Increase the Life of the Wireless Sensor Network by Using Cross Layer Model Based on TDMA and Distance Index

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Received: 22 September 2024 – Revised: 2 February 2025 - Accepted: 12 march 2025

Abstract—**Wireless sensor networks (WSNs) are advanced tools for monitoring and controlling the environment, which are powered by a limited capacity battery, and the depletion of the sensor battery leads to the end of the life of the network life. Therefore, it is crucial to use protocols that are energy efficient. In this paper, using a new cross layer model based on distance from base station (BS) and (Time Division multiple access) TDMA, the optimal use of available resources and increasing of the life time of the network are discussed. By modifying the method of selecting the cluster headers (CHs), the selection of low energy CHs, which are far from the BS, has been prevented. It also balances the transmission of data packets in different clusters, resulting in fair energy consumption between sensors. By comparison with the ATEER model in [12], the proposed model has reduced energy consumption by 45%, increased the life time of the network by 67% and increased packets sent to the BS by 15%.**

Keywords: Wireless Sensor Network, Life time, Cross layer, Energy efficient, distance index, TDMA

Article type: Research Article

I. Introduction

WSNs are advanced autonomous devices that have found many applications in recent years. For example, in the military and civilian fields such as environmental monitoring, air pollution control, intelligent highway design, and health care have been used [1]. A WSN consists of a large number of limited-power sensor nodes scattered throughout the environment [2]. In order to investigate the functional behavior of a sensor

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network, which is usually a difficult task, the article examines three layers of this type of network including node, network and system level [3].In [4], in order to increase the lifetime of wireless sensor networks and reduce energy consumption, the cross-layer based opportunistic routing protocol (CORP) has been discussed. In addition, Bacterial Foraging Optimization (BFO) and Harmony Search Algorithm (HSA) are used in combination with each other to select the cluster header in the WSN.

In [5], communication channel scheduling solutions, routing protocols, efficient energy consumption in wireless sensor networks are discussed.

One of the most important challenges facing sensor networks is energy efficiency (EE). In order to reduce the transferring cost of data packets from source to destination, routing protocols with energy efficient are needed. To choose an energy efficient path, networks must interact with high layers that have limited bandwidth or energy. This is possible by using the cross-layer model. The use of a cross layer model cause the exchange of multiple parameters in the protocol stack that significantly increases the life time of the network [6].

Routing protocols generally use a clustering method in which the network is divided into small units called clusters. One of the clustering methods that make optimal use of energy sources is the low energy adaptive clustering hierarchy (LEACH). The selection of CHs in the LEACH algorithm is based on random rotation between different nodes, which causes one node not to be continuously threaded, and this leads to a fair consumption of energy between sensor nodes. Although, the LEACH conserves energy in the nodes, it does not pay attention to the residual energy of the sensor node in the cluster selection process [7]. In [8], a heterogeneous network (HN) model with three energy levels for the sensor nodes is proposed. The process of selecting the CH and members is based on the ratio between the remaining energy in the sensor nodes and the energy of the whole network. In [9], a homogeneous network increases the life time of the network by offering two solutions. First, by applying the two remaining energy factors of the node and the distance of the node from the BS, the selection of the CH has been modified. Secondly, by modifying TDMA, it has created a balance to send data packets in different clusters.

In [10], an algorithm to collect data from the shortest path is presented, which aims to maximize the life time of the WSN using the multi-hum method.

It has studied parameters such as the percentage of live nodes and network life. However, it has not provided any results regarding the number of packages sent to the BS. In [11], based on a new algorithm, a main node is selected in each cluster with maximum energy and minimum distance inside and outside the cluster, which reduces the workload on the thread. The simulation results for this type of algorithm show an increasing in EE compared to the LEACH protocol.

In [12], a cross layer model called ATEER with three energy levels is considered for sensor nodes. This type of model prevents the transmission of data that is not in the desired range. Therefore, the ATEER increases the life time of the network. Also, this type of model has not paid attention to the distance of nodes from the BS.

In [13], for each cluster, a second CH is selected, which doesn't stop sending information to the BS if the main header dies. Besides, no comparisons have been made in the presented diagrams.

In [14], the selection of CH is based on the LEACH algorithm, but the closest CHs to the BS are used to send data packets. Although energy consumption has improved slightly, no statistics on grid life have been provided. In [15], improving the life time of the network has been done by using a method based on genetic algorithm (GA) and due to the energy heterogeneity of the sensor nodes.

