Energy Efficient Sensor Node Deployment Scheme for Two Stage Routing Protocol of Wireless Sensor Networks assisted IoT

Anshu Kumar Dwivedi[*†],
Awadhesh Kumar Sharma[*], and **Pawan Singh Mehra**[**‡], Non-members

ABSTRACT

Wireless sensor networks (WSNs) and the Internet of Things (IoT) together play an important role in real-time smart applications. Nowadays, IoT is becoming an essential component in human life for easiness and comfortable living. WSNs are used in various applications such as surveillance systems, human health monitoring, military operations, environmental monitoring etc. WSNs have tiny devices called sensor nodes (SN). These SNs have limited battery. WSN assisted IoT consumes more energy in SN communication. All traditional protocols divide network into zones for communication. No existing protocols discuss about the SN deployment ratio in each zone. Therefore, a novel energy-efficient SN deployment scheme for two-stage routing protocol (EE-DSTRP) has been proposed to lessen the energy depletion of SNs and extend the stability period of the network. A novel approach for SN deployment is proposed which is based on the golden ratio. The deployment method is an important factor for reducing the energy usage of a network. To validate its efficiency, simulation experiments are conducted and obtained results prove that the proposed EE-DSTRP protocol is superior to its comparative protocols.

Keywords: Cluster Head, Golden Ratio, Network Lifetime, Node Deployment, Internet of Things

1. INTRODUCTION

The main purpose of the future Internet is to combine numerous wireless technologies as well as wired technologies for smart living. IoT [1] is a ubiquitous network that unites many elegant devices and objects. A WSN helps in monitoring, communicating, and collecting data for the betterment of societal needs [2]. Wireless sensor technology is a low cost alternative; hence the importance and applications of WSNs can be seen in dissimilar areas like health, territorial attack, smart buildings, agriculture, etc. Many devices are interconnected with around 5 billion smart units coupled and about 24 billion entities probable to be added by 2021 [3]. Not only smart devices and objects will be connected but also continuous functioning objects such as cars, satellites, jet engines, etc. This may cause huge data traffic congestion. The power of WSNs is to connect the digital world to the real world. This opens up many opportunities to search for IoT in different research fields due to its challenge [4]. Some nodes in WSNs are designed to be IoT friendly, which easily collaborates and executes various sensing tasks and sends data toward the sink. The aggregated data is sent out to the sink by single-hop or multi-hop communication as depicted in Fig. 1. The IoT based SNs are also deployed randomly [5] and have various constraints such as limited memory, limited battery power, and computational power. All the SNs have their own processing and storage capability. These are embedded in the large physical environment and have multipurpose applications in determining humidity, temperature, pressure, security purpose, and so on [6], [7]. They are most likely to be deployed in hostile environments for the maximum time [8], so their batteries cannot be replaced or recharged. The lifespan of a WSN is dependent on the life of the SNs, so it is necessary to reduce their energy consumption by proper administration.

A WSN can be either homogeneous or heterogeneous in terms of node capability. But most of the time, it depends upon the environmental situation, the heterogeneous nodes of the SNs are in demand for longer lifetime. The layout of WSNs for IoT applications have different challenges e.g, hardware cost, computational cost, battery, and many more. It is also facing new challenging situations in terms of security and Quality of Service [9]. A number of challenges encountered through IoT can be determined through the methods used for WSNs. This article is mainly focused on the energy utilization of WSNs for

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*The authors are with the Department of Computer Science and Engineering, Madan Mohan Malaviya University of Technology, Gorakhpur, India.

**The author is with the Department of Computer Science& Engineering and Information Technology, Jaypee Institute of Information Technology, Noida, India.

Corresponding author. E-mail: †anshucse.dwivedi@gmail.com, ‡pawansinghmehra@gmail.com

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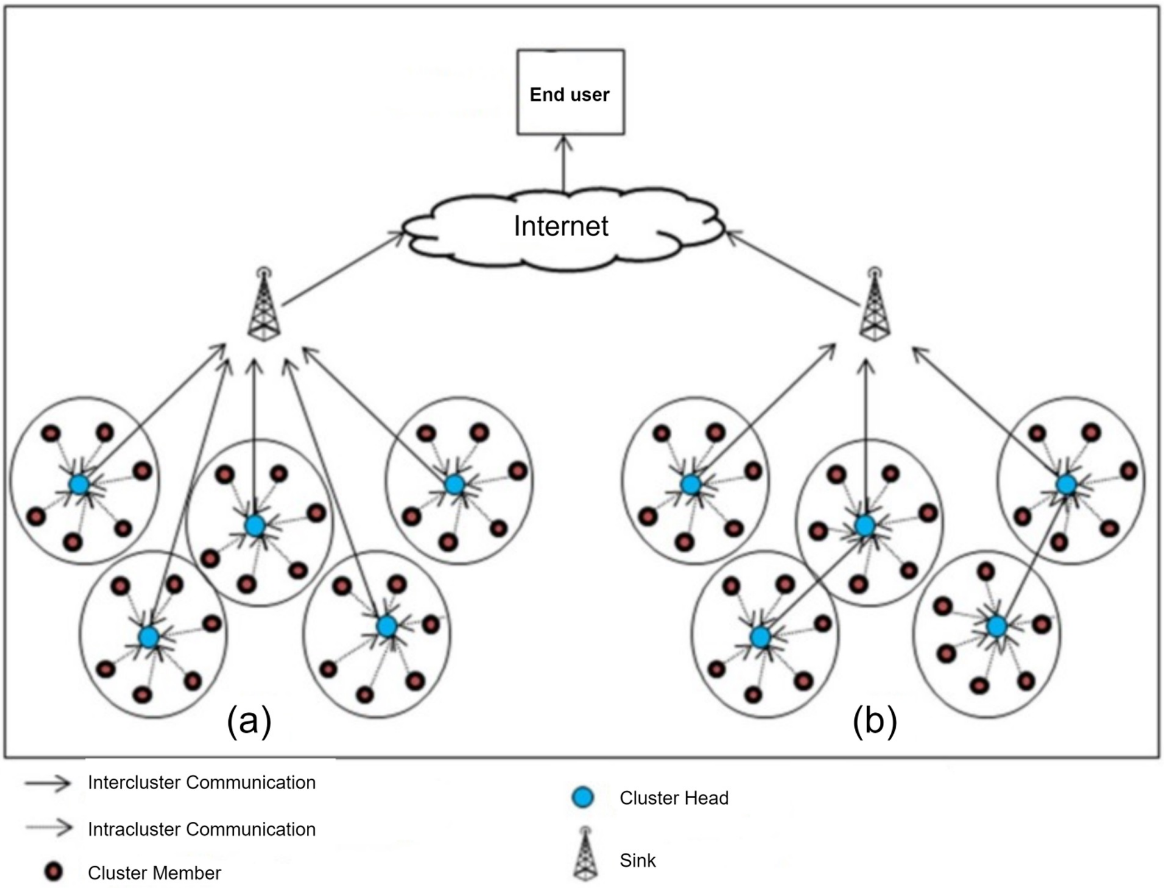

