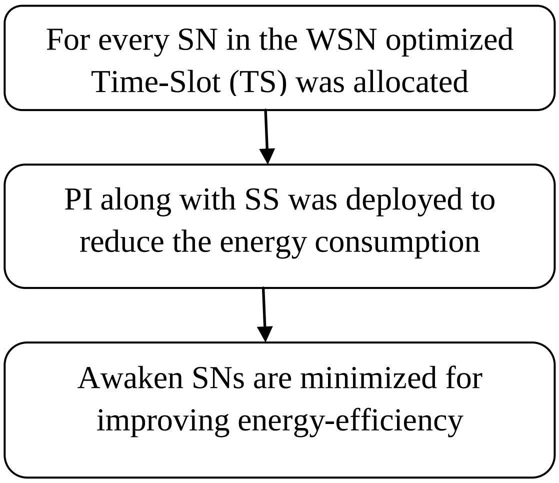

Figure 1. Proposed AOSS Protocol Architecture

3.1. DOR Protocol

The protocol "Clustering Based Dynamic Optimized Routing (DOR)" was proposed existing for enhancing energy-efficiency in the WSN for regular data gathering. While using this method, the whole WSN region is partitioned into "Cluster Regions (CR)", with each CR housing a unique CH. The CH could be able to communicate with the BS more efficiently using this approach. Within the clustering, the SNs respond to the "hello" signal sent by the BS at a predetermined amount of energy to verify their presence and determine their relative location. In particular, the retransmission's RE may be used by the SNs to determine the range between their location and the BS. Utilizing signal computation, the SN may determine the optimal power for communicating with the BS. During some intervals, a fresh CH was selected in a rotational mechanism. Throughout the RE evaluation of CH, an SN only with the highest energy gets chosen first as CH. Only until SN's energy level decreases underneath the cluster mean, it will continue to be labeled as CH. The rotation of the CHs disperses the

SN's entire energy uniformly. Whenever CH is chosen at the highest energy frequency, the longevity of the network could be prolonged. A CH could be chosen concerning certain other CMs in terms of their relative proximity [16].

3.2. PAHCR Protocol

The protocol "Power Aware Hierarchical Cluster Based Routing (PAHCR)" was proposed existing for enhancing energy-efficiency in the WSN. The PAHCR protocol contains two stages of operation: the "Setup Stage (SS)" and the "Steady-State Stage (SSS)". Initially in SS, the SNs were grouped into clusters. When in the next SSS, the message gets transmitted from SNs towards BS. Incorporating the clustering approach into the data collecting and distribution process helps cut down on the overall energy needed for the operation. To take full use of this benefit, the proposed PAHCR groups SNs together into distinct clusters. By accumulating the transmission of lower-energy SNs inside the cluster, the technique often chooses SN as CH which consists of the highest energy. This PAHCR protocol effectively controls energy usage by making use of the SNs during multi-hop connectivity inside a specific cluster and minimizing transmissions to the SiN. Routing and SN's behavior in the multi-hop and multi-level contexts are based on the HCR approach and diverge most sharply from one another. This protocol decreases the WSN's energy requirements and extends its service life by performing the cluster creation and routing stages simultaneously, right after the WSN is set up.

3.3. AOSS Protocol

This proposed AOSS protocol was developed to reduce energy consumption and enhances data rate. Assigning every TS from "$1 \leq t \leq T$" to any of 4 states: "Transmitting State (TrS)", "Receiving State (RS)", "Listening State (LS)", and "Sleeping State (SS)" enables a scheduler to coordinate the operations from all SNs.

