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A Novel Opinion Dynamics Model Based Clustering Protocol in High-level Heterogeneous WSN

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ABSTRACT

In Wireless Sensor Networks (WSNs), many sensor nodes, with restricted energy, co-operate to accomplish a sensing task. In WSN, the key issue for designing the protocol is energy efficiency because sensor nodes have limited battery. Many modern protocols have been proposed to extend the lifetime of the network by using the battery power efficiently. In this project, a novel opinion dynamics model based clustering protocol has been developed for prolonging the stability period using different levels of heterogeneity such as 4-level, 5-level, 6-level, 7-level in terms of node energy. An opinion model is used for optimal cluster head election via LEACH mechanism. The opinions are updated using social influence factors. It is shown that the stability period is improved. Also the packet delivery ratio is improved for most of the stable zone.

Keywords: Heterogeneous wireless sensor networks, clustering algorithms, advanced stable election protocol, Four-level stable election protocol, HODs model, Stability region, Packet delivery ratio, Network lifetime, Throughput ratio.

I. INTRODUCTION

Wireless sensor networks (WSNs) consist of several thousands of sensors that can collect precise information in remote and perilous environments. All nodes in the homogeneous networks have same amount of energy. In heterogeneous networks some nodes may have more energy than other nodes.

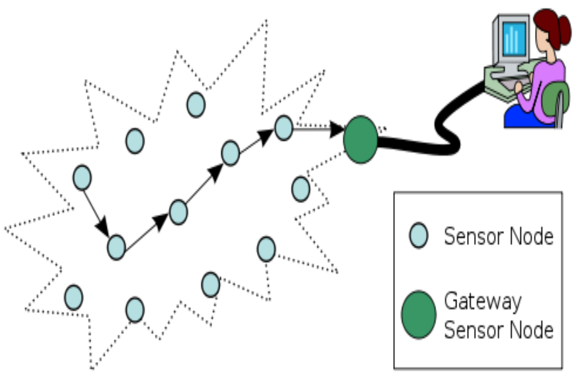

Figure1. Wireless Sensor Network structure

Wireless Sensor Networks (WSNs) is an important technology for the past two decades. There are a lot of advances in wireless communication technologies. The sensors can be deployed anywhere and connected through wireless links [7]. A sensor node mainly consists of five components:

- Sensing
- Memory
- Processor
- Transceiver (transmitter and receiver)
- Battery

The prices of sensor nodes vary depending on the type, size, functionality, applications and complexity of the sensor nodes. The cost of the multifunctional sensor is higher than the normal single functional sensor node. Size and cost limitations on sensor nodes result in corresponding limits on resources such as power backup, memory, computational speed, processing speed, durability, efficiency, accuracy and communications bandwidth. The network layout and topology of the WSNs may differ from a simple star network to an advanced multi-hop wireless mesh and hybrid network [13].

Now a day, the WSNs are used in many applications, such as industrial, commercial, consumer and so on. In WSN, the sensor nodes can sense and send their data to the sink. Then, the base station can receive the sensed data from sensor nodes collectively. We know that, the battery of the sensor nodes cannot be replaceable manually once the network is deployed. Without manual interpretation, the wireless sensor networks should perform their operations automatically. Therefore, the main focus is to improve the network lifetime as well as to reduce the energy consumption. For this purpose, the many cluster based routing protocols were introduced and proposed.

A. Routing in WSNs

In Wireless Sensor Networks, energy efficiency is the main considerations for routing protocols. The routing protocols can be varied depends upon the WSN applications and also the WSN characteristics are varied from one network to other networks simultaneously. Therefore, the process of routing protocols is also varied.

B. Key Issues on WSN

In broadcasting method, a message is distributed to many other nodes in the network. A many unnecessary messages are created in a network. This causes nodes to scatter the amount of energy rapidly. Therefore, the efficient clustering algorithms have to be proposed that can minimize the amount of unessential transmissions.

C. Clustering on WSN

The characteristic of wireless sensor network is scalability and have a large number of sensor nodes. Due to wide area network, a long path communication is difficult and single level network topology does not work systematically. For this reason, the concept of clustering can be used here.

The goal of clustering is the task of grouping a set of nodes in such a way that nodes in the same clusters are more similar to each other than to those in other clusters [12]. In each clusters, one node act as a cluster head (CH). The clustering approach applied in homogeneous sensor networks is called homogeneous clustering strategy and the clustering approach applied in the heterogeneous sensor networks is referred to as heterogeneous clustering strategy.

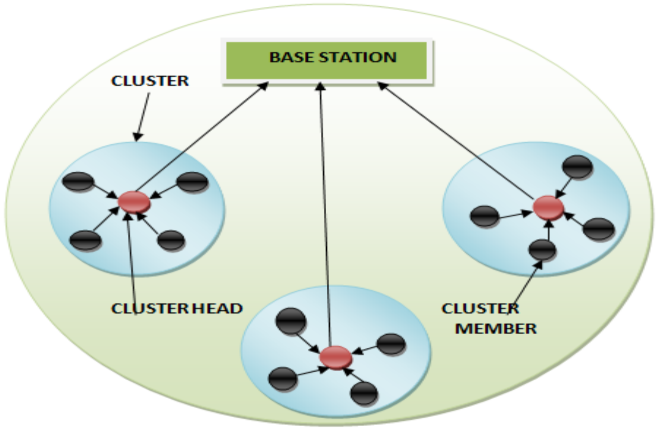

Figure2. Cluster formations on WSN

1) Advantages of clustering

To ignore the unnecessary data transmission and reception by switching the nodes into sleep mode, if there is no data to transmit or receive. For this purpose, there are various clustering protocols are developed efficiently like LEACH, SEP, ESEP, HEED, DEEC etc.