Fig.1: *Cluster based single-hop and multi-hop communication in WSN.*

IoT. In the current scenario, many studies have been proposed to reduce energy utilization and prolong the life span of the network [10]. Some authors and researchers proposed solutions that include clustering, routing, scheduling for improving the energy efficacy of IoT-based WSNs.

Various energy-efficient algorithms have been designed; the major intention of these algorithms is to provide better communication along with enhancing the lifespan of Cluster Heads (CH) and SNs [11], [12]. One of the hierarchical routing protocols, such as LEACH [13] and its various modification protocols use the same energy despite equal distances between senders and receivers, and the network lifetime can also be extended by using multiple levels of data transmission of data packets between sender and receiver [14].

In this research article, we proposed a novel protocol for SN deployment based on the golden ratio to minimize the energy utilization of the SN. Clustering is a mechanism used for periodic collection of data for reduction of energy utilization. Basically the network is separated into two parts; one part is large and the other part is small as per the golden ratio. The large area is again divided into clusters in which a leader is chosen as the cluster head (CH) and all nodes other than the CH act as member nodes. A SN senses data and sends to the CH, and the CH sends that data to the forwarder node and finally, the forwarder sends that data to the sink. The forwarder node is the highest energy node in a smaller region. This node is replaced if another node possesses higher energy and the role of forwarder node is rotated. Many protocols take a lot of time to transmit data to the sink due to unnecessarily changing the role of CHs, and unnecessary cluster formation. All these issues have been rectified in this paper. The input parameters remaining energy, and distance to sink are used to minimize the energy dissipation of SNs for IoT based WSN to prolong the lifespan.

1.1 Highlights of the paper

The highlights of this paper are:

- SN deployment is based on the golden ratio. As far as our knowledge is concerned, this is the first protocol using the golden ratio in WSN assisted IoT applications.
- CH selection is based on a threshold value which is dependent on two parameters: remnant energy and distance to sink.

- Reduction of energy expenditure in unnecessary cluster formation and changing the role of CHs.
- Proposed multi hop-routing algorithms based on golden ratio based zones.

The rest of this article is categorized as follows: Section 2 discusses related work. Section 3 elaborates the Preliminaries & System Model. Section 4 describes the proposed algorithms. Simulation and assessment are described in Section 5. Section 6 presents the overall conclusion of the paper.

2. RELATED WORK

The Internet is a complete world in itself. This is a huge achievement in human history, and now with the concept of the Internet of Things, Internet demand is increasing. The Internet of Things is playing a big role in the life of a human being, due to which their life is becoming increasingly smart. It consists of a huge quantity of SNs that can be deployed anywhere. Some issues arise with IoT when they are in use but the main issue is its maintenance cost. Deployment of IoT based SNs is very difficult in a harsh atmosphere [15] for IoT based applications. LEACH [16] protocol plays a vital role to enhance the life time of the IoT system. Some other modified protocols of WSNs are also used to improve the performance of the IoT system. IoT plays a huge role in connecting smart entities with the cloud. Approximately 70% of the energy is dissipated in the communication process. An energy-efficient routing protocol for WSN has always been a vital assignment for researchers. When WSNs combine with IoT, it becomes a more important task. So it is important to maintain the standard of IoT until we reduce the energy consumption in the devices. Clustering and CH selection techniques are used to reduce the use of energy in the communication of an IoT based SN.

A WSN operates in a large physical environment and it faces a lot of challenges and opportunities when sending data from transmitter to receiver; numerous routing protocols are available for efficiently transmitting data in a WSN. One of the hierarchically based protocol designs for WSN is LEACH [16]. LEACH creates a group of massively deployed SNs. Each cluster has its own CH and the other members are nodes. Each member node of the cluster sends the data directly to the CH of its region instead of transmitting it to the sink. The CH undertakes the responsibility of collecting data from member nodes, compressing this data, and sending it directly to sink. The function of the CH is complex compared to member nodes, so it uses more energy than other member nodes. LEACH proved to be better than other non-hierarchical routing protocols with a lot of challenges which include the following: It has a single-hop routing operation, CH directly contacts the sink, it does not determine distances, and the leftover energy of the node is not taken as a parameter in determining CH which may result in a SN with low energy becoming a CH.