In [16], a hybrid method is used according to parameters such as the remaining energy of the node and the length of time that the node can support the path. In [17], a new protocol has designed based on a GA to improve the life time of the network which called LEACH-GA. The weakness of this protocol is the selection of CHs in the BS, which causes the exchange of large control packets in the network and energy loss.

In [18], an improved protocol from LEACH is called I-LEACH was provided. This type of protocol uses a multi-jump routing strategy to transfer packets of data to the BS. The presented diagrams show only energy consumption and diagram of life time is not provided.

In [19], the complexity of the CHs selection algorithm has been provided and the life time of the network has been increased by simplifying the CHs selection process .The proposed method in [20], reduces energy consumption by reducing the number of control messages and performing regular clustering.

A. Main Contribution and innovation

In most research on HNs, the distance of the sensor node from the BS has not been taken into account when selecting the CH. Nodes away from the BS lose more energy due to the long distance if used as a header. Another issue that has not been addressed is the unbalanced energy consumption between clusters with different members.

Data packets sent faster in low-member clusters than in high-member clusters, which results in more power consumption in small clusters.

This paper deals with optimizing energy consumption and increasing the life time of a HN By modifying the method of selecting the CHs.

In the proposed model, the amount of initial energy and the remaining energy of the node and the proximity of the node to the BS, a criterion for selecting the headers has been set. Also, by applying two hard threshold (HT) and soft threshold (ST), data packets have been filtered before sending and unnecessary and duplicate data has been prevented. In the proposed model, modified Time Division Multiple Access (TDMA) has led to the optimization of the ATEER model [6]. Comparison of the simulation results between the ATEER model in [12] and the proposed model shows a significant improvement of the proposed model in terms of increasing the life time of the WSN by 67%, reducing energy consumption by 45% and increasing packets sent to headers by 15% compared to the ATEER model.

In this paper, in section 2, the proposed model system is introduced. Section 3 simulates and compares the results of the proposed model with the ATEER model. Section 4 summarizes and offers suggestions for future work.

II. Proposed Model

The network consists of a field of sensor nodes that are randomly scattered in a square environment. The BS is located in the center of the square. The sensor nodes are motionless after installation. The network has no locator and the distance between the sensor nodes is detected from the received signal. Sensor nodes have different initial energies and are divided into three categories: normal and advanced, which have E_0, $E_0(1+a)$ and $E_0(1+s)$ energies, respectively [12].
In this paper, to send and receive data packets, the standard radio model is used in [21], which depends on the distance from sender to receiver. For sending mode, if the distance is less than the threshold value d_0, the free space model ε_{fs} is used, and if the distance is more than d_0, the amplified model ε_{amp} is used. The calculation of the amount of energy lost to send data is obtained by Equation (1)[21].

$$E_{TX(L,d)} = \begin{cases} L\times E_{elec} + L\times \varepsilon_{f} \times d^2, & d \le d_0 \\ L\times E_{elec} + L\times \varepsilon_{amp} \times d^4, & d > d_0 \end{cases} \quad (1)$$

In equation (1), L is the length of the transmitted packet, E_{elec} is the amount of energy consumed in internal circuits, and depends on factors such as digital coding and modulation. d is the distance between the sender and receiver, and d_0 is the threshold value obtained from equation (2).

$$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{amp}}}. \quad (2)$$

And the amount of energy lost in the case of receiving the package is calculated by equation (3) .

$$E_{RX}(L) = L \times E_{elec}. \quad (3)$$

After the sensor nodes are established, the network starts working. The sensor nodes obtain information from the environment and send their data indirectly to the BS. First, each sensor node calculates its distance to the BS. Then, the setup phase begins and the average energy value of the network is estimated. Each sensor node generates a random number between 0 and 1 that if this value is less than the probability function $T(s_i)$, the node in this phase is selected as the header. Due to the nature of the network, which is heterogeneous, the new probability functions are selected based on the amount of initial energy and the ratio of residual energy to the average energy of the network.

For normal nodes, the distance from the BS criterion is also considered as a factor in the selection of the header, and the closer the nodes are to the BS, the better the chance of header.

Once the headers are selected, each header broadcasts a message stating that it is header on the network. Other nodes that are not selected as headers join the nearest header according to the received signal strength.