2) Limitations of clustering

- To reduce the number of cluster heads (CHs) under any node in a network is either a cluster head or connected to at least one cluster head. It would leave the sensor nodes in sleep mode. This problem is called as the dominating set problem.
- The sensor nodes run outs of energy immediately when the cluster heads is in busy for processing, sensing and transmitting data whereas other nodes are left with some extent energy. This decreases the network lifetime and prompts a lack of proportion in the energy reserve in nodes. In nodes heterogeneity, the behavior of sensor networks becomes very unstable once the first node dies.

D. Clustering Parameters

The clustering parameters are,

- Number of clusters (cluster count)
- Intra-cluster communication
- Mobility of nodes and cluster head
- Nodes types and roles
- Methods of cluster formation
- Selection of cluster-head

- Algorithm complexity
- Multiple levels
- Overlapping [3]

II. CLUSTERING ALGORITHMS

A. LEACH Clustering Protocol

Low energy adaptive cluster hierarchy (LEACH) is a self-organizing and an adaptive clustering protocol. In LEACH, the nodes are distributed into clusters and one node in every group (clusters) acts as a cluster head. The remaining nodes are known as cluster node (cluster member) that transmits their data to the cluster head. Cluster head perform data aggregation process and transmit the aggregated data to the sink (BS). Cluster head takes more energy than cluster nodes. As the CH runs out of energy, then all the nodes belong to the cluster lose communication ability. To overcome this problem, LEACH introduces randomized selection of CH so that amount of energy is balanced between nodes [11]. The operation of LEACH protocol is divided into rounds and each round has setup phase and steady state phase.

In setup phase, select the cluster heads randomly and the nodes closer to CH forms a cluster dynamically. In steady state phase, the nodes in each cluster groups would send their data to corresponding CH, and then CH would aggregate the data and send it to base station (BS).

The sub-phases are advertisement phase, cluster set-up phase, schedule creation phase and data transmission phase that are comes in the above phases. In advertisement phase, each node randomly choose a number between 0 and 1 and if the randomized number is less than threshold value then it advertise itself as CH by broadcasting an ADV message(advertisement) using CSMA MAC protocol (carrier sense multiple access). The value of T (n) is calculated using the following formula:

$$\mathbf{T(n) = \int p / 1 - p[r \bmod (1 / p)],\ n \in G} \qquad \mathbf{(1)}$$

Where, n=given number of nodes in the network

P=predefined percentage of CH (P=0.05)

r = r is the current round

G=nodes that have not been cluster head in the last 1/P rounds

After CHs are selected, they start to advertise their node to the other sensor nodes. When it receives ADV message from more than one CH node, a sensor node starts to make a decision about its respective cluster head. Each node listens to the ADV signals and chooses the sensor node whose signal is received with higher energy. This ensures that the node which is close to cluster nodes act as a cluster head.

3) Advantages of LEACH

- ✓ LEACH protocol reduces energy consumption in case of multi-hop data packets transmission and it is a completed distributed protocol.
- ✓ Due to uniform distribution of CH, all the sensor nodes in the network die at the same time.
- ✓ In LEACH protocol, the control information from sink node is not needed for sensor nodes compulsory.
- ✓ In LEACH technique, sensor nodes do not need global knowledge or any identification in the network [13].

4) Limitations of LEACH

- ✓ The implementation of LEACH protocol is not suitable for large regional areas.
- ✓ LEACH protocol does not provide clear definition about the position of sensor nodes and the number of CHs in the network.
- ✓ In LEACH protocol, the CH will consume more energy if the distance between the CH and BS is far.
- ✓ When the CH die, the cluster will become useless because the data collected by cluster nodes will never reach the BS.
- ✓ In LEACH protocol, the nodes are distributed with same energy level in the beginning and each node has an equal chance of being chosen as a CH of the cluster so that there is loss of minimum data packet and increases the instability period if the nodes are distributed with different energy level.

B. Stable Election Protocol

Stable Election Protocol is a two level heterogeneous aware protocol and address the effect of nodes heterogeneity of the sensor in terms of energy that is hierarchically clustered.SEP protocol uses cluster based routing protocol based on the nodes heterogeneity in the sensor networks [7].In stable election protocol, cluster heads are selected by using weight election probabilities according to the extra energy reserve in each node. SEP is the modification of LEACH protocol developing two types of nodes:

- ✓ Normal nodes
- ✓ Advance nodes

The probability of normal node and advanced node to become cluster heads is calculated as

$$P_{nrm} = P_{opt} / 1 + ma \quad (2)$$

$$P_{adv} = P_{opt} (1 + a) / 1 + ma \quad (3)$$

Where P_{opt} is the optimal probability to become CH in the network. In SEP, the advance node gets more energy than normal node [13]. Choose a random number for each node type that is compared with their threshold value. If a random number is less than threshold value then that node will become cluster head. The nodes (normal and advance) whose having more energy will become cluster head.