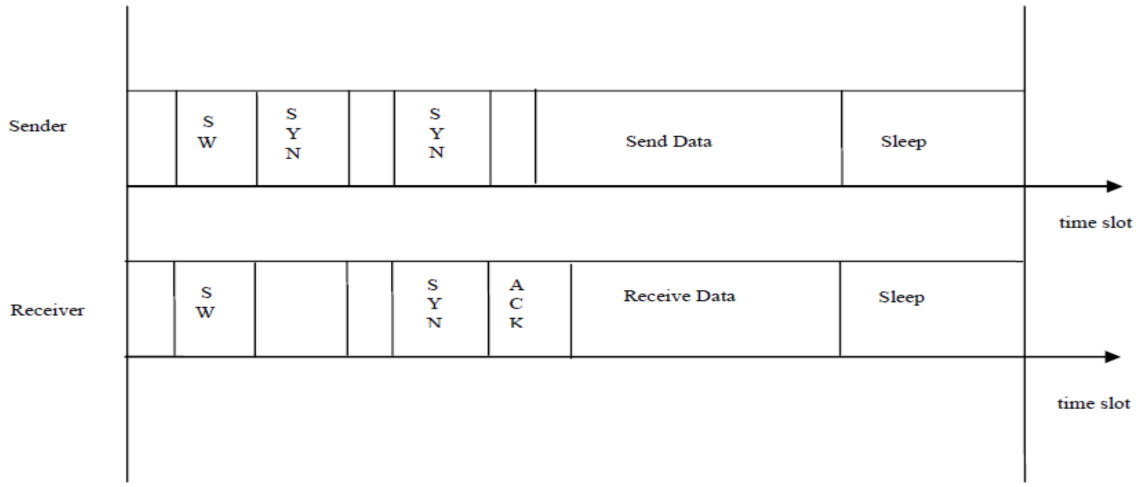

Figure 2. Synchronization activities between two SNs

As TDMA is used, hence no SNs need to stay in LS, in this case, all SNs are synchronized. In case, synchronization is required, SNs can also have added LS to allow adjacent SN to synchronize their activities as shown in Figure 2. This method is comparable to "X-MAC" since it relies mostly on source SN using a small prefix for synchronization of the destination SN.

Whenever a source SN comes back alive, it sends out a signal called "SYN" to initiate a data transmission, and afterward, it waits for a signal "ACK" from the receiving SN. Following a recent SW, the destination SN will become awake, at which point it will wait again for signal SYN and, if it receives a valid SYN, it will respond with a signal ACK. The data transmission process begins once the sender SN receives an accurate ACK signal.

For instance, "$U_{i, S,t}$=1" would indicate that SN "n_i" was set for transmission at TS "t", while "$U_{i, S,t}$=0" would indicate that it doesn't. There are also three more variables, "$U_{i, R,t} \epsilon \{0,1\}$", "$U_{i, P,t} \epsilon \{0,1\}$", and "$U_{i, L,t} \epsilon \{0,1\}$" which indicate whereas if SN "ni" was assigned to RS, SS, or LS at TS "t" or not.

Furthermore, as Table 1 indicates with all of its notation, "$V_{P, S}$", "$V_{P, R}$", and "$V_{P, L}$" reflect energy spent by "State Transition (ST)". The energy needed to transition between an "Active State (AS)" with TrS, RS, and LS toward an "Idle State (IS)" although SS is typically discarded. The time allocation for each SN for one period is shown in Figure 3.

Table 1. Notations used

Symbol	Meaning
$U_{i,S,t}$	Indicator whether node n_i transmitting at time t
$U_{i,R,t}$	Indicator whether node n_i receiving at time t
$U_{i,P,t}$	Indicator whether node n_i sleeping at time t
$U_{i,L,t}$	Indicator whether node n_i listening at time t
$V_{P,S}$	Energy consumption from sleeping to transmitting
$V_{P,R}$	Energy consumption from sleeping to receiving
$V_{P,L}$	Energy consumption from sleeping to listening

It is important to note that energy cost by an "SN (n_i)" in all states is denoted in Equation (1) as:

$$\sum_{t=1}^{T}(U_{i,S,t}\cdot P_{tu}+U_{i,R,t}\cdot P_{rcv}+U_{i,L,t}\cdot P_{Lst}+U_{i,P,t}\cdot P_{slp})\cdot t_s \quad \text{Eq}\rightarrow 1$$

The energy cost for ST is given in Equation (2) as:

$$\sum_{t=1}^{T}(X_{i,P,t}\cdot X_{i,S,t+1}\cdot V_{P,S}+X_{i,P,t}.X_{i,R,t+1}\cdot V_{P,R}+X_{i,P,t}\cdot X_{i,L,t+1}\cdot V_{P,L}) \quad \text{Eq}\rightarrow 2$$

In this context, "T+1" has the value of 1. The primary objective of any given "Schedule (S)" would be to find the best possible balance between those 2 energy-costs.

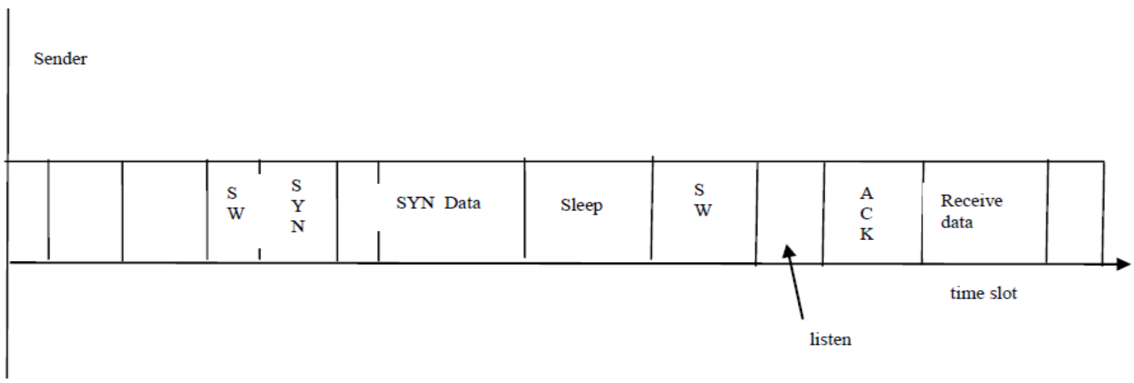

Figure 3. Allocated TS for SN in one period

3.3.1. Sleep Scheduler (SS) with Cluster Aggregation (CA)

Some SN awakens up more than once during a "Scheduling Period (T)", making it impossible for the standard scheduling method to reduce the total cost of energy of all SN. The new SS approach uses less power than previous approaches. This goal is attained by grouping together the time slots covered by a selected group of SNs.