After the formation of clusters, the stability phase of the network begins. Sensor nodes receive information from the environment and are ready to be sent. For the first time, if the numeric value of the data is greater than the HT value, the sensor node is allowed to send data to its header. Otherwise the node will fall asleep. The number recorded is stored in the sensor node memory.

Next time, in addition to the fact that the numeric value of the data must be greater than the HT, the difference between the new value and the previously stored value must also be greater than the ST for the data to be allowed to be sent. In order to maintain data balance and equal energy consumption between sensor nodes, the process of sending data packets to clusters is based on a modified TDMA, so that each sensor node sends packets to its cluster only once in each stability cycle and then goes to sleep.

After sending the packets to the headers, they aggregate the packets and send them to the BS. The next round starts again with the setup phase to run out of network energy. Fig.1 shows the flow chart of the proposed model.

A. Correction of header choice based on distance from the BS

In the proposed system model, the ATEER model is used in which the headers in each round are selected using the probability function c, which is obtained from equation (4). $T(s_i)$ is the function of probability of header for each sensor node, p_i is the percentage of header for each sensor node, r is the current round number and G is the set of sensor nodes that have not been selected as header in previous rounds [9].

$$T(s_i)=\begin{cases}\dfrac{p_i}{1-p_i(r\times\mathrm{mod}(\frac{1}{p_i}))} & \text{if } S\in G\\ 0 & \text{otherwise}\end{cases} \quad (4)$$

In the ATEER, the p_i value for each sensor node is calculated based on the initial parameters and the residual energy, and the header is selected in each round of the sensor nodes that have the highest residual energy [12].

However, the ATEER does not pay attention to the distance of the node from the BS when selecting the headers. Normal nodes lose their energy and die faster than other nodes because they have less energy than advanced and super-advanced nodes. Therefore, headers should be selected more from super-advanced and advanced nodes. In the proposed model, the proximity to the BS is a criterion for selecting normal nodes as headers, and normal nodes are selected as headers if they are close to the BS [9].

The method of calculating p_i is modified by Equation 5 where P_{opt} is the desired pre-determined amount of clustering and m_a is the percentage of frequency of advanced nodes compared to normal nodes, m_s is the percentage of frequency of super-advanced nodes compared to advanced nodes, a is the energy factor of advanced nodes, s is the energy factor of the super-advanced nodes, E_i is the residual energy of each sensor node and E_{avg} is the average network energy.

In equation (5), $dtoBS_i$ is the distance of the sensor node to the BS and $dtoBS_{Max}$ is the distance of the farthest point to the BS. Therefore, the nodes are selected based on the initial energy and the ratio of residual energy of the node to the average network energy. If the sensor node is of normal type, its distance from the BS also affects the choice of headers, and the closer the normal nodes to the BS, the larger the value of p_i. As a result, they have a higher chance of being header.

$$p_i=\begin{cases}\dfrac{p_{opt}}{(1+m_a\times(a+m_s\times s))}\times(\dfrac{E_i}{E_{avg}})\times(1-\dfrac{dtoBS_i}{dtoBS_{Max}}) & \text{if } s_i \text{ is normal}\\ \dfrac{p_{opt}(1+a)}{(1+m_a\times(a+m_s\times s))}\times(\dfrac{E_i}{E_{avg}}) & \text{if } s_i \text{ is advanced}\\ \dfrac{p_{opt}(1+s)}{(1+m_a\times(a+m_s\times s))}\times(\dfrac{E_i}{E_{avg}}) & \text{if } s_i \text{ is super}\end{cases} \quad (5)$$

B. Calculate the average amount of energy

Calculating the value of p_i requires the average grid energy per cycle. The energy discharged in each cycle in the network is obtained from equation (6), where K is the number of branches and is $K\approx N\times P_{opt}$ [21].

$$E_{Round}=K\times E_{Cluster}. \quad (6)$$

Equation (7) shows that the energy consumed by each cluster in each cycle is equal to the energy consumed by the header and the energy consumed by the members of the cluster [21].

$$E_{Cluster}=E_{CH}+E_{non\ CH}, \quad (7)$$

The energy consumed by the header in each cycle is estimated by equation (8), where m is the number of members of the cluster and is $m\approx N/K$.

$$E_{CH}=L\times E_{elec}\times m+L\times E_{DA}\times m+ L\times\varepsilon_{amp}\times d^4_{toBS}, \quad (8) \quad (8)$$

d_{toBS} is the average distance of the headers to the BS, which is obtained from equation (9) [21].