5) Advantages of SEP

- SEP prolong the stability period, which is suitable for many applications where the sensor network reliable.
- Sensor nodes do not need the global knowledge of energy of sensor node or any identification in SEP technique at each round of cluster head selection process.

6) Limitations of SEP

- The sensor nodes are far away from cluster head (CH) will die first when the CH selection is not dynamic.
- In SEP, higher level of nodes does not utilized efficiently.
- It decreases the lifetime of the network due to the energy of advanced nodes depletes more quickly than normal nodes.

III. RELATED WORK

Georgios Smaragdakis et al. (2004)[5] designed the Stable Election Protocol (SEP), is a heterogeneous protocol that improves the stability period. Based on weighted election probabilities of each node, to elect the cluster head according to their extra energy. This protocol introduce two types of nodes are normal and advanced nodes. Advance nodes having more energy than normal nodes. In SEP both nodes (normal node and advanced node) have weighted probability to become cluster head. If a random number is less than threshold value then that node is selected as CH. Advance nodes have more chances to become CH than normal nodes. These protocols do not require any global knowledge to select CHs. But, the whole energy of the system will be modified. In SEP, the CH selection process among the nodes is not dynamic, which results that nodes that are distance away from the powerful nodes will be dead first. The energy of higher level nodes is not utilized in SEP efficiently. The authors extended the LEACH protocol except the heterogeneity. But the cluster formation is varying in this algorithm and also stable period is good. **Arwinder Kaur et al. (2013)[2]** analysed the SEP in 4-level hierarchy named as ASEP-E that is self-organized using 4-types of nodes: super advanced nodes, advanced nodes, intermediate nodes and normal nodes. Thus, in SEP and SEP-E, the nodes are die soon than ASEP-E. So, there is a good improvement in the performance of the network with ASEP-E protocol in terms of network lifetime and number of packets received at BS that is well enhanced than SEP and SEP-E protocol. **Rishemjit Kaur et al. (2013) [9]** discussed about the Human opinion dynamics model for solving complex optimization problems. Human interactions give rise to the formation of different types of opinions in a group. Here, CODO (Continuous Opinion Dynamic Optimizer) algorithm had been proposed. This algorithm is governed by social structure, opinion space, social influence and updating rule. These models are very limited in nature but the present research will have a path towards real world problem solving by human beings. Later, the effect of CODO basic elements is discussed etc. And also the effect of adaptive noise is also studied and compared the overall performance of CODO with lbest PSO. This proposed algorithm making it easy to tune and does not perform well in the case of multimodal problems, but it can be studied and adapted to improve its performance by evolving strategies to dynamically update parameter to observe finer-grained approach. **Archana et al. (2015)[1]** introduced the different levels of heterogeneity: 3-level, 4-level, 5-level, 6-level and 7-level in terms of the node energy. In each level, different types of energy nodes are developed based on SEP. The proposed work has focused to enhance the network lifetime of SEP using multilevel heterogeneity. The proposed heterogeneity algorithm had been proposed and implemented in the MATLAB. The comparison of all levels of heterogeneity based on SEP has also been done using First node die, Last node die and the number of clusters. The simulation results show that the network lifetime and stability period increases efficiently with each levels of heterogeneity. **Virpal Kaur et al. (2016)[12]** introduced the HOD models for cluster head selection based on SEP in three level hierarchies for reducing the instability period. The proposed algorithm, advance SEP enhances the stability period and packet delivery ratio as compared to the SEP clustering protocols. The protocol works such that first the nodes are distributed randomly. The nodes are divided into three levels: normal, advanced and super advanced nodes. The normal node is expected to die first when the LEACH protocol is applied, advanced nodes have higher energy than normal nodes and the super advanced nodes have higher energy than advanced nodes. Thus, the super advanced nodes have more chances to become the cluster head (CH).As the heterogeneity levels increases in a network, the stability period also have to be increased as well as the packet delivery ratio is found to be increased sharply.

IV. PROBLEM FORMULATION

The major problem in wireless sensor networks is energy efficiency. Now a day, the on-going challenge is to find a efficient way to transfer data with improved throughput ratio, energy consumption and network lifetime in WSN. The lifetime of the network is expressed in two ways:

- The time before the first node dies (FND) in the network - stability period.
- The time before the last node dies (LND)in the network - network lifetime.

The period gap between the depletion of origin and final element in the sensing area is defined as instability period. The aim of this paper is to maximize the stability period efficiently.

A. Three-level Stable Election Protocol with HODs

An advance SEP is a heterogeneous aware protocol to increase the lifetime and stability period of the network, which is suitable for many applications in the sensor network reliably. An opinion dynamics based 3-level SEP is used for optimizing the value of probabilities of each level cluster head selection. The functioning of this protocol is that the nodes are distributed randomly in the network area [12] and the nodes are divided into three levels such as:

- **Level one (normal node):** Given an initial set of energy and it is expected to die first if we use the LEACH technique.
- **Level two (advanced node):** Given an initial set of energy that is higher than normal nodes.
- **Level three (super advanced node):** Given an initial set of energy that is higher than advanced nodes.

Here, the super advanced nodes having more chances to become the cluster heads(CHs).Due to three levels of heterogeneity in SEP, the stability period and network lifetime of the network is found to be improved as compared to the two-level SEP protocol.

B. Four-level Stable Election Protocol with HODs

The proposed protocol functioning is as same as existing protocol named as ASEP (3-level SEP with HODs). Only the difference is that the proposed protocol can be extended to four-level nodes heterogeneity. As the level of node will be increased, the instability problem can be reduced efficiently than 3-level SEP.