Under "Data Gathering Tree (G)", consider "$I_T(n_i)$" which denotes the collection of SNs that are children of SN "n_i". Hence, it can be concluded that "$I_T(n_i)$" comprises of "Virtual Cluster (V_i)". For each (V_i) cluster, its weight is defined in Equation (3) as:

$$X_i = \sum_{n_j \in I_T(n_i)} x_j \qquad \text{Eq}\rightarrow 3$$

Therefore, the sum of the TSs which SN "n_i" must awaken in sequence to collect the information of its children within "G" was depicted by Equation (3). A portion of "Consecutive TS (X_i)" has been scheduled here to "Cluster V_i" among these children SNs despite arranging the entire TS to every individual child SN from SN "n_i".

Next, a "Consecutive TS (x_j)" has been selected from this part and assigned to every "Child (n_j)". Consequently, throughout that time frame, every child would send its information to its parent during a similar time. Every SN only needs to start waking up 2 times: first to receive all information from its children's SNs, and then again to send that information to their respective parent SN, significantly reducing the amount of energy needed to perform ST.

According to decreasing weights, the cluster has been scheduled. A "first-fit" method is employed to schedule the "Cluster (V_i)". The chunk of TSs scheduled to SNs in "V_i" is the earliest "Consecutive TS (X_i)" such that it will not have any interference with scheduled conflicting clusters.

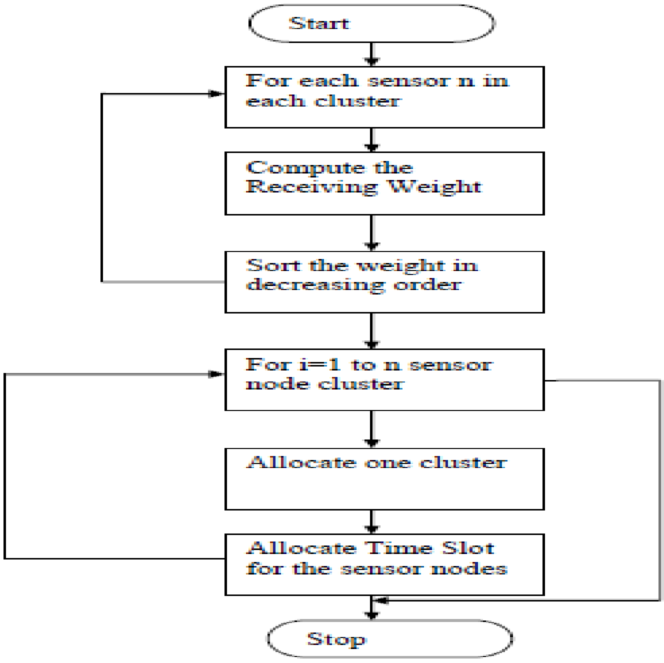

Figure 4. SS Algorithm Flow diagram

Hence, the proposed schedule assures that it will cause any interference in the transmission of any SNs in "V_i". It is important to notice that two conflicting clusters can be scheduled together. For example, consider that "V_1 = {m_1, m_2}", "V_2 = {m_3, m_4}",and each SN requires "x_i=2" TSs for transmission. Also, consider that only one pair of SNs "m_1" and "m_3" cannot be scheduled simultaneously. Then, the following schedule is considered valid: SN "m_1" uses TS "1,2", SN "m2" uses TS "3,4", SN "m_3" uses TS "3,4", and SN "m_4" uses TS "1,2". Figure 4 shows the SS algorithm flow diagram. In this, each SN calculates the receiving weight and then sorts the weight in descending order. Now the SN in each cluster with maximum weight allocates the TM first and it repeats for all the cluster SNs.

3.3.2. Probability Identification (PI)

Two approaches, "Controlling the scope of the awake region" and "Selecting a subset of SNs in an awake region", assist in reducing the actual population of "Awakened SNs". In most cases, the "Transmission Range (Y)" of an SN will be significantly greater than most of its "Sensing Range (y)". So, whenever SNs have been distributed sparsely to guarantee sense scope, a broadcasting alarm signal reaches almost all of the neighbors across the communication range. However, not every one of the neighbors could reliably spot the destination, and few of them have ever seen it. Therefore, those SNs are wasting their time and resources by being in AS. An efficient method is utilized to choose a subset of neighbor SNs to minimize the actual population of "Awakened SNs" and so minimize such wastage.

