Improved - Energy Efficient Sleep Awake Aware Sensor Network Routing Protocol (I-EESAA)

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***Abstract*—Typically, in the smart city concept, a wireless sensor network contains a large number of power constrained sensors. The sensors sensed data from the environment and transmit them towards the base station in a cooperative way. Efficient energy consumption strategy leads to extend the lifetime of wireless sensor network. The clustering structure pattern is largely used to regulate the data transmission and reduce the total consumed energy. In this paper, we propose a new routing protocol represents an improvement on Energy Efficient Sleep Awake Aware Sensor Network Routing Protocol (EESAA) called Improved –EESAA (I-EESAA) for heterogeneous wireless sensor networks (WSNs). I-EESAA protocol consists of many algorithms for clustering, cluster head selection, grouping, sensor mode scheduling and data transmission. The main idea of I-EESAA is the grouping concept which aimed to form groups of sensors, which have the same application type and located in the same communication range. After groups formed, one sensor in each group will still in active mode while the others entered in sleep mode. Simulation results show that I-EESAA protocol performs better than the DEEC, DEV-DEEC, and EESAA in the terms of network lifetime, first node dies, cluster head selection process, and throughput. Three system models are present to test I-EESAA with different environments.**

Keywords—WSN, Sensors, Routing, Clustering, Pairing, Sleep Awake, Smart City

I. INTRODUCTION

There is no doubt that smart cities and electronic services are increasing daily in the era of the electronic and technological renaissance that is occurring in this period. Many of the services provided by the sector or the private sector have turned into a smart electronic method that depends on software and algorithms. The smart city environment consists of many interconnected applications and components according to work protocols, but many of the smart city applications depend mainly on sensing and wireless sensors, so it became clear the extent of the interconnection between the smart city and wireless sensing networks as shown in figure 1. The wide diversity of sensor nodes presents WSNs with a wide range of applications in military, industry, security and environmental research [1]. That means WSNs entered in each side of our life. The real challenge in WSNs is energy. Energy consumption in WSNs based on transmissions which manage by many routing techniques. In other words, we can clearly conclude that routing is the key factor for maximizing network lifetime [2]. So, there are many existing routing protocols presented to solve this challenge. In this section, we implement a survey of literature on some existing universally used wireless sensor routing protocol from which clustering based routing protocols will be focused essentially and some of the improvements on each routing technique. Clustering is one of the major network structure used in WSNs [3]. Due to the energy limitation, cluster presents a good solution to manage data transmission form sensors to base station. Clustering is divided sensors into many groups work together by select a head sensor for each group. Cluster head, gathers sensed data from others associated sensors and forward data to base station directly or by other cluster heads. The main purpose form using the clustering technique is to extend the lifetime of sensor networks by decrease power consumption and reduce data transmission, which needs to run transmitters and amplifiers digital circuits [4].

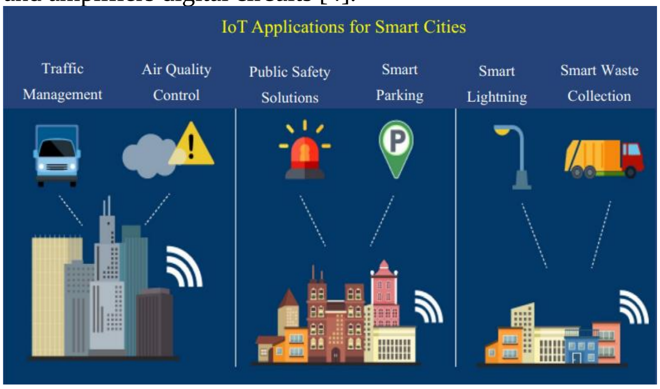

Figure 1: IoT Applications for Smart Cities

Clustering makes the network more scalable and represents a good strategy to gain an enhanced lifetime of wireless sensor networks. So far, much clustering technique has been proposed and differs in cluster head selection process [5]. The leader node of a cluster region is mentioned to as cluster head (CH) [6]. Clustering results in a two range hierarchy in which cluster heads (CHs) represent the higher range while member nodes represent the lower range. The member nodes broadcast their data to the corresponding CHs [7]. The CHs aggregate data and transmit to the base station through other CHs or directly. The base station accommodates the communication link between the sensor network and the network administrator [8].