The proposed protocol (opinion dynamics based four-level SEP) is the heterogeneous protocol to increase the network lifetime and stability period, which is useful for many applications in the sensor network where reliable evolution is required.

Four-level distributions are examined and an effort has been made to develop a novel scheme for the network with 4-level heterogeneity. The functioning of proposed protocol is that first the nodes are scattered randomly and the nodes are divided into four levels such as:

- **Level one (Normal node):** Given an initial set of energy and is expected to die first if we use the LEACH technique.
- **Level two (Advanced node):** Given an initial set of energy that is higher than normal nodes.
- **Level three (Super advanced node):** Given an initial set of energy that is higher than advanced nodes.
- **Level four (Highest energy level node): G**iven an initial set of energy that is higher than advanced, normal and super advanced nodes.

Here, the highest energy level nodes having more chances to become the cluster heads (CHs) based on their optimal probabilities according to their residual energy of each nodes. An Advanced 4-level SEP is based on an opinion dynamics-based model to optimize the probabilities of each level cluster head selection.

C. Human Opinion Dynamics model

Human Opinion Dynamics model is a metaheuiristic technique (novel approach) which is used to solve complex optimization problems based upon human decision making process. Here, the opinion formation is an evolutionary process that is assessed to be continuous to suit our optimization problem where optimizing parameters can have any value within a finite range.

A human opinion dynamics model has been developed for solving complex optimization problems and is referred to as SITO (Social Impact Theory based Optimizer) which is based on discrete opinion formation and are limited to low dimensional real valued problems. The various continuous opinion models have been proposed and the most popular one is Deffuant and Hegselmann-Krause model. This model is the interaction between the individuals is determined by a preset threshold value and typically assumes 'bounded confidence' (BC). Thus results in early convergence of opinions as being deterministic in nature. Researchers experimented by adding an opinion noise for avoiding this convergence. In addition to, the uniformly distributed opinion noise leads to change the opinion of individuals suddenly.

The work of Durkheim towards the separation of labor in society originated from the relations of the individual to social solidarity. The author argued on the parallelism between collectivism and individualism in the society. Also he argued that integrating forces stimulate individuals to observe and validate values similar to others. At the same time, the disintegrative forces that encourage individualism threaten the social integration.

Based on Durkheim's theory, the model of social influence combines the tendencies of social influence with the disintegrative effects of individualization, which is achieved by integrating an adaptive noise. To develop a real valued optimizer named as the Continuous Opinion Dynamics Optimizer (CODO) by the characteristics of Mas's computational model.

A Continuous Opinion Dynamics Optimizer is developed and it is also called as CODO algorithm. This algorithm has four basic elements such as:

- Social Structure
- Social Influence
- Opinion Space
- Updating Rule

1) Social Structure is the interaction between group of individuals, individuals, the frequency and the way of interaction which is simulated in social physics. Example: small world, cellular automata model, random graphs and so on.

2) Opinion Space is the opinion of individuals that is discrete and continuous opinions whereas continuous opinion could be any real value and discrete opinion may take values as [0,1] and [-1,1].

3) Social Influence is the influence in which individuals act according to others expectation and has two factors:

- Social Ranking
- Distance between two individuals

The social influence of individual j on individual i is calculated by:

$$\mathbf{W_{ij}(t) = SR_j(t)/d_{ij}(t)} \qquad \mathbf{(4)}$$

Whereas $d_{ij}(t)$ is the Euclidean Distance between two individuals, $SR_j(t)$ is the social rank of individual according to their fitness value.

4) Updating Rule is an iterative optimization algorithm which is used to update the position of individuals in search space. The update rule according to the equation is calculated by:

$$\Delta \mathbf{o_i = \sum o_j(t) - o_i(t)\, w_{ij}(t) \setminus \sum w_{ij}(t) + \eta_i(t)\ ,\ j \neq i} \qquad \mathbf{(5)}$$

Whereas $o_j(t)$ is the opinion of neighbors of individual i, $w_{ij}(t)$ is the social influence and $\eta_i(t)$ is a distributed random noise with mean value zero.

After acquiring maximum number of objective function or assigned fitness error value, the iterative process has to be terminated.

D. CODO Block Diagram

The functions of CODO algorithm is explained in one by one step:

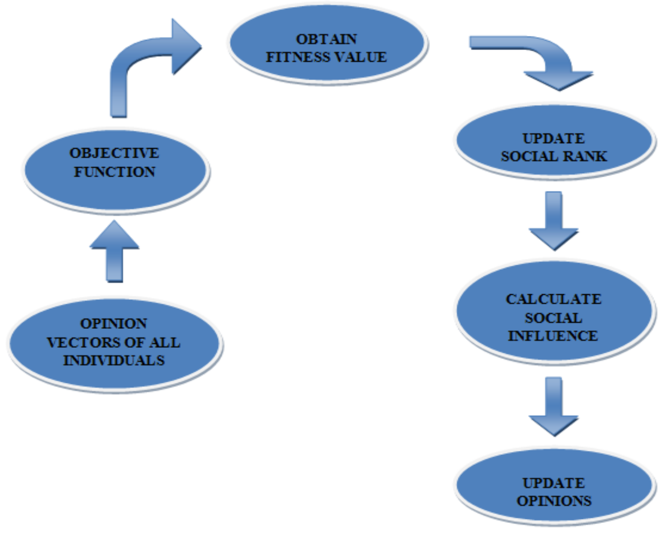

Figure 3. Optimization process of CODO

1) The opinion of all the individuals is calculated by the objective function at a certain time.
2) The output value of the objective function is taken as a social rank to each individual. Higher the fitness value, the lower the social rank and vice versa.
3) The same fitness values store the same social rank of individuals. The social influence of each individual is evaluated using equation (4).
4) The opinion vector of each individual is updated at the end of each iteration process.
5) This iterative process terminates after acquiring maximum number of objective function or assigned fitness error value.