For a specific amount of time when the "Alarm SN" is in the "Sleep Delay Phase," the destination could travel a distance from it. Since the destination already has departed, there is no point for nearby SNs to awaken. Each of the remaining SNs inside the awake area should be within a single hop of an "Alarm SN" for it to send out its signal. Therefore, a functionally awake zone has to have the form of a ring, defined as the space that separates 2 concentric-circles. Choosing only a subset of the SNs inside the awake zone to be considered "Awakened SNs" is another way to decrease the total number of awoken SNs. The "Awakened SN" could be drastically reduced by picking one relying on a PI associated with the direction of travel.

(i) Constrain Awake Region Scope

Let "q" be the distance of wakened SN from the alarm SN. To ease the computation, assume that the location of the destination SN is comparable to the location of the "Alarm SN". The step involved in the proposed technique to control the awake region can be explained below:

- Determine the range of the "q" value to calculate the "Awake Region's Scope".
- The target then moves by "Dn+1", during "Sleep Delay (LD)".
- Sleep-delayed SN has a "(1-68%)/2=16%" probability of failing to reach the destination whereas if the "$q \geq \eta D_{n+1} - \tau D_{n+1}$" parameter is specified.
- While SNs beyond the alarming SN's broadcast distance can't get awakened, "q≥Y" also comes into consideration.
- Calculate the size of the awake zone using the formula in Equation (4):

$$\{\eta D_{n+1} - \tau D_{n+1}, 0\} \leq q \leq D \qquad \text{Eq}\rightarrow 4$$

Equation (5) could be used to calculate the total quantity of SNs inside an awakening area:

$$\sigma\pi[Y^2 - \max\{\eta D_{n+1} - \tau D_{n+1}, 0\}^2] \qquad \text{Eq}\rightarrow 5$$

The SN density has been denoted by "σ". Figure 5 below depicts the flowchart of the Constrain Awake Region Scope algorithm, which determines how many SNs are accessible in a given awake zone.

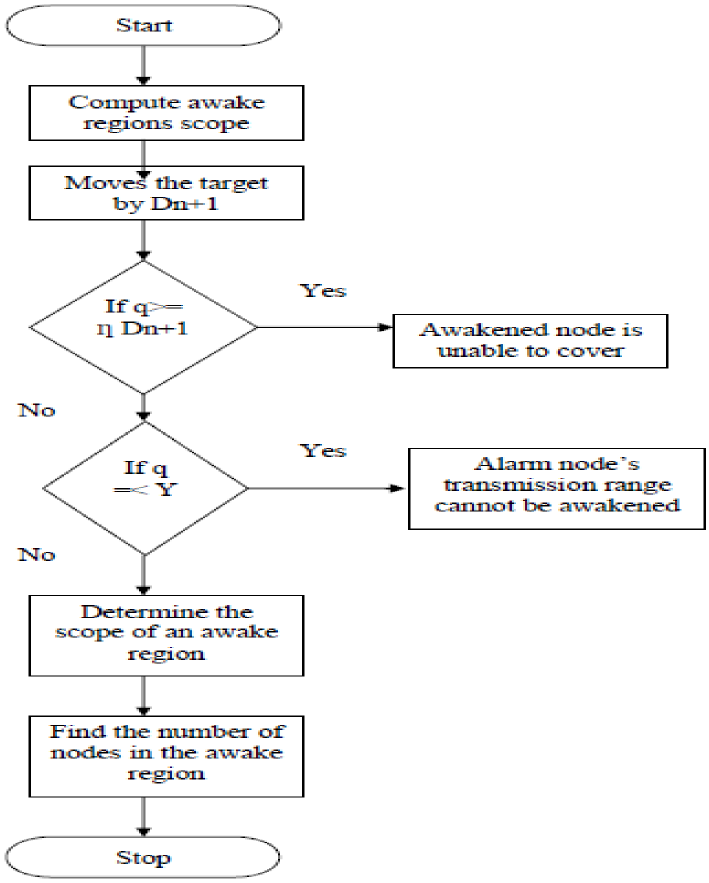

Figure 5. Constrain Awake Region Scope Flow diagram

(ii) Selection of Awakened SNs

The scalar velocity of a target is taken into account while calculating the size of an awakened zone. Equation (6) could be used to calculate the percentage decrement of SN awakenings:

$$\frac{\max\{\eta D_{n+1} - \tau D_{n+1}, 0\}^2}{Y^2}$$

Eq→6

If "Y=60", "ηD_{n+1}= 20", and "τD_{n+1} = 5", then the "6.25%" does not represent a significant improvement in energy-efficiency. The primary purpose of the proposed strategy should be to conserve energy by minimizing the quantity of awakened SN while taking into consideration the prediction performance depending on the direction of motion of awakened SN.