Different types of LEACH protocols are included and one of them is called MODLEACH i.e. a modified version of the LEACH protocol. MODLEACH [17] added attributes to the LEACH protocol. It uses a feature like a threshold value to change CH in each round. If the energy of the existing CH exceeds the defined threshold value then the existing CH also serves as the CH in the next upcoming round, otherwise using the CH selection technique to determine other SNs to act as the CH for the next round. MODLEACH has also been revised and introduced its new variant called MODLEACHHT [17] and MODLEACHST [17] which operate at hard and soft limit values. They respond better than MODLEACH but these algorithms also have some dark parts. This is not good with a large network, and they also use a single-hop strategy during the transmission of data. Multihop-LEACH (MH-LEACH) [18], uses multiple hops to transmit data from the SN to the sink. MH-LEACH works in the following way: SN sends sensed data to CH and CH sends to next CH. This process is repeated until the data packet finally arrives at the sink. Multihop-LEACH (MH-LEACH), uses multiple hops to transmit data from the SN to the sink. MH-LEACH overcomes the problem of single-hop strategy in MODLEACH but faces many challenges such as the energy consumption of sending data packets across multiple hops consuming more time as packets pass through multiple CHs. The packet takes longer time to travel through more CHs.

Assisted LEACH (A-LEACH)[19], is another protocol that adds auxiliary nodes to each cluster with a CH. The SN has sufficient energy because it is close to the sink and chosen as the auxiliary node of its cluster. The SN collects data from its nearby SNs. The helper node performs routing operations and thus transmits the data to another helper node. Only the helper nodes are operating during the routing operation, with all other SNs and CHs turned into sleep state.

The region based Advanced Zonal Rectangular LEACH (AZR-LEACH) [20] basically divides the target area into three logical parts called advanced clusters, zonal clusters and rectangular clusters. The deployed SNs region has a sink at its center. All the clusters near this sink are called advanced clusters. These advanced cluster CHs collect data from other member nodes or other CHs, and pass it on to sink. As an advanced cluster, the distance to sink is very short, thus it consumes less energy. The rectangular cluster divides the originally deployed SNs into a fixed cluster. Zones are formed by groups of rectangles that have at least one advanced cluster. The best part of this ARZ-LEACH is that it divides the network area equally and thus handles network load equally.

LEACH-C [7], [21] is one of the protocols that have a feature similar to the actual LEACH protocol except for the process of CH selection. At the beginning of a new round of energy, every SN sends their local information and the residual energy to their sink. The sink uses their information to determine the average energy of each SN in a given network. All those nodes that have more leftover energy than the calculated average energy are called candidate nodes. Between these candidate nodes, a simulated annealing procedure is used to determine the groups of CHs. After a CH is elected by the sink, it will broadcast this information to the specified network [22]. This algorithm proved to be good but additional work was added to the sink. Stable Election Protocol (SEP)[23] provides a better stability period. It divides the deployed SNs into two parts, one of them is called the common SN and the other is the advanced SN. The common SN has a lower probability of becoming CH than the advanced SN because the normal SN has more battery power than the advanced SN. In line with the same principle, another stable protocol proposed is Enhanced Static Election Protocol (E-SEP) [24]. It divides the SNs into separate categories with their roles. The different categories are as follows; simple nodes, intermediate nodes, and advanced nodes. The normal SN has very little energy; the intermediate SN has energy level between the common SN and the advanced SN. An advanced SN has a greater level of energy than an intermediate SN. It has only one addition and that is intermediate energy level is introduced, similar to SEP. Thus, energy expenditure is also reduced in E-SEP as compared to actual SEP.

MR-SEP [25] is a protocol that divides the SN area deployed at the upper layer of the cluster. Each layer of a cluster has its own CH and member nodes. In every layer, the CH gathers data from its member nodes and then forwards it to an upper layer CH. The upper layer CH is called super CH for all lower layers CHs. This protocol not only divides the network area into layers but sends data from one hop to another and thus increases the stability period of nodes [26], [27].

3. PRELIMINARIES & SYSTEM MODEL

The network model is built with the help of SN deployment ratios. This ratio is called the golden number (ratio). The golden ratio has been used so that the network is completely covered in a good proportion so that no hole can be found in the network. A hole can cause a communication break between the SN and the sink in the network. The routing protocol will then be developed consisting of N SNs, sink, and forward nodes. All SNs deploy randomly. The sink is positioned on the borderline of the network zone that is (100, 50).

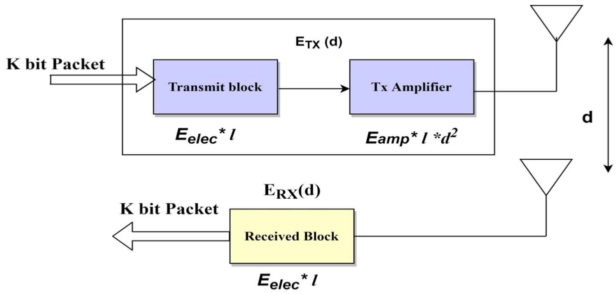

Fig.2: *Radio energy model.*

3.1 Assumptions of Network

There are some assumptions that are made while designing EE-DSTRP protocols which are mentioned below:

- Each and every SNs are consistent, in terms of communication, sensing and processing capabilities.
- Energy is constrained for all SNs apart from the forwarder node.
- Forwarder nodes are introduced in the network sector, the battery of which is changed from time to time.
- Power supply is always available for the sink.
- Receive signal strength index (RSSI) plays an important role in the distance estimation between two devices.
- Communication over network is symmetric in nature.
- If a battery level reaches zero, then the node becomes dead.
- The area of interest (AOI) is assumed to be 100×100 m^2 with a randomly scattered sensor network over the AOI with sink position (100, 50) as depict in Fig. 5.

3.2 Energy Model

Energy management is an important task with respect to SNs, because energy is limited for SNs. Therefore energy consumption only reduces by best communication process. The radio model [28] is used for each communication process. Fig. 2 shows the radio energy model with three key modules, power amplifier, transmitter and receiver.