$$d_{toBS}=\frac{\sqrt{2}\times M}{4}. \quad (9)$$

M is the length of the test range and the energy dissipated by the non-threaded nodes in each cycle is obtained from equation (10) [21].

$$E_{non\ CH}=L\times E_{elec}+L\times\varepsilon_{fs}\times d^2_{toCH}, \quad (10)$$

In equation (10), d_{toCH} is the average distance between the nodes of the cluster member and its head, which is obtained from equation (11) [21].

$$d_{toCH}=\frac{M}{\sqrt{2\pi\times K}}. \quad (11)$$

Therefore, the energy consumption in each cycle is calculated by equation (12) [21].

$$E_{Round}=K\times L(E_{elec}\times m+E_{DA}\times m+ \varepsilon_{amp}\times d^4_{toBS}+E_{elec}+\varepsilon_{fs}\times d^2_{toCH}). \quad (12)$$

E_{rem} in each round is the sum of the total network energy, which in the first round is equal to the initial energy of the whole network, and the average energy of the whole network is initially calculated by equation (13), where N is the total number of sensor nodes.

$$E_{avg}=\frac{E_{rem}}{N}. \quad (13)$$

In each cycle, the amount of energy consumed decreases from the previous amount. E_{rem} and equation (14) is obtained.

$$E_{rem}(r)=E_{rem}\times(r-1)-E_{round}, \quad (14)$$

And the average energy in each cycle is calculated by equation (15).

$$E_{avg}(r)=\frac{E_{rem}(r)}{N}. \quad (15)$$

After selecting the headers and starting the stability phase, the sensor nodes receive information from the environment.

But in any case, they are not allowed to send the package. For the first time, the sensor nodes that want to send the packet must have a numeric value greater than the HT value that they are allowed to send, and this value is stored in an internal register. For the next time, the sensed value must be greater than the HT value, and also the difference between the new sensed value and the previous value must be greater than the ST value so that the node is allowed to send the packet is prevented.

C. Modified TDMA code

Each network cycle consists of two phases of setup and stability. In the setup phase, headers are formed and in the stability phase, packets are sent. The stability phase is longer than the setup phase. In the setup phase, when the cluster is selected, it broadcasts a message and announces the cluster. Each sensor node decides which cluster to become a member according to the strength of the input signal, and notifies the cluster. Therefore, each branch knows the number of its members. Sending packets is based on TDMA, which is programmed based on the largest cluster. As a result, in small clusters, each node sends data more than once, leading to more energy consumption in smaller clusters. For example, if cluster 1 has 12 members, cluster 2 has 8 members and cluster 3 has 3 members. According to the standard TDMA, nodes in cluster 1 send packets once in the stability cycle, and in cluster 2 each node sends 2 times and in cluster 3 each node 4 times. This causes the nodes of cluster 3 to lose more energy than cluster 1. In order to balance the energy consumption between the sensor nodes, a modified TDMA has been used in such a way that each node sends a packet only once in a stable cycle [9]. In this method, TDMA is set based on the largest cluster, and the nodes of each cluster in each stability cycle turn off and go to sleep after sending the packet. According to reference [9], Table 1 shows an example of a modified TDMA for 3 clusters. The use of modified TDMA prevents the transmission of duplicate and useless data and conserves the energy of the sensor nodes. After sending the packets according to the modified TDMA, the headers aggregate the packets and send them to the BS, and the setup phase begins again and new clusters are formed, a process that continues until the end of the entire network energy. The proposed model simultaneously increases the life and stability of the network by reducing energy consumption and equitable energy consumption between sensor nodes.

III. SIMULATION AND RESULTS

Simulation in MATLAB 2017b software environment has been performed for both ATEER model and the proposed model with the same conditions. The number of 100 sensor nodes are scattered in a square environment with an area of 10,000 square meters. The location of each sensor node is random, and for both models, the location of the sensor nodes is the same. The BS is located in the center of the square.