II. RELATED WORK

Current progress in wireless sensor networks (WSNs) has led to many new protocols specially produced for sensor networks where power awareness is a fundamental point. The main challenge in WSNs is energy due to the bounded energy

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source attached with each sensor therefore, many techniques have been proposed to enhance energy consumption of sensor nodes in a better way and maximize lifetime as possible. The clustering structure produces good results in optimizing energy cost for both homogeneous and heterogeneous networks. In clustering, the sensors which selected as cluster heads in each round act as a router and manager for data transmission, therefore, these sensors will consume an extra amount of energy.

In some techniques, CHs are selected depending on energy to ensure balance, but in other are selected depending on neighbor's counts [9, 10]. This high energy consumption is due to data aggregation and long range transmission. Many clustering algorithms have been developed to enhance the efficient usage of energy in sensor networks. CHs in LEACH [9, 11] protocol are chosen systematically and energy drains consistently by role rotation. In PEGASIS [12] which, depending on chain concept, energy load is distributed by forming a chain itself or being organized by the BS. For such chain formation, global knowledge about the network is required and results in wastage of resources. SEP [13] protocol also represents an extension of LEACH but it is a heterogeneous aware protocol. SEP Protocol is based on weighted election expectations values. The weighted election expectations are calculates of each node to become a cluster head corresponding to their respective energy. In E-SEP [14], the main idea in this protocol is classifying the nodes into three kinds depending on the initial energy of each one. Three class of nodes are normal nodes, intermediate nodes and advance nodes used in E-SEP. In DEEC [15], CHs selection depends on initial energy and residual energy of each node and independently elected as CHs. Figure 2 illustrate the clustering process and data flow.

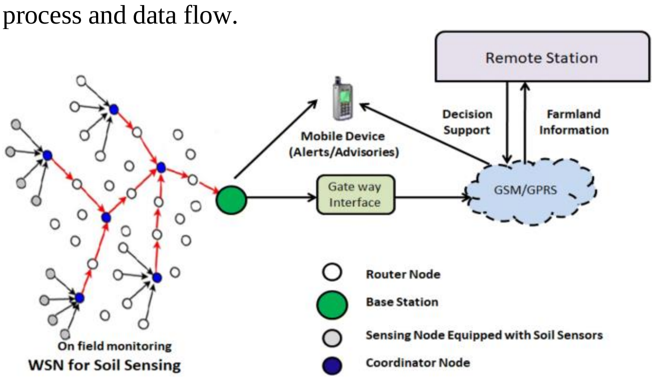

Figure 2: Clustering Strategy In WSN

Developed DEEC (DEV-DEEC) [16] is based on DEEC scheme, where all nodes use the initial and residual energy level to define the cluster heads. To evade that each node needs to have the global knowledge of the networks, DEEC and DDEEC estimate the ideal value of network lifetime, which is used to compute the reference energy that each node should expand during each round. EESAA protocol [17] is trying to minimize energy consumption in order to enhance network stability period and network lifetime. For this purpose, EESAA introduced the concept of pairing. Sensor nodes of a same application and at the minimum distance between them will form a pair for data sensing and communication. In EESAA protocol, also enhance CHs selection technique, by selecting CHs on the basis of remaining energy of nodes. Performance is evaluated on the basis of network stability, the first node dead, all nodes dead, clustering process and throughput. In routing techniques which proposed for distributed trust-based clustering framework in order to adapt the active topology and to secure MANET a special clustering scheme is designed with the ad hoc environment to form stable clusters for the underlying network operations. The flexibility of diameter of any cluster adopted in order to adapt the dynamic mobility of MANET and each cluster has exactly one CH elected based on trust value even if was the node with the most energy comparing with the rest [18].