The direction "D_{n+1} as $Z[\Theta_{n+1}]$"represented as "∝" has the greatest possibility of having a target heading along this, causing all SNs going in that direction to become active. The frequency of awakened SN could be minimized because "$[\Theta_{n+1}]$" decreases in a different direction.

As a result, Equation (7) may be used to determine the probability how a "Candidate SN" moving in the "∝+δ" direction will alter its sleeping pattern or transform into an "Awaken SN":

$$B_{cc}(\delta) = \frac{f_{\Delta_{n+1}}(\delta)}{f_{\Delta_{n+1}}(0)} = \begin{cases} -\frac{1}{b}\delta + 1 & (\delta \geq 0) \\ \frac{1}{b}\delta + 1 & (\delta < 0), \end{cases}$$

Eq→7

In which "cc" stands for the scheduling of sleep. As a result, the sum of the awoken SN in a fully alert zone is given by Equation (8):

$$N = \int_{-\pi}^{\pi} B_{cc}(\delta) \cdot \frac{\sigma\pi(Y^2 - \max\{\eta D_{n+1} - \tau D_{n+1}, 0\}^2)}{2\pi} d\delta$$

Eq→8

$$= \sigma(Y^2 - \max\{\eta D_{n+1} - \tau D_{n+1}, 0\}^2) \cdot \int_0^{\pi} (-\frac{1}{b}\delta + 1) d\delta$$

$$= \frac{\sqrt{6}}{2}\sigma\tau_{n+1}(Y^2 - \max\{\eta D_{n+1} - \tau D_{n+1}, 0\}^2))$$

While "Y=60", "ηD_{n+1}= 20", "τD_{n+1} = 5", and " τD_{n+1} = Π/6", the suggested method yields "19%" fewer SNs than the circle scheme. The suggested strategy only requires "19%" of the energy used by the circular method.

4. Results and Discussions

Using networking measures like "Energy Efficiency", "Packet Delivery Ratio", "Throughput", and "Routing Overhead" throughout the WSN, the effectiveness of the already deployed E-BEENISH, DOR, PAHCR, and proposed AOSS protocols are being evaluated. The research was conducted in a simulated environment, and from that environment, numerous cases were drawn. Table 2 lists the simulation settings used in this analysis. All of these protocols using the battery component to construct SNs were put through their paces in the Ns2 simulation model.

Table 2. Simulation Parameters

Parameters	Values
Data aggregation energy	5nJ/bit
Data packet size	1024 bytes
Network size	200 m ×200 m
Node initial energy	0.5 J
Transmitter amplifier where $d < do$	10 pJ/bit/m2
Transmitter amplifier where d≥do	0.0013 pJ/bit/m4
Transmitter circuitry dissipation	50 nJ/bit

4.1. Energy Efficiency

To measure energy-efficiency, compare the amount of energy required to produce a certain amount of communication to the amount of energy produced. An outcome to the problem of how to enhance energy-efficiency may be found in the efficient transport of specific data over a given amount of energy. Another word for energy-efficiency is "the use of less energy to provide the same function", which is a further generalization of the original definition. When applied to these scenarios, energy-efficiency is a key factor since it improves detection accuracy while maintaining the same level of power usage. Figure 6 and Table 3 show the energy savings achieved by implementing the E-BEENISH, DOR, PAHCR, and AOSS protocols. In this case, the proposed AOSS in communication throughout the WSN with varying sizes of packets provides improves energy-efficiency.

Table 3. Energy Efficiency

Packet Size (Bytes)	E-BEENISH	DOR	PAHCR	AOSS
20	90.32	96.43	98.12	99.78
40	81.23	92.32	96.09	98.23
60	72.56	88.78	94.43	96.98
80	63.54	84.12	92.04	94.56
100	54.65	80.12	90.04	92.64