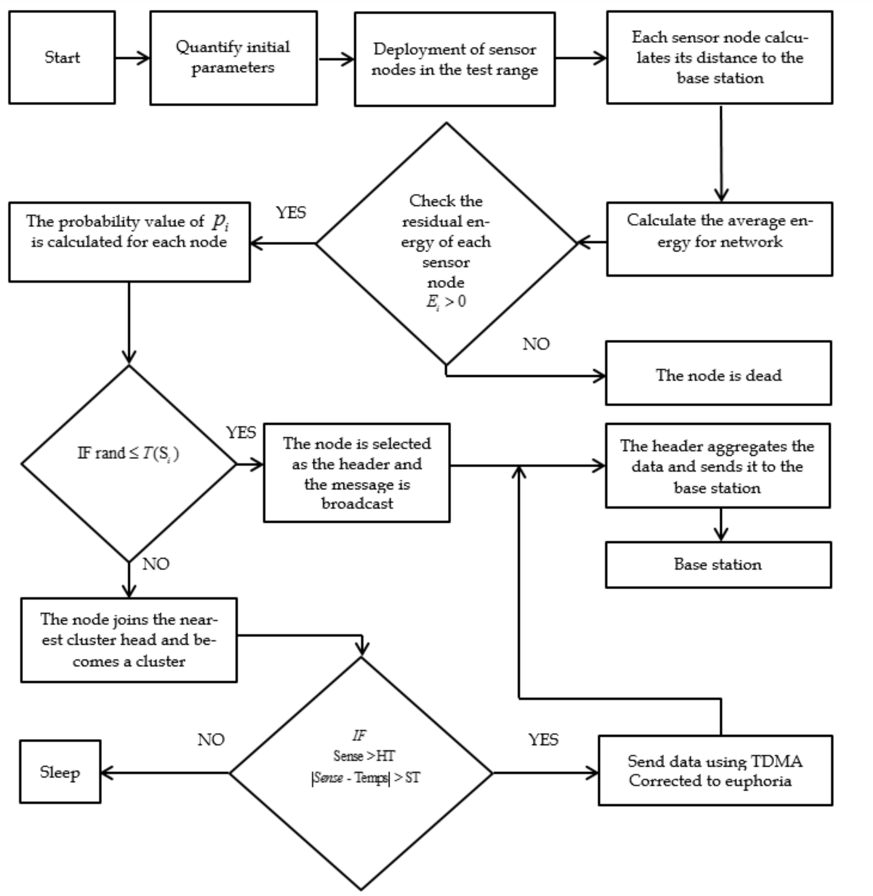

Figure 1. Flowchart of the proposed model based distance to the BS and TDMA

TABLE I. SAMPLE OF MODIFIED TDMA FOR THREE CLUSTERS

Number of cluster	Stability phase											
Cluster 1	16	22	10	6	15	1	57	63	23	34	8	90
Cluster 2	25	14	3	80	19	72	The nodes go to sleep					
Cluster 3	33	62	5	The nodes go to sleep								

TABLE II. PARAMETERS REQUIRED FOR SIMULATION

Parameters	Symbol	Value	Unit
Network area	M^2	100×100	--
Initial energy of a normal node	E_0	0.5	J
Advanced node energy factor	a	2	--
Super-advanced node energy factor	s	3	--
Frequency of advanced nodes compared to normal nodes	m_a	0.4	--
Frequency of super-advanced nodes compared to advanced nodes	m_s	0.6	--
Threshold distance	d_0	70	m
Optimal percentage of header	P_{opt}	0.08	--
Transmitter or receiver circuit energy	E_{elec}	50	nJ/bit
Data aggregation energy	E_{DA}	5	nJ/bit/message
Booster transmitter $d \succ d_0$ if	ε_{amp}	0.0013	pJ/bit/m^4
Booster transmitter if $d \prec d_0$	ε_{fs}	10	pJ/bit/m^2
Data package length	L	512	bit
Hard threshold	HT	200	--
Soft threshold	ST	4	--

The nodes are then fixed. In terms of primary energy, nodes are divided into three categories: normal, advanced and super-advanced. According to the reference [12], and some of the initial values predicted in the simulation process, Table 2 shows the values of all simulation parameters. The initial energy of advanced nodes is 3 times that of normal nodes and the initial energy of super-advanced nodes is 4 times that of normal nodes. Also, the number of normal nodes is 61, advanced nodes are 24 and super-advanced nodes are 15.

The range of variations of the numerical value that each sensor node senses is assumed to be between 0 and 1000, which is randomly generated by a function. Fig.2 shows the state of cluster formation and sending data packet for the proposed method at (a) 1000 rounds, (b) 1500 rounds, and (c) 2500 rounds. Normal nodes are shown with a circle, advanced nodes with +, and super-advanced nodes with a square.