V. HODs BASED HIGH-LEVEL SEP

Assume some percentage from the population of sensor nodes that has a maximum energy and the remaining sensor nodes has minimum energy by generating heterogeneity in the network operation. This heterogeneity starts from the initial set of the network. The sensor nodes are distributed randomly or uniformly that are not mobile. The behavior of sensor networks becomes very doubtful after the reduction of the leading element in the existence of heterogeneity. In clustering schemes, the energy of all sensor nodes is same that enable the nodes in terms of the nodes energy level.

A human opinion dynamics model based clustering protocol is proposed for prolonging stability period of the wireless sensor network effectively. The proposed work is focused to extending the three level nodes heterogeneity into four level nodes heterogeneity. The proposed method introduced three types of nodes such as low-power, high-power and ultra nodes. Thus having more chances to be elected as CH as in the case of highest energy level nodes. As the nodes heterogeneity level increases over the area, the stability period is found to be increased as well as the packet delivery ratio is also seen to be improved i.e., instability period can be reduced sharply as compared to existing protocol.

A. Five-level Stable Election Protocol with HODs

The proposed protocol functioning is as same as existing protocol named as 4-level SEP with HODs. Only the difference is that the proposed protocol can be extended to high-level nodes heterogeneity. As the level of node will be increased, the instability problem can be reduced efficiently than 3-level SEP.

The proposed protocol (opinion dynamics based four-level SEP) is the heterogeneous protocol to increase the network lifetime and stability period, which is useful for many applications in the sensor network where reliable evolution is required.

The proposed protocol works such that first the nodes are distributed randomly. The nodes are divided into five levels as follows:

- **Level one (Normal node):** Given an initial set of energy and is expected to die first if we use LEACH protocol.
- **Level two (Advanced node):** Given an initial set of energy higher than that of normal nodes.
- **Level three (Super advanced node):** Given an initial set of energy higher than that of advanced nodes.
- **Level four (Highest energy level node):** Given an initial set of energy higher than that of super advanced nodes.
- **Level five (Ultra node):** Given an initial set of energy higher than that of highest energy level node.

Here, the ultra node having more chances to become the cluster heads (CHs) based on their optimal probabilities according to their residual energy of each nodes. An

Advanced 5-level SEP is based on an opinion dynamics-based model to optimize the probabilities of each level cluster head selection.

B. Six-level Stable Election Protocol with HODs

The proposed protocol works such that first the nodes are distributed randomly. The nodes are divided into six levels as follows:

- **Level one (Normal node):** Given an initial set of energy higher than that of low-power node.
- **Level two (Advanced node):** Given an initial set of energy higher than that of normal nodes.
- **Level three (Super advanced node):** Given an initial set of energy higher than that of advanced nodes.
- **Level four (Highest energy level node):** Given an initial set of energy higher than that of super advanced nodes.
- **Level five (Ultra node):** Given an initial set of energy higher than that of highest energy level node.
- **Level six (Low-power node):** Given an initial set of energy lower than that of normal, advanced, super advanced and highest energy level node.

Here, the high-power node having more chances to become the cluster heads (CHs) based on their optimal probabilities according to their residual energy of each nodes. An Advanced 6-level SEP is based on an opinion dynamics-based model to optimize the probabilities of each level cluster head selection.

C. Seven-level Stable Election Protocol with HODs

The proposed protocol works such that first the nodes are distributed randomly. The nodes are divided into seven levels as follows:

- **Level one (Normal node):** Given an initial set of energy higher than that of low-power node.
- **Level two (Advanced node):** Given an initial set of energy higher than that of normal nodes.
- **Level three (Super advanced node):** Given an initial set of energy higher than that of advanced nodes.
- **Level four (Highest energy level node):** Given an initial set of energy higher than that of super advanced nodes.
- **Level five (Ultra node):** Given an initial set of energy higher than that of highest energy level node.
- **Level six (Low-power node):** Given an initial set of energy lower than that of normal, advanced, super advanced and highest energy level node.
- **Level seven (High-power node):** Given an initial set of energy higher than that of normal, advanced, super advanced, low-power node and highest energy level node.

Here, the highest energy level nodes having more chances to become the cluster head (CHs) based on their optimal probabilities according to their residual energy of each nodes. An Advanced 7-level SEP is based on an opinion dynamics-based model to optimize the probabilities of each level cluster head selection.

D. Data Communication Process

First, the nodes are distributed over the network field randomly with different energy levels and the nodes are mobile. The base station distributes the data to all their neighbor nodes. The nodes are communicating their data with one another. And then elects the cluster head based on their energy levels using HODs model, most probably which nodes having more energy to become the CH. Before electing the CH, it starts to find the dead nodes simultaneously. The cluster nodes are sending their data to its neighbor cluster heads and the cluster heads send that data to the base station. The cluster heads maintain the entire data communication process in the sensor field between CHs and BS [10].