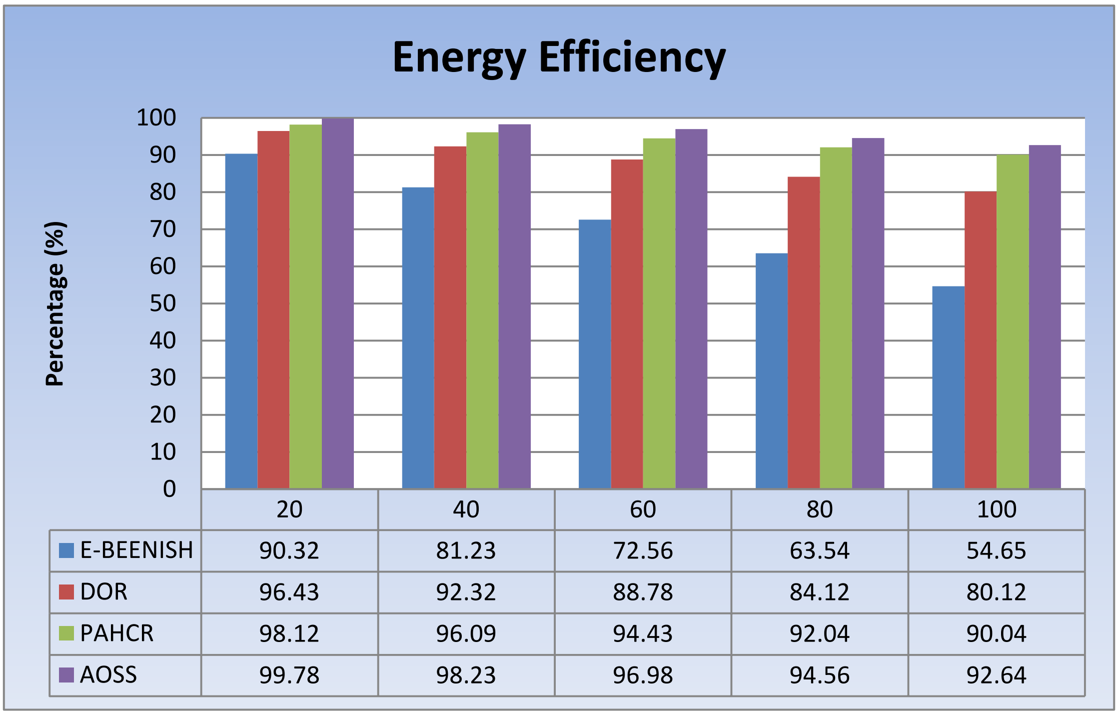

Figure 6. Energy Efficiency

4.2. Packet Delivery Ratio (PDR)

The PDR is calculated by dividing the quantity of properly delivered packets by the total quantity of packets transmitted from the origin. This indicator shows how packets must be routed by a protocol. Thus, the higher transmitting frequency is indicative of a more efficient procedure. PDR results from E-BEENISH, DOR, PAHCR, and AOSS protocols were shown in Table 4 and Figure 7. The proposed AOSS protocol provides a higher PDR than E-BEENISH, DOR, and PAHCR protocols at the varying size of packets.

Table 4. Packet Delivery Ratio

Packet Size (Bytes)	E-BEENISH	DOR	PAHCR	AOSS
20	92.34	97.23	98.42	99.87
40	88.32	96.12	97.31	98.78
60	84.12	95.34	96.54	97.89
80	80.35	94.32	95.46	96.83
100	76.23	93.12	94.35	95.82