A. Comparing the number of live nodes in different cycles between the ATEER and the proposed model

With the death of the last sensor node, the life time of the network ends. Evaluation of network performance in terms of the number of live nodes in different cycles as well as the death of the last sensor node shows the progress of the proposed model compared to the ATEER.

The death of the last sensor node for the ATEER and the proposed model occurs at 8905 and 19869 based on the number of rounds, respectively, indicating that the proposed model has increased the overall life of the network. Fig.3 shows the number of living nodes in different cycles. Modifying the method of selecting headers and paying attention to the distance of normal nodes when selecting headers has led to not selecting nodes far from the BS as headers, which has led to the conservation of node energy.

Also, TDMA modification also reduces energy consumption and equitable energy consumption between sensor nodes. Table 3 shows a comparison of the number of live nodes in different cycles for the two ATEER models and the proposed model. It is obvious that at all times the number of live nodes for the proposed model is much higher than the number of live nodes for ATEER, which indicates the stability of the network while maintaining the maximum number of sensor nodes for the proposed model.

B. Comparison of the death time of the first node between ATEER and the proposed model

The time of death of the first sensor node is very important in discussing the life time of sensor networks because with the death of a sensor node, part of the network coverage is defective. If in some definitions, the life time of the network is considered the death of the first sensor node.

The later the death of the first node, the longer the network will be able to send data with full coverage and the more stable it will be.

Simulation results and comparison of the two models ATEER and the proposed model, the death of the first sensor node occurs for ATEER in 1822 rounds and for the proposed model in 3024 rounds. The use of both energy reduction and equitable energy consumption techniques in the proposed model conserves energy in the sensor nodes and prevents their premature death. Fig.4 shows a comparison diagram of the death of the first node for the two models.

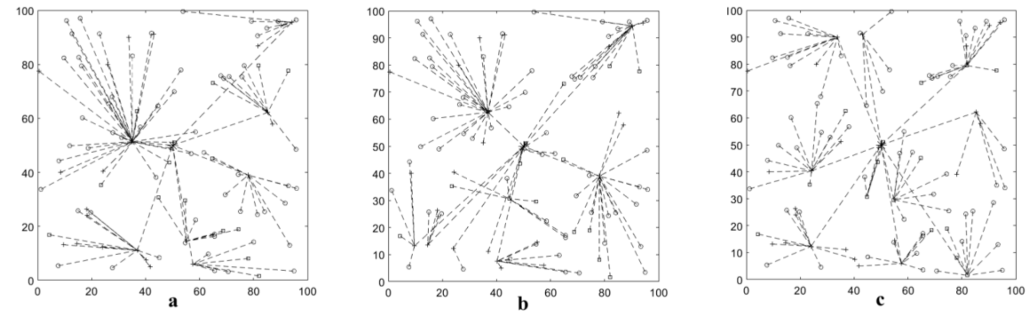

Figure 2. The formation of clusters in different cycles (a) 1000 cycles (b) 1500 cycles and (c) 2000 cycles

TABLE III. COMPARISON OF THE NUMBER OF LIVE NODES IN DIFFERENT CYCLES FOR THE TWO ATEER MODELS AND THE PROPOSED MODEL

Rounds	1000	1500	2000	2500	3000	4000	5000	7000	10000
Alive ATEER	100	100	94	55	39	38	15	11	0
Alive Proposed	100	100	100	100	100	52	37	23	10

TABLE IV. COMPARISON BENCHMARKS BETWEEN ATEER IN REF.[12] AND THE PROPOSED MODEL (FROM FIG.3 TO FIG.8)

Benchmarks	Value	ATEER in Ref.[12]	Proposed model	Benefit
Network life	The number of live nodes	8905	19868	The lifetime of the network in the proposed model has been increased compared to the ATEER.
The death time of the first sensor node	The number of round	1822	3024	The network coverage in the proposed model is better than the ATEER.
Useful life (Based on the death of 70 nodes in the network)	The number of round	2235	3489	The performance of the communication network in the proposed model is better than the ATEER.
Energy consumption	Joule	More	Less	The Energy consumption in the proposed model is less than the ATEER up to 9000 rounds.
Total sending data packets	The number of round	From 3000 onward	From 5000 onward	The network coverage in the proposed model is better than the ATEER.
The number of sending data packets to BS	The number of round	More (From 4000 onward)	Less (From 4000onward)	The network stability in the proposed model is better than the ATEER.