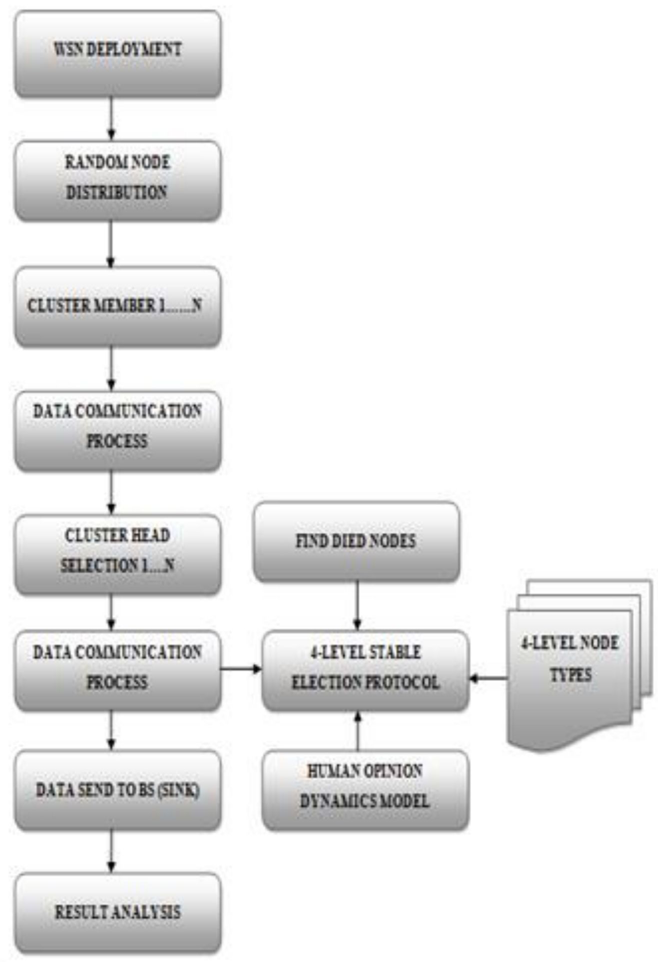

Figure 4. Dataflow diagram of high-level SEP with HODs

1. Communication between CHs and CNs

The cluster heads are selected; the cluster heads broadcast ADV message to all sensor nodes in the network that they are the new cluster heads like as LEACH protocol. And then other nodes act as local clusters by choosing the closest cluster head. Thereafter the CH receives sensed data from cluster nodes according to preset time (TDMA) schedule that was collected and transmitted to BS.

2. Communication between CHs and BS

Each cluster nodes send their data during their allocated time to the required cluster head. The CH node must receive all the data from the cluster nodes within the cluster. When all the data is received, the cluster head compress the data into a single signal and then each cluster head can send the aggregated data to the BS.

VI. PERFORMANCEANALYSIS

A. Performance Metrics

The parameters considered for the better performance of the network during simulation time [5]. The definitions of parameters in the WSNs related to this project are:

1. Stability Period

The time period from the start of the network operation until first node die is referred as "stability region". The stability period according to the equation is given by:

SP =receiver *1000*8/ (txpower*rxpower)

2. Packet Delivery Ratio

The ratios of number of packets send and received from the source to destination is referred as PDR. The better performance of the protocol is identified by greater the value of PDR. The PDR according to the equation is given by:

PDR = (recv/sends)*100

3) Network Lifetime

The time period from the start of operation of the sensor network until the last node die is referred as network lifetime. The lifetime of the network according to the equation is given by:

Network Lifetime =(recvdtime-sendtime)*1000

4) Throughput Ratio

To measure the total rate of data sent over the network, from cluster heads to the sink as well as from cluster nodes to cluster heads is referred as throughput. The throughput ratio according to the equation is given by:

Throughput=(recvdsize/startTime-stopTime)*(8/1000)

B. Simulation Parameters

TABLE I. SIMULATION PARAMETERS

Parameters	Values
Simulation	ns2
Mac Type	IEEE 802.11
Routing Protocol	high-level SEP with Human opinion dynamics model
Transfer Model	UDP
Number of nodes	50
Simulation Time	10 seconds
Mobility Model	Random Distribution model
Transmission range	100-200 m
Data rate	512 Mbps
Transceiver (Tx) power	0.175 W
Receiver (Rx) power	0.175 W
Initial energy	0.5 J

C. Simulation Results

The above problem is simulated for a condition of 50 nodes distributed randomly over the network area. The nodes are given an initial set of energy as specified in simulation settings. All the simulations are done on a PC of 4 GB RAM, 2.20 GHz processor on ns2. The simulation results are shown in Fig. 5.

The total number of dead nodes and alive nodes per round are shown in Figure 4.2 and comparison is performed between 4-level SEP and high-level SEP protocols. Here, the "black color" nodes represent the normal nodes, while "brown color" represents the advanced nodes, the "violet color" nodes represent the super advanced nodes, the "sky blue color" represents the highest energy level nodes and the "blue color" represents the ultra nodes. Finally, the "red color" represents the dead nodes over the sensor network field.