Both the transmitter and receiver consume energy in the radio model for sending and receiving data. It is signified by E_{elec} and energy dissipation for transmit amplifier is signify by E_{amp}. In this model, two transmission models have been used. One is a free space and the other is a two-way field [29], [30]. The free space provides a straight line of visual traces from sender to receiver, but in the two-way position transmission model, transmission between sender and receiver nodes is not instantaneous and electromagnetic waves arrive at different receivers at different times. In any network, energy is consumed in transferring

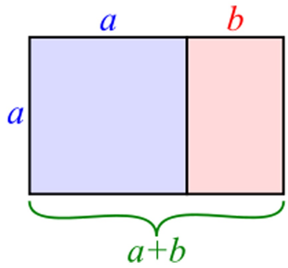

Fig.3: *SN deployment method.*

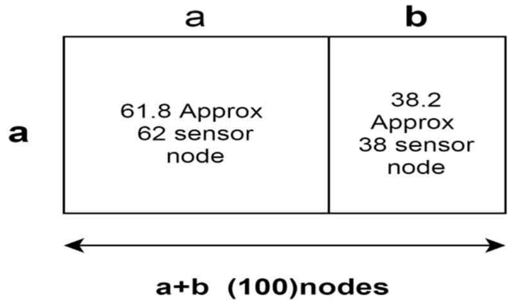

Fig.4: *Deployment of 100 SN.*

data packets, in the same way energy is also used in receiving data as shown by Eqs. 1 and 2.

$$E_{TX}(l,d) = E_{TX} \times l + E_{TX} \times l \times d^2 \quad (1)$$

$$E_{RX}(l) = E_{elec} \times l \quad (2)$$

where the data packet is shown with an l bit and the distance represented as d.

Eq. 3 shows the energy dissipated for sending and receiving of s bit data in terms of E_{TX} and E_{RX} respectively.

$$E_{TX}(s,d) = \begin{cases} sE_{elec} + s\varepsilon_{fs}d^2, d < d_0 \\ sE_{elec} + s\varepsilon_{amp}d^2, d > d_0 \end{cases} \quad (3)$$

where $d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{amp}}}$ and d is the separation distance.

The required energy is calculated by Eq. 4 for receiving s-bit data.

$$E_{RX}(s) = E_{RX-elec}(s) = sE_{elec} \quad (4)$$

3.3 Golden Ratio for Node Deployment

A basic diagram of golden ratio is depicted in Fig. 3. Mathematically, the golden ratio [31], [32] is represented using Eq. 5. It is denoted by (Greek letter "phi") φ and their value is approximately equal to 1.618.

$$\frac{a}{b} = \frac{a+b}{a} = \varphi = 1.618 = 2 \times \sin(54°) \quad (5)$$

On the basis of this golden ratio, SNs are deployed. In most of the protocols, the CH communicates directly to sink after collecting data from member nodes which can lead to huge degradation in energy level or even death of SNs. Premature death of SNs will create a hole in that area and coverage is impossible. The golden ratio can contribute to mitigate this issue because SNs which are farther from the sink (i.e. in the larger area of the golden ratio) will expend more energy in communicating to the sink as compared to SNs in the smaller area. Thus the CHs in the larger region will forward the data to a forwarder node in the smaller region which can conserve large amounts of energy for CH nodes. Suppose the AOI is 100 × 100 m^2 and the count of SNs is 100 then the ratio of AOI in terms of sensor deployment is the $a + b = 61.8$ and $b = 38.2$ as depicted in Fig. 4.

According to this deployment model, SNs are deployed in the network as depicted in Fig. 5. There are two zones, one is Z1 which is near to the sink and other is Z2 which is far from the sink. Z1 has 38 nodes and Z2 has 62 nodes scattered randomly.

4. DESIGN OF PROPOSED PROTOCOL EE-DSTRP

Multistage routing protocol takes maximum time for sending the data from the targeted area to the sink, because there is n number of stages for sending data. EE-DSTR is proposed to reduce the communication time. In the proposed protocol, there are only two stages for communication from the targeted area to the sink. In the first stage cluster formation and CHs selection operation performs for larger-scale networks [33]. The second stage consists of the forwarder node and all positions of the SNs are near the sink. There are no clusters and CHs. The forwarder node is sufficient for communication at this level. The goal of the proposed protocol is to maximize the life span of the network and to save energy utilization in communication. Fig. 6 depicted the network architecture of the proposed protocol. In this network, SNs are homogeneous in nature and deploy in a networked area in a random manner. The forwarder nodes placed near the sink are also in a fixed state (90, 50) and the sink location (100, 50) placed in this proposed protocol.

The function of EE-DSTRP in one round can be classified into two phases: Setup Phase and Steady-State Phase.

4.1 Setup Phase

In this phase SNs deploy in two stages or zones (Z1, Z2) on the basis of golden ratio in network area. Z1 is a non-clustered region and Z2 is a clustered region. All the SNs of region Z2 send data to the CHs and