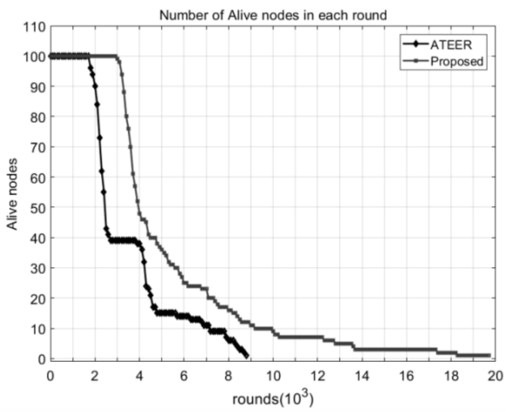

Figure 3. Evaluation of network life in terms of the number of live nodes in different cycles between the two ATEER [12] and the proposed models.

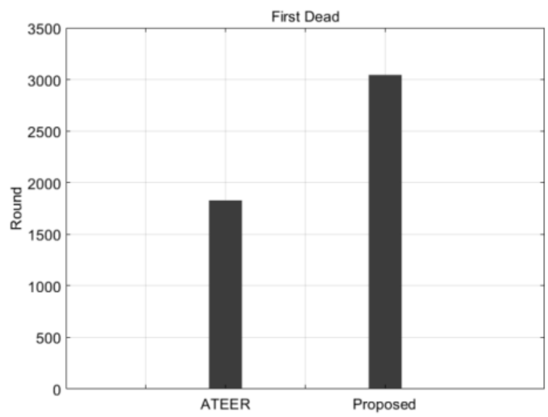

Figure 4. Comparison of the death time of the first sensor node between the two ATEER [12] and the proposed models

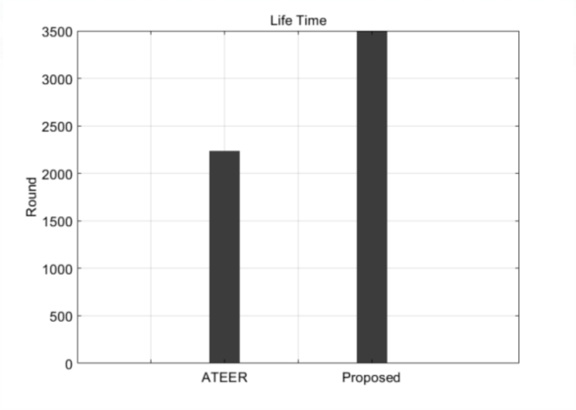

Figure 5. Comparison of useful life between ATEER [12] and the proposed models

C. Comparison of useful life between ATEER and proposed model

The useful life time of the network is the period of time that the network starts operating until some of the sensor nodes expire. In this case, the network is no longer efficient because the network coverage is no longer complete and in some places, there is no sensor to transfer data. The useful longevity in this paper is the length of time that 20% of sensor nodes die. The useful life time of the network is 2235 for ATEER and 3498 for the proposed model based on the number rounds. Comparison of the simulation results between two models show an increase in useful life time of the network for the proposed method. Fig. 5 shows comparison the useful life time of the network for the two models.

D. Comparison of energy consumption between two models ATEER and the proposed model

The use of modified TDMA in the proposed model eliminates the need to send duplicate and unnecessary data, and this leads to less energy consumption in the proposed model than the ATEER. The simulation and comparison results of energy consumption between the ATEER and proposed model show that the proposed model consumes less energy in different cycles than the ATEER, and this has led to energy retention in the network and increased grid life. Fig.6 shows the energy consumption in different cycles for Shows both the ATEER and the proposed model.

E. Comparison of submitted packages between ATEER and the proposed model

The proposed model, in order to balance the energy consumption between clusters with large members and clusters with low members, by controlling the sending of packets in the stability phase to the headers, creates a balance of data transmission between different clusters so that all sensor nodes are equally stable in each sending cycle.

The data is processed and duplicate and unnecessary data is avoided. By comparing the number of packets sent to the headers between the ATEER and the proposed model, it is determined that in the proposed model, the number of packets sent to the headers is less than the ATEER. Although, the volume of sending packets data has been reduced, but the network in the proposed model sending packets data cause at higher cycles.