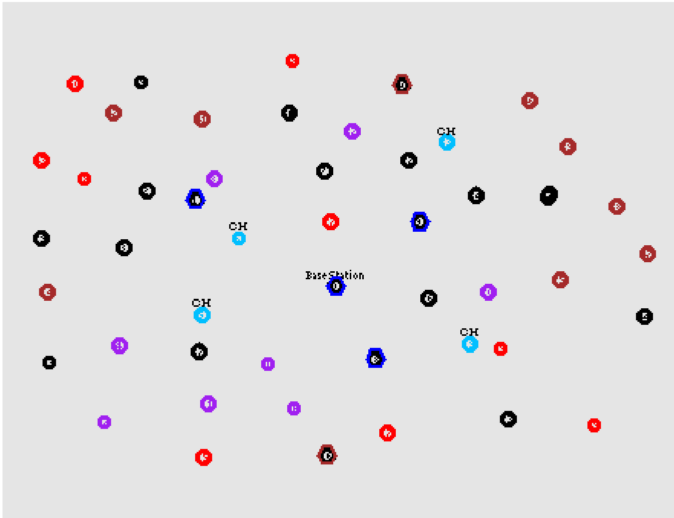

Figure 5. Heterogeneous WSN with high-levels SEP

1) Performance of Stability Region

Fig. 6(a) represents the stability graph. The node alive is plotted. It's shown some nodes start dying out when the rounds are increased that should be as minimum as possible for maximum number of rounds. The proposed algorithm is designed in such a way that all the sensor nodes start dying out simultaneously. As a result, the slope of the curve increases around 100 rounds. This is reduces packet data loss during stable period.

From the graph, the stability period of proposed protocol can be found to be improved than 4-levelSEP approach. The performance of stability period is achieved through limited energy consumption. Finally, the stability of 7-level SEP gives better performance than 4-level, 5-level and 6-level.

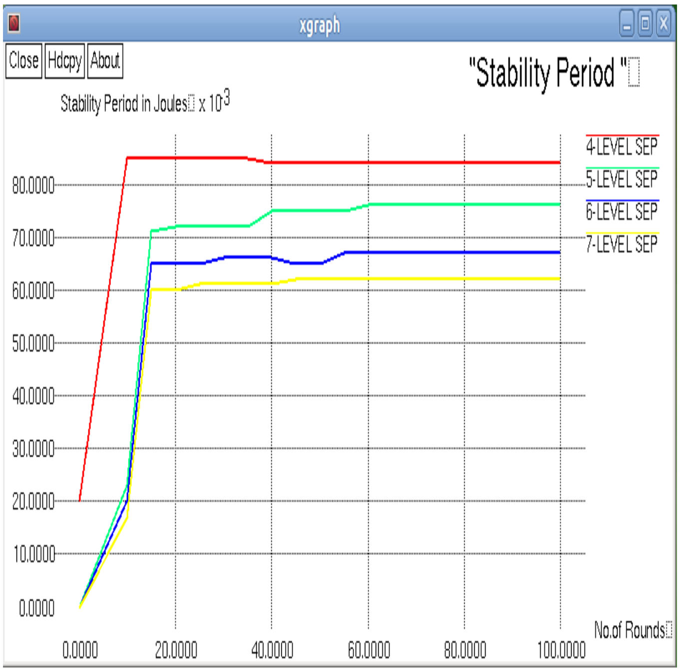

Fig. 6 (a)

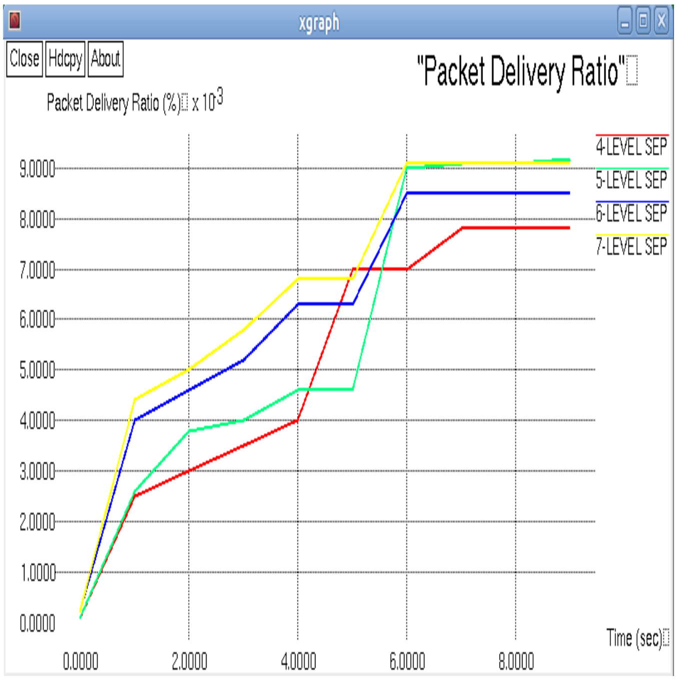

Fig. 6 (b)