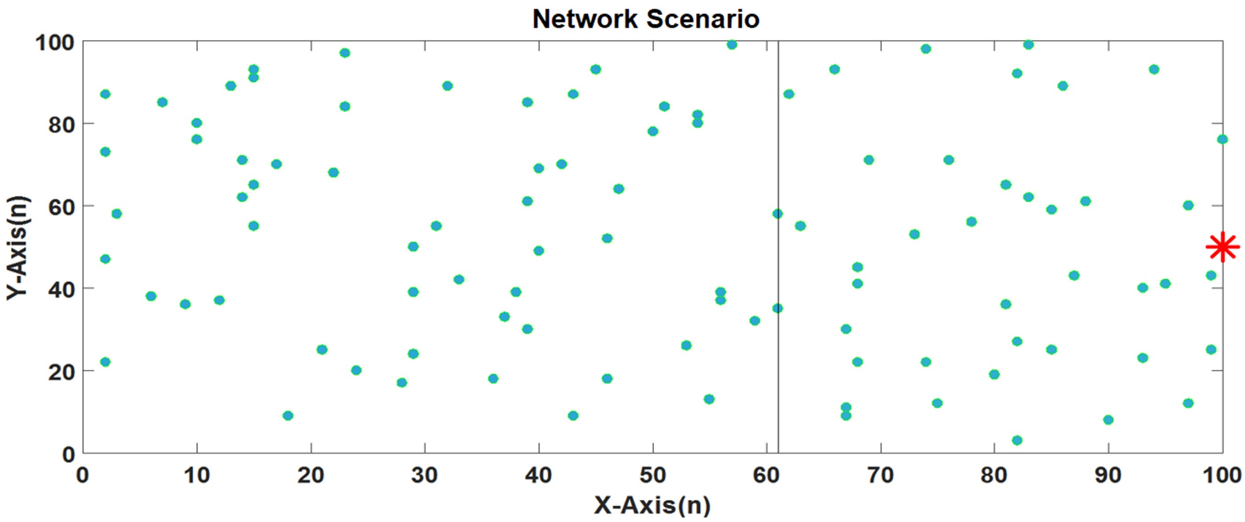

Fig.5: *SN deployment using golden ratio.*

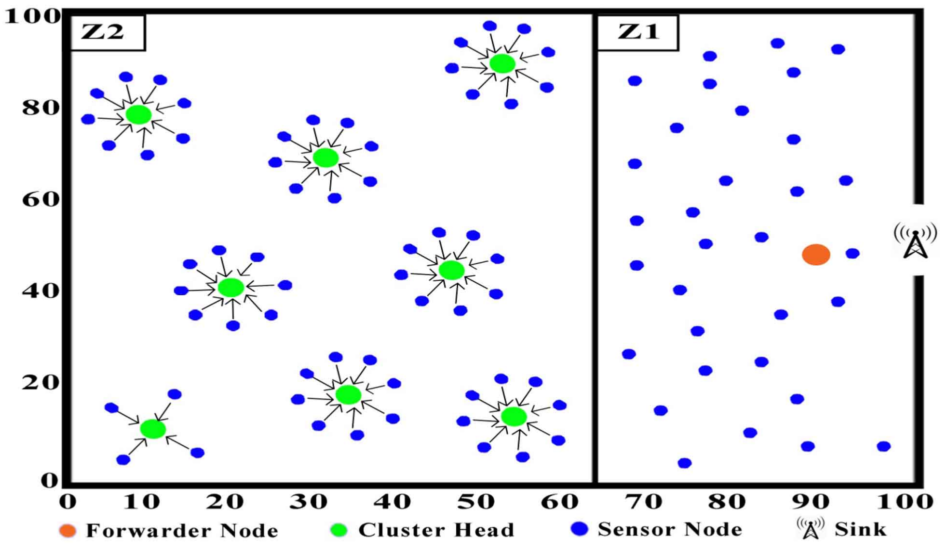

Fig.6: *Basic architecture of EE-DSTRP.*

CHs aggregate the data and then forward to the sink with the help of a forwarder.

In region Z1 all SNs forward the sensed data to the forwarder and the forwarder aggregates the data and sends to the sink. All the operations are performed on the basis of distance calculated between node to CHs, CHs to forwarder, CHs to sink, minimum distance followed for sending and receiving the data. Introducing the concept of forwarder node in communication infrastructure, energy consumption is reduced compared to direct communication between CH and sink.

4.1.1 Cluster Head Selection and Cluster Formation

Once the cluster creation process is successfully completed, the other operation is to select the appropriate node as CH in each subsequent round. All SNs(n) elect itself as a CH in the process of selection, choosing an arbitrary number between 0 and 1. If the value of selected CH is less than the threshold (n) between 0 and 1, then in that round the common node will play the role of CH. Eq. 6 is used to calculate the value of (n) [21], [35].

$$T(n) = \begin{cases} \dfrac{P}{1 - P * \left[rmod\left(\dfrac{1}{p}\right)\right]}, & \text{if } n \in G \\ 0, & \text{otherwise} \end{cases} \tag{6}$$

where p is optimum %CH, r is present round, n is total number of SNs. The selected CH then uses two protocols to communicate with its member nodes in that round. One of them is called CSMA (Carrier Sense Multiple Access) which is used to relay CH position and the other one is TDMA which divides the entire channel into different timelines. Each simple node has its own time frame to communicate with the CH and remains in sleep mode beyond its time frame. Each simple member node calculates the RSSI for the chosen CHs [36]. After each round of communication, the role of CHs changes according to the TDMA schedule. Therefore at the end the TH for each node is calculated using Eq. 7, after the eligibility index of all SN has been computed.

$$T(n) = \frac{Node(i).P \times mean[\text{Eligibility Index}]}{1 - Node(i).P \times mod\left(r, \dfrac{1}{Node(i).P}\right)} \quad (7)$$

Cluster formation operation performs after setup phase [34]; traditionally numerous cluster-based routing protocol distribute the CHs in a random manner in the entire network. Some areas of the network may have more CHs and some areas may have fewer CHs. Due to this problem, the SN may first end up in that part of the network area and a part of the network may be isolated. In the proposed protocol, the CHs are only considered in stage Z2 and the number of CHs are uniformly distributed in stage Z2. In stage Z1, the communication takes place with the help of forwarder node. Each SN can associate with CHs positioned in their own zone. The cluster formation is described in Algorithm 1.