Also, the sending packets are from all sensor nodes, for example, at 3000 rounds, the packets sent in the ATEER from 39 sensor nodes, while in the proposed model at 3000 rounds, the packets sent from all sensor nodes, which means WSN has full coverage. In the proposed model, Fig. 7 shows a comparison of sending packets data from nodes to headers. In each stability cycle, the headers aggregate the packets and send one packet to the BS. Comparing the sending packets data to the BS between the ATEER and the proposed model shows that in the proposed method, the WSN sends data in more cycles, and this means more stability of the proposed model.

The total number of sending packets from the headers to the BS for the ATEER is 127324 packets and for the proposed method are 146980 packets. Fig. 8 shows the number of sending packets from the headers to the BS. In Table 4, all benchmarks between ATEER in [12] and the proposed model are summarized. The achieved improvements in the proposed model are due to the modification of the method of selecting CHs for normal nodes, which has caused no selection of nodes with large distances. In addition, applying TDMA has also reduced energy consumption and fair energy consumption between sensor nodes in the proposed model.

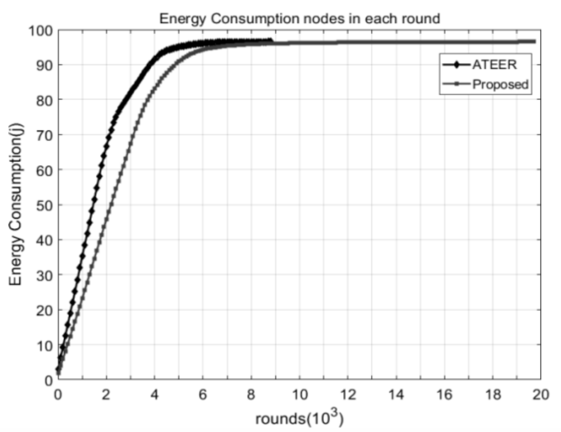

Figure 6. Comparison of energy consumption between the two ATEER [12] and the proposed model

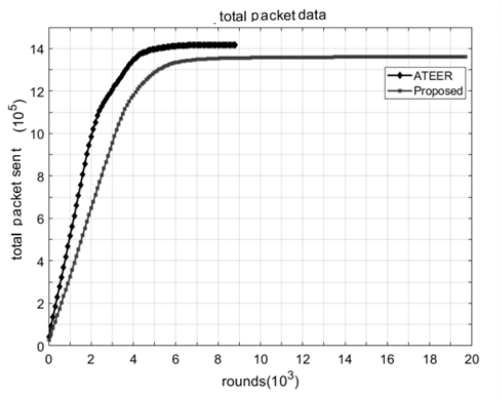

Figure 7. Comparison of sending data packets to headers between ATEER [12] and proposed model

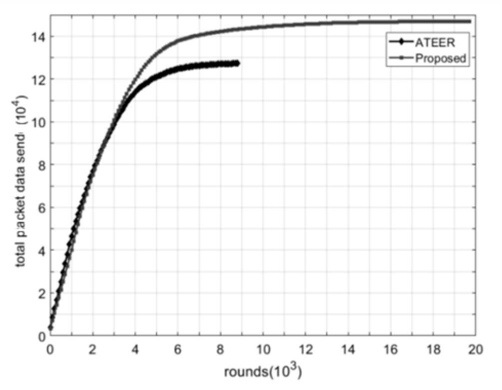

Figure 8. Comparison of sending data packets from headers to BS between ATEER [12] and proposed model

IV. CONCLUSION

In this paper, using a cross layer model, the optimal use of available resources is discussed. The method of selecting the CHs has been modified and the selection of headers with low energy and long distance to the BS has been prevented. Therefore, using a cross layer model based on the optimal use of available resources is discussed. The method of selecting the CHs has been modified and the selection of CHs with low energy and long distance to the BS has been prevented. The simulation results of the proposed model shows that the life time of the network based on the death time of the first sensor node increases approximately 67%. Also, the life time of the network based on the death time of the last sensor node is increases approximately 65%. The reduction of energy consumption in the whole network within a certain interval is about 45% and the number of data packets to the BS increase about 15% compared to the ATEER model.

In this study, the aim and focus was on energy consumption and increasing the life of the network. Future studies will examine the effect of the proposed model on other criteria such as scalability, latency, error rate, security and cost.

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