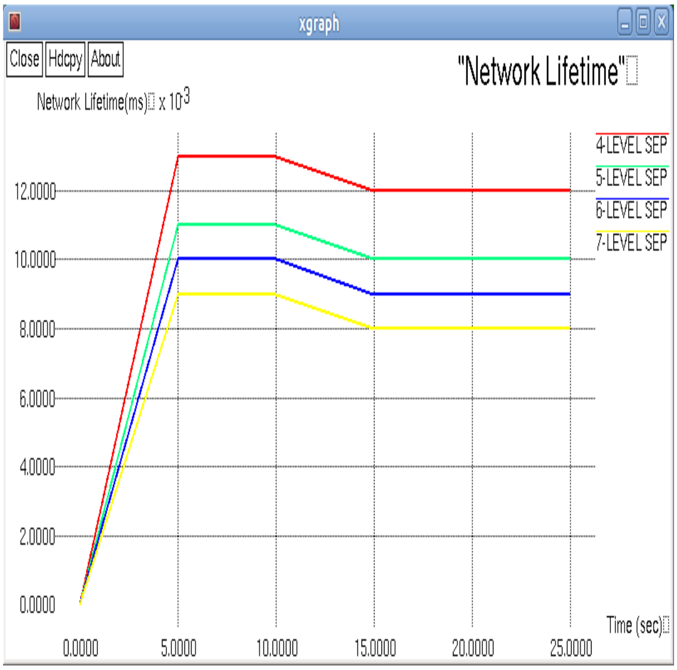

Fig. 6 (c)

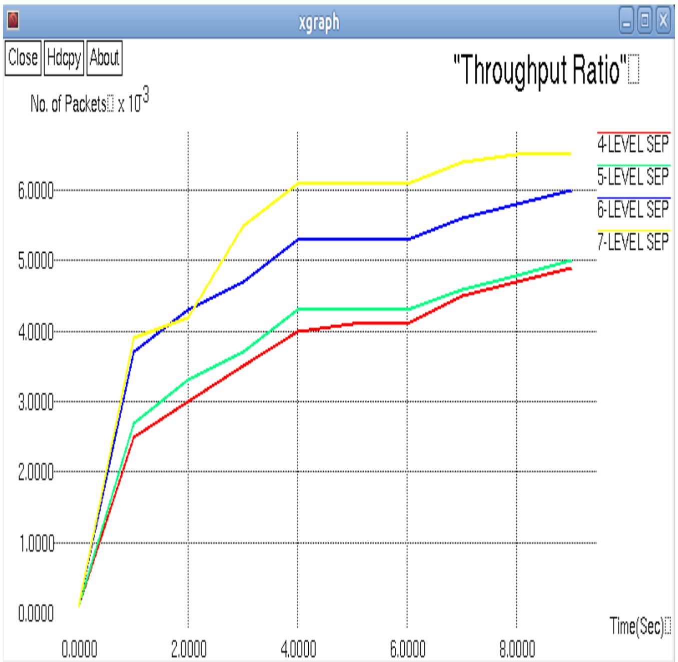

Fig. 6 (d)

Figure6. Performance results of high-level SEP compared to 4-level SEP (a) Stability period (b) PDR (c) Network lifetime (d) Throughput ratio

2) Performance of PDR

Fig. 6(b) represents the packet delivery ratio which shows percentage close to 90% for most of the stability period. This ensures a smooth operation and reliable network operation. The packet delivery ratio (PDR) is described by the number of packets transmitted and received from source to destination. It is desired that the PDR range should remain high.

The proposed protocol is designed such that most of the nodes die simultaneously so that they are alive together for most of the time thereby maintaining the prolonged stability zone. Finally, the packet delivery ratio of 7-level SEP gives better performance than 4-level, 5-level and 6-level.

3) Performance of Network Lifetime

Fig. 6(c) represents the network lifetime that is increases with level of heterogeneity. The dead of first node of all heterogeneity levels are compared as shown in Fig. 6(a), which shows as level of heterogeneity increases. The performance of network lifetime is achieved through end to end delay i.e., take a less time delay for communication. Finally, the network lifetime of 7-level SEP gives better performance than 4-level, 5-level and 6-level.

4) Performance of Throughput Ratio

Fig. 6(d) represents the throughput ratio. Here, the data sent over the entire network using proposed protocol is increased efficiently with levels of heterogeneity as compared to 4-level SEP. Finally, the throughput ratio of 7-level SEP gives better performance than 4-level, 5-level and 6-level.

VII. CONCLUSIONS

An improved stable election protocol has been implemented to enhance the stability period of sensor elements during hierarchical node distribution. In proposed protocol, the node distributions (4-level, 5-level, 6-level and 7-level) are examined and an effort has been made to develop a HODs model for large network using different-level heterogeneity of SEP algorithm. The solution is found by varying the probabilities of a node to be elected as cluster head in every round as per the network conditions and an opinion dynamics-based model is applied to optimize the value of probability for the election of the cluster head. The social rank and social influence factor has been calculated and the opinions are updated based on the social influence factors. It is shown that the stability period is extended and the instability period is reduced sharply. Also the packet delivery ratio is seen to be improved for most of the stable zone than 4-level SEP. From the simulation result analysis, the 7-level stable election protocol has been performed better than other protocols.

In future, one of the emerging networking standards that gap between the physical world and the cyber one is the Internet of Things [IoT]. In IoT, the smart objects communicate with each other, data are gathered and certain requests of users are satisfied by different queried data. Based on IoT applications, we use clustering to find similar batches of data that have similar status indicate the quality. Sensor data are time-sensitive and it collects different values at different times. These are considered as challenges for data mining in IoT. For effectively, cluster the sensor data and predict the uniqueness data from the clustered data set, the currently developed algorithm (HODs model based high-level SEP) will be applied in IoT applications.

VIII. REFERENCES

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