Algorithm 1: Pseudo code for EE- DSTRP

Begin
Input: non cluster WSN

N: total SN deployed in network area
j: ID of alive SN
initial energy of deployed Node(j) is equal to E_0
initially Node(j) treated as member node (m)
initialize the value of CHs under a common list like
CH list: 0
number of CHs count from 1
Node(j).l: Area based likelihood
distance of deployed node within transmission range is
Node(j).D: N
distance between nodes to sink is Node(j)D.sink
while (CH_count <= Prob%) **do**
    Find *Eligibility index* for every Node(j)
    Evaluate [*Eligibility Index*]
    Find *Threshold* (TH) for every SN(j)
    Create random integer (RI) to every Node(j)
    if RI < Node(j).TH **then**
        Node(j).status ← CH
        increase the no of CHs
        Add Node(j) to Cluster head list
    end if
end while
All cluster heads (CHs) sends message to every node
Node(i) choses nearest CH and join the cluster
Output: A clustered WSN
Terminate

Once CH is elected, CHs broadcast request messages to common nodes associated with the CH and become member nodes. Common SNs wait for request messages from CHs in their region, and SNs send messages to the nearby CH based on distance

4.1.2 Cluster Head Retention Scheme

Different traditional routing protocols like LEACH, M-LEACH, and MH-LEACH have an affinity to change clusters every round, the role of cluster head is fixed once as they each have another SN to become a CH in every $1/p$ rounds. CHs selection and cluster formation occur after each round of communication in wireless networks. A well-organized CH replacement method is adopted in EE-DSTRP. If the Energy level and Eligibility index of CHs are larger than threshold after each round of communication then the role CHs are unchanged but if it is less than the threshold limit, clustering takes place. Hence EE-DSTPR protocol minimizes the unnecessary use of energy in each round of communication. Algorithm 2 describes the CH retention scheme.

Algorithm 2: Cluster Head retention scheme

Begin
N ← total no of node
Node(i) ← CH
TH ← Current round Threshold
EI ← Eligibility index of CH
CH_{energy} ← energy of cluster head
after cluster setup
if (Node(i).type = CH) **then**
    if ((CH_{energy} × EI) > TH) **then**
        Node(i) will remain CH
    else
        node(i).type = N
    end if
end if
Terminate

4.2 Steady-State Phase

Fig. 7 shows the communication model of the proposed protocol. The development of a steady phase starts after the election of CHs and the allocation of TDMA slots for SNs. With the help of TDMA protocol, communication begin among SNs and their relevant CH in their predefined time slot. If a time slot is not assigned to the SNs, they remain in sleep mode for energy efficiency. All CHs gather the data from the SNs and send them to the forwarder node

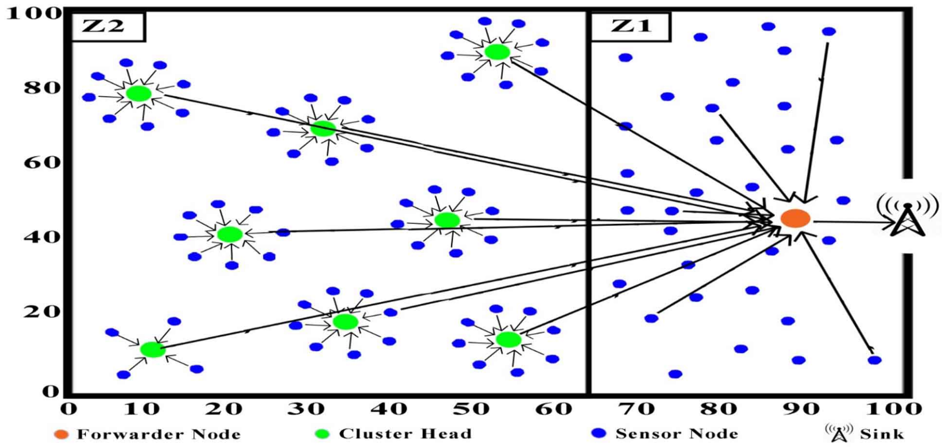

Fig.7: *Communication paradigm.*

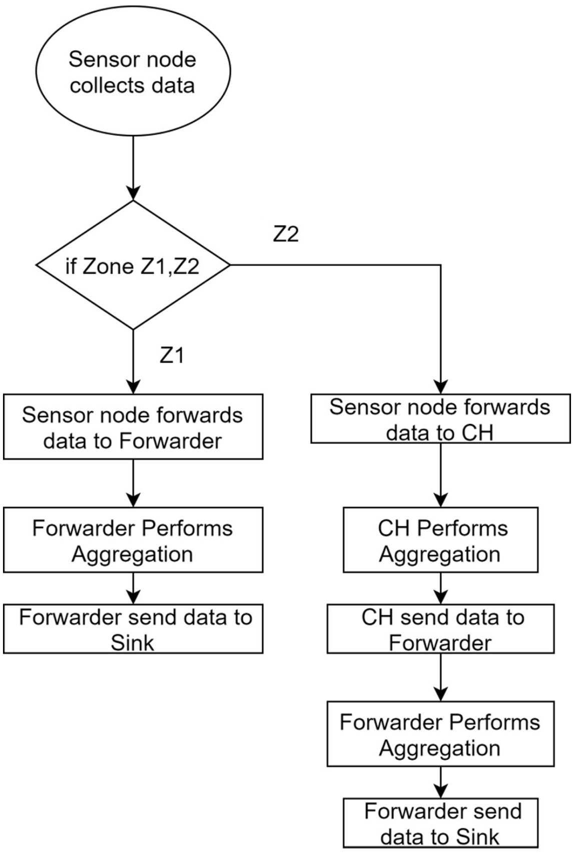

Fig.8: *Flowchart of routing algorithm.*

after aggregation. The forwarder node also performs aggregation on data and after that sends it to the sink. The communication performs on the basis of two-stage communication Z1 and Z2.

In segment Z2 all the SNs send sensed data to CHs and CHs perform aggregation and they send to the forwarder. The forwarder again aggregates the data and send them to the sink. In segment Z1, all the CHs send information directly to the forwarder without the CH because the distance between the SN and forwarder is near the sink; there is no need for the concept of CHs selection in this segment. Fig. 8 depicts the flow chart of the routing algorithms.