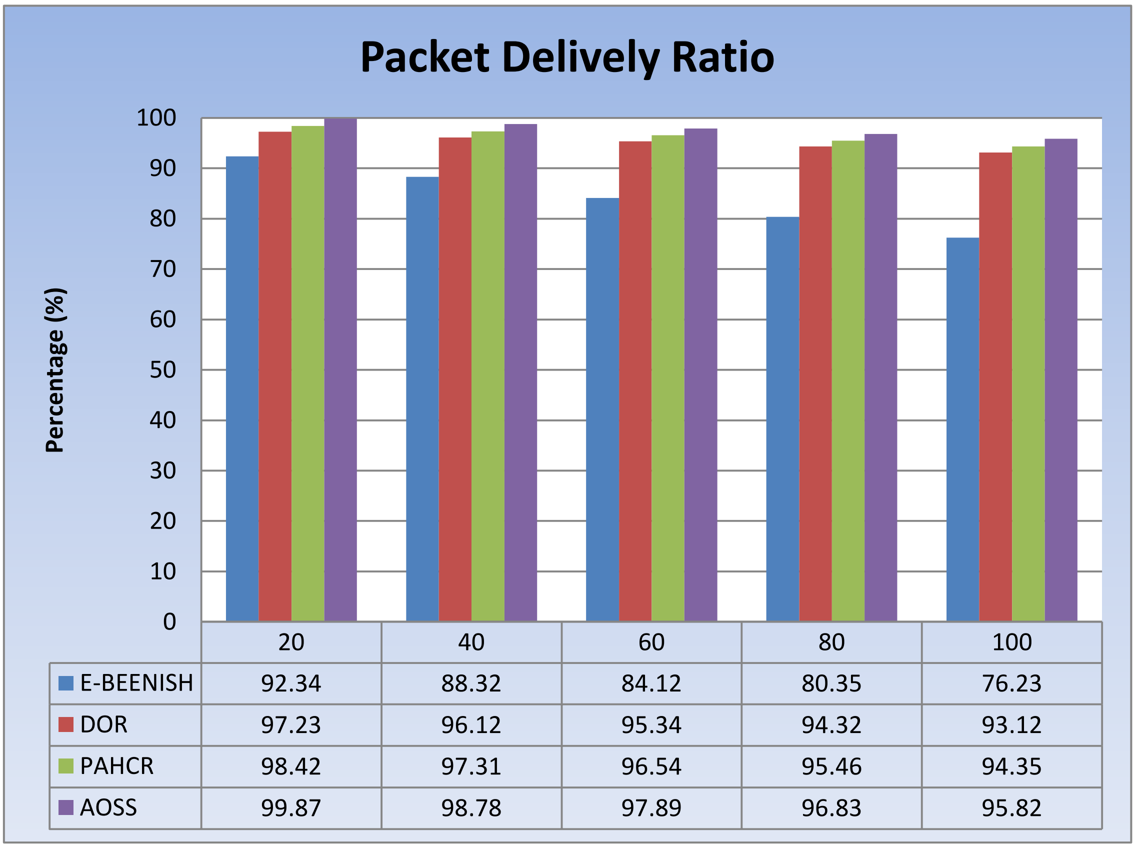

Figure 7. Packet Delivery Ratio

4.3. Throughput

Considerable attention should be paid to throughput as a measure of energy-efficiency. The throughput is a measurement of how many bits of information can be sent in a given amount of time. It is because of this feature that we can quantify the data throughput. The efficiency could be enhanced and packet drop decreased by rotating the CH by the threshold settings at SNs. Throughputs for E-BEENISH, DOR, PAHCR, and AOSS protocols at a multitude of bit rates are shown in Table 5 and Figure 8. In contrast to E-BEENISH, DOR, and PAHCR protocols the proposed AOSS always achieves a higher system throughput.

Table 5. Throughput

Transfer Rate (Kbps)	E-BEENISH	DOR	PAHCR	AOSS
100	90.32	97.12	98.34	99.87
200	85.12	95.53	97.61	98.99
300	80.12	93.12	96.23	97.82
400	75.12	91.23	95.39	96.89
500	70.34	89.12	94.23	95.97