5. SIMULATION AND PERFORMANCE ASSESSMENT

The simulation experiments are conducted using MATLAB tool which is very commonly used in WSNs. For the comparison of proposed protocol, LEACH [6] and Z-SEP [37] are chosen. The reason of choosing LEACH is that it is state of the art protocol in WSN. Z-SEP is another protocol which is selected because it divides the network into zones for energy efficiency in WSNs. All the simulation experiments are performed in MATLAB. The total area of interest is assumed to be 100×100 m^2. SNs are static in nature. The experiment is performed for normalization consequences. The optimal percentage (p %) of CHs is kept at 10%. In this paper, we have set up a common scenario of a network. The sink is positioned at the center, say (100, 50). Basic parameter values that are used in the simulation are depicted in Table 1.

5.1 Evaluation Parameters

The critical evaluation parameters chosen are stability period, network lifespan, number of alive nodes per round, the energy level of a network, packet forward to sink, number of a dead nodes in the network, which are described below.

Stability Period

A stability period of the network determines if all the SNs cover the entire network as long as all the SNs are alive and do not allow holes to form in the network.

Network Life Span

Network life span of WSNs is called the overall network lifetime from the establishment of the network process until the death of the last time node.

Table 1: *Network parameters.*

Parameter	Values for N#1
Network area ($N \times N$)	100×100 m^2
Total number of SNs (N)	100
Sink location	(100, 50)
ε_{amp}	0.0013 pJ/bit/m^4
ε_{fs}	10 pJ/bit/m^2
Data packet size (L)	6000 bits
E_{DA}	5 nJ/bit/report
CH probability (p_{opt})	10 %
Initial energy (E_0)	0.5 J
Electronic circuitry (E_{elec})	50 nJ/bit
E_{TX}	50 nJ
E_{RX}	50 nJ

Table 2: *Stability and network lifespan.*

Protocol	Stability period (Rounds)	Network lifespan (Rounds)
LEACH	210	3457
Z-SEP	731	5772
EE-DSTRP (Proposed)	991	4792

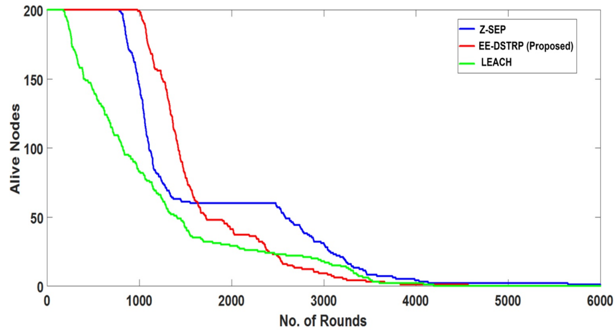

Fig.9: *Total alive node in every round.*

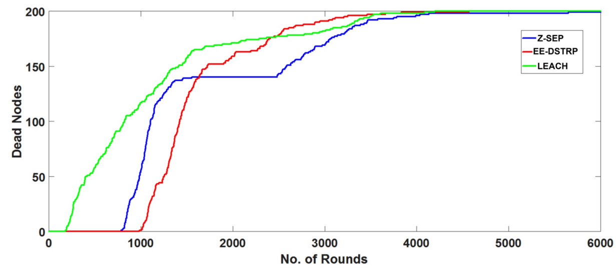

Fig.10: *Total dead node in every round.*

Alive Nodes
Alive nodes are nodes that dissipate energy after each round of communication but still have enough energy to prolong communication without interruption.

Dead Nodes
Dead nodes are nodes that dissipate energy after each round of communication but still do not have enough energy to continue communication. They are useless and do not participate in commutation in wireless networks.

Throughput
Throughput is the rate of sending data from the SN to the forwarder or directly into the sink. Throughput describes the overall lifespan of WSNs.

5.1.1 Stability and Network Life Span

Stability period is round number at which the first node death occurred, and network life span is the round number at which the last node death occurred in the network. It is depicted in Table 2. We can observe that the stability period of EE-DSTRP is better as compared to LEACH and Z-SEP protocol. The lifespan of EE-DSTRP is better than LEACH but lower than Z-SEP. The reliability of any protocol is completely dependent on stability period because if 100% nodes are alive then the network coverage is assured. We have made a comparative study of lifespan for fair comparison. The network lifespan i.e. last node death is not a concern because even if only one node is alive then also the network is operational but with only one node coverage is a serious issue as one node can't cover the complete network region.

5.1.2 Alive Nodes per Round

Alive nodes per round are depicted in Fig. 9. It is shown that EE-DSTRP has a larger stability period than LEACH and Z-SEP. If larger numbers of SNs are alive for a long time, then the information collected from the deployed region is increased. In-network scenario, the first node dies at 480 rounds in LEACH and 1200 for Z-SEP whereas in EE-DSTRP no SN death occurs till 1400 rounds.

The proposed protocol has a uniform energy dissipation. According to the network scenario, LEACH and Z-SEP have poor performed whereas the IoT based EE-DSTRP performs better because the CHs selection and cluster formation and uniform CH positions in each section is determined in the proposed protocol to enhance the network life span of the WSN.

5.1.3 Dead Nodes per Round

The dead nodes per round for the network scenario is depicted in Fig. 10. The premature death of SNs makes the network unstable and unreliable. After the formation of the cluster and its CHs selection, communication began from the target area to the sink through the SNs. The graph shows that the proposed protocol has a lower number of dead nodes for the larger numbers of rounds, compared to all existing protocols as the ratio of dead nodes per round is maximum compared to EE-DSTRP.

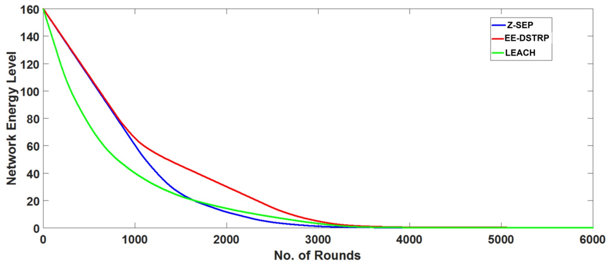

Fig.11: *Analysis of network energy level.*

5.1.4 Average Network Energy

The average energy of the network is depicted in Fig. 11. It is clearly shown that the proposed protocol EE-DSTRP outperforms LEACH and Z-SEP in terms of energy dissipation. The maximum energy of an SN is 0.5 joules for the purpose of calculating the average energy of a network. If there are 100 nodes in the network area it will take 50 joules of energy for communication and 100 joules if there are 200 SNs.

5.1.5 Throughput

Fig. 12 depicts the comparative study of packets received by the sink for different position of the sink. Throughput of the network is better as compared to existing protocols. In this paper, the location of the sink is considered at different places as compared to LEACH and Z-SEP, which consider the location of sink at the center only, limiting the protocol suitability for all types of applications of WSN.

The reason for considering different positions of sink is that the proposed protocol can satisfy almost every application of WSN. There are some applications of WSN where human reachability is not possible like Forest Fire, Natural Calamity etc. where the sink can't be positioned inside the target area. There are applications where human reachability is possible like structure monitoring, environment monitoring, agriculture etc. where we can locate the sink at the center. Various important parameters are used in the proposed protocol for better performance of the WSNs. If a greater number of packets are delivered to the sink, then more information is collected fulfilling the objective of WSNs dependent on the network lifespan and the residual energy. In the proposed clustering approach network lifespan and residual energy is high. Hence the sink received a greater number of packets. A brief overview to enhance the life time of WSNs in terms of throughput is as follows.

i) Apply the golden ratio for SN deployment to minimize the communication cost and increase residual energy of WSNs.
ii) Avoid unnecessary repetition of CHs rotation.
iii) Use two stage transmissions of data to improve the communication process and increase the stability period of WSNs.

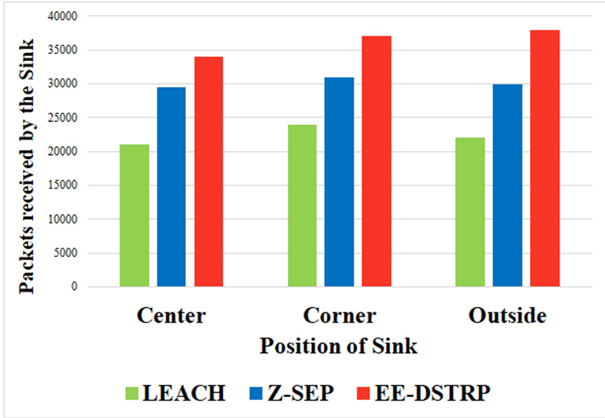

Fig.12: *Comparison in terms of packets received by the sink.*

iv) Use forwarder nodes to improve the communication process.

6. CONCLUSION

WSNs have several resources restrictions; Energy restriction of SN is a big issue for IoT based WSNs. After deployment of SNs, they start communication and after each round of communication the energy depletion starts; all SNs die after a specific round of communication. To reduce energy utilization of SNs per round, we have developed a two-stage routing protocol (EE-DSTRP) with the optimal deployment of SNs based on the golden ratio to enhance the life span of WSNs. Firstly, the network is divided into two zones as per the golden ratio. Cluster formation starts in the network after the selection of CHs on the basis of a threshold. CHs forward data to a forwarder node which in turn sends the same to the sink conserving energy. The contrast among the proposed protocol (EE-DSTRP) and the existing routing protocols (LEACH and Z-SEP) clearly shows that the performance of the proposed protocol is far better than the existing protocol in terms of stability, alive nodes and dead nodes. The better average energy of the network and improved throughput are also helpful in validating that EE-DSTRP used a better CHs and forwarder based energy efficient routing approach. Two-stage routing and node deployment strategies incorporating the golden ratio have addressed the energy efficiency issue in routing protocols. In future work, simulation experiments can be conducted on mobile SNs.

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Anshu Kumar Dwivedi received the B.Tech Degree in Computer Science & Engineering from Uttar Pradesh Technical University Lucknow, India, in 2007 and M.Tech (HONS) degree in Computer Engineering from YMCA University of Science & Technology, Faridabad, India, in 2012. Now he is a research Scholar in Department of Computer Science & Engineering from 2017 to till date. His current research interests in Wireless Sensor Network, Ad-Hoc Network, Theory of computation, remote monitoring and control. He has served on various IEEE conferences as a technical program committee member.

Awadhesh Kumar Sharma is a Professor in Department of Computer Science & Engineering at the Madan Mohan Malaviya University of Technology Gorakhpur, India. He holds M.Tech and Ph.D degrees from IIT Kharagpur, India. His area of interests include wireless sensor network, DBMS and AI. He is member of IEEE, FIE (India), FIETE, MCSI, MISTE.

Pawan Singh Mehra is currently working as Assistant Professor (Senior Grade) in Jaypee Institute of Information Technology, Noida, India. He received his Ph.D. degree in Computer Engineering from Jamia Millia Islamia and M.Tech. Degree in Computer Science and Engineering from Center for Development of Advanced Computing (CDAC). He completed Bachelor of Engineering from RJIT, Gwalior, India. His research interests include wireless sensor network, image processing, block chain, cryptography and network security. He has authored research papers published in leading International Conferences and Peer-reviewed International journals from IEEE, Elsevier, Springer, John Wiley, etc. He is reviewer of Scopus/SCI Indexed International Journals.