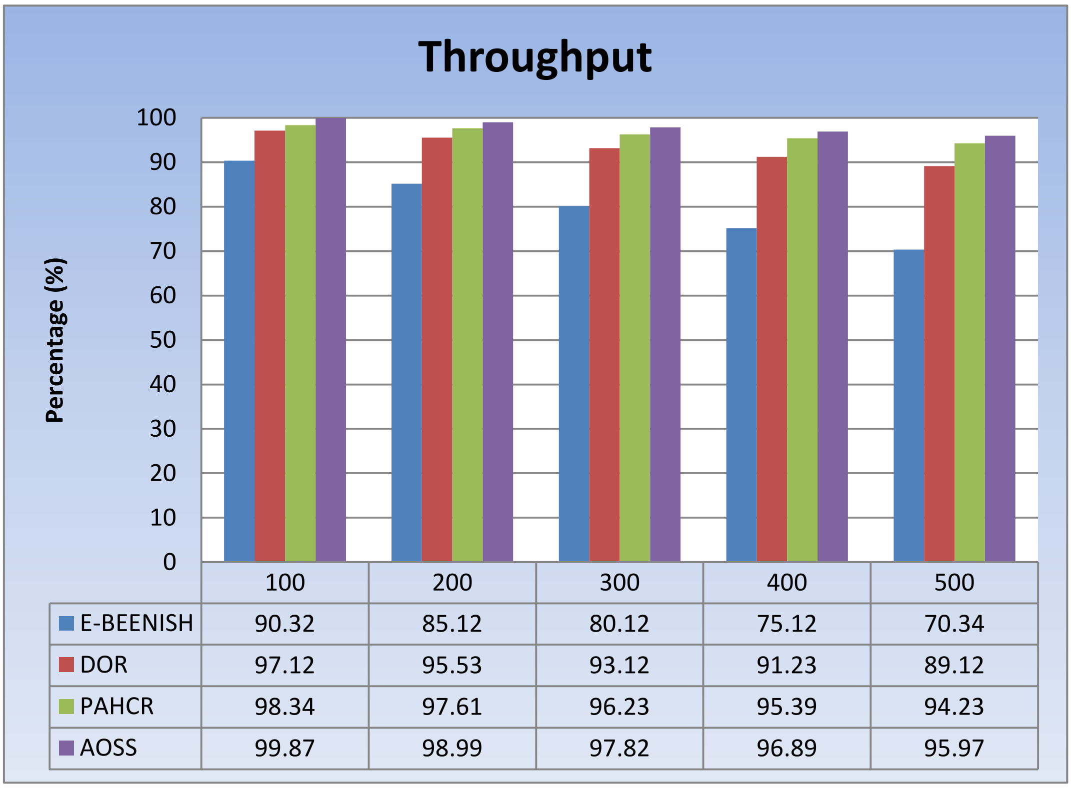

Figure 8. Throughput

4.4. Routing Overhead

As the number of SNs increases, more of them will want to participate in the transmission of the packets. As a result, there is a rise in communication overhead. Either the SN speed was increased or the latency affects a route from the origin to the destination. Repeatedly, in an attempt to deal with the routing overhead, route creation or exploring should be initiated. To maintain the region dimension, choose the border SNs, and adjust the behavior, the protocol requires a vast number of packet commands. As the number of SNs grows, so does the routing complexity. Routing Overhead performance for E-BEENISH, DOR, PAHCR, and AOSS protocols are shown in Table 6 and Figure 9. Comparing the proposed AOSS protocol to the E-BEENISH, DOR, and PAHCR protocols for varying numbers of SNs reveals that the PAHCR has a much lower overhead for routing.

Table 6. Routing Overhead

Number of Nodes	E-BEENISH	DOR	PAHCR	AOSS
200	20.42	5.12	3.07	1.89
400	32.42	8.34	5.12	2.92
600	48.21	14.21	7.11	3.98
800	68.22	23.12	9.07	4.99
1000	91.21	32.56	11.23	5.95

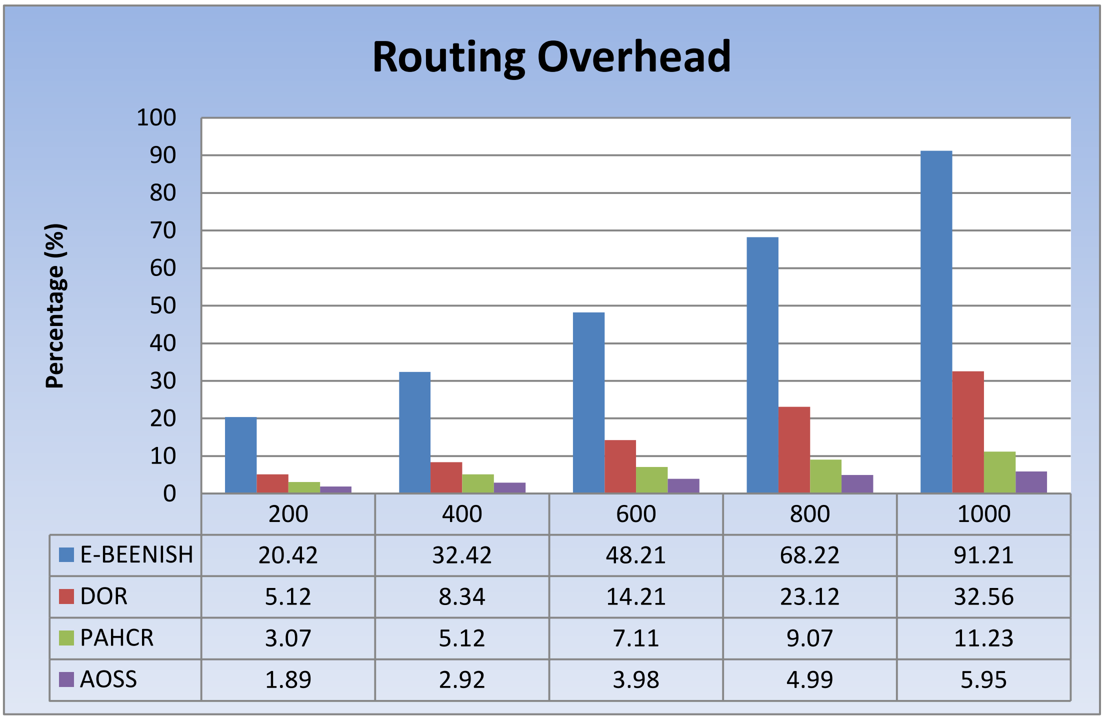

Figure 9. Routing Overhead

5. Conclusion

This research proposes a new AOSS protocol for WSNs to reduce power consumption while maintaining data integrity. The main objective of this AOSS protocol is to support higher data rate transmission and reduces energy consumption. In this AOSS protocol, an efficient time allocation is done for all the states of scheduling activity, to maintain the synchronization between the SNs. Here, each SN wakes up only twice, that is, once to receive the data from the neighbor SN and the next time to transmit data to BS. Then, to reduce the total energy consumption, PI with SS is used. As this proposed AOSS protocol coordinates the actions of a group of SNs, it may significantly cut down on the energy required to perform those actions. Compared to other current protocols including E-BEENISH, DOR, and PAHCR, the proposed AOSS protocol demonstrates much improved "Energy Efficiency", "Packet Delivery Ratio", "Throughput", and reduced "Routing Overhead" in the simulation findings. This strategy may be expanded in the future to investigate areas like mobility SNs and also the optimum frequency of CHs.

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