Another proposal as an improvement of LEACH as source, called CH-leach. In CH-leach, the idea of based clustering scheme to reduce the power consumption to maximize the network lifetime [19]. Based on game theory and autoregressive model, another scheme for routing technique proposed in order obtaining two main gaols for energy consumption metric and ensuring of high WSN efficiency by proposes an intrusion detection model. obtains the optimal defence strategy that balances the wanted gaols by analysing the model's mixed Nash equilibrium solution [20]. For the purpose of increasing the security and efficiency of IoT networks another scheme proposed based on the Protocol for Low-Power and Lossy Networks (RPL). The main idea of it is to secure IoT networks from routing attacks, is to adopt a time-based trust-aware RPL routing by uses a trust-based mechanism. This mechanism aimed to detect and isolate attacks while optimizing the performance of network [21]. In another protocol, there are many metrics used as a basis of the proposed mechanism due to the characteristics of radio parameters and channel conditions by relaying an optimal fixed size of packet. Also, in this protocol there is another main idea which adopted a multi-level of power for transmitting data among CH, members nodes, and base station. All these assumptions aimed to gain extra power to increase network lifetime [22]. The proposed protocols differ in working methodologies by adopting different algorithms for the purpose of forming a cluster and selecting its head. The methodology of the proposals aims to follow a reliable and efficient routing technique and these methodologies. However, the desired result is the same for all proposals and papers submitted, which is to increase the lifetime of the network and increase its efficiency. For example, one of the proposed routing techniques is based on an improved particle swarm optimization gravitational algorithm to enhance the procedure of search for clustering and routing in WSNs [23][24]. In the same process another proposed algorithms are based on Gravitational and fuzzy algorithms for clustering, selecting headers, and routing [25].

Three directions and keys aimed at the algorithm presented in [26]. First is to propose a new technique for cluster formation and another for how to rotate and re-select the cluster heads depending on the centroid position method and finally new mechanisms to achieve the largest possible energy waste for the same goals that we explained previously which are increase network lifetime and its efficiency. Some of the proposed protocols depend on a different improvement path, which is to provide algorithms to detect the aggressors and soft areas in the network that can be exploited by the attackers to achieve a specific failure in a specific aspect that affects the entire work of the network and leads to its inclusiveness undermining its efficiency and even its life cycle [27][28][29][30]. In reference [31], another method proposed called fuzzy C means cluster based light weight social spider optimization (FLSO) protocol. The gaols are for improving secure transmission with less energy consumption. individual cluster's membership used for grouping the nodes and clustering. Also, for the process of heads of clusters selection, the used metric is the lowest ID of the corresponding nodes. For security, a cryptographic algorithm is used called Diffie Hellman. Figure 3 illstrate an example of cryptography algorithm. Sensor networks consist of several nodes that receive and re-transmit information periodically according to the application for which the network was created. It is known that this communication leads to the loss of the node to energy, especially if there is one of those nodes suffering from the focus of communications on it, so it will be the first of the nodes that will lose their full energy and raise the banner of the shafle. The decrease in the power of the node affects the overall efficiency and reliability of the network. Therefore, many of the proposed protocols have set this point as a standard for the quality of the proposed protocol and this is called the load balancing method [32][33][34].

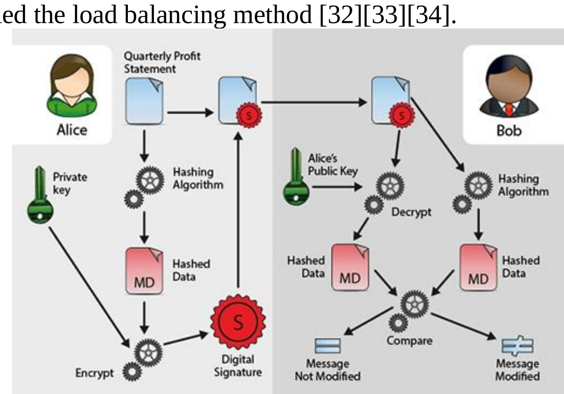

Figure 3: example of cryptography process

Networks vary according to the applications provided by these networks, but sometimes the networks are for sensitive applications related to armies, intelligence, battlefields, and other than the dangerous work environment. Therefore, the routing techniques proposed in such types of applications are based on cryptographic techniques for the purpose of ensuring cybersecurity according to the sensitivity of the situation. In other words, these applications are difficult to penetrate to ensure the longest reliable network life. This means that some of the services provided by the network require following different paths to ensure security and efficiency [35][36][37].

The sensitive environment for work, as mentioned previously, is considered one of the difficult circumstances that require procedures and algorithms that raise the level of trust and security that the node that is sent or received is a reliable node and not fake. Some of the proposed protocols are based on the node selection process on the trust principle, which is calculated in a number of ways, some of which are calculated according to the history of the node and others according to probability theory and so on. However, the amount of trust is the decisive factor in choosing the node, and thus it is the basis for the routing technique [38][39][40][41]. And for the purpose of reliability and trust, some algorithms rely on encryption and find a mechanism based on keys. No node can be involved in the work unless it is fully aware of the working keys and any required encryption operations [42][43][44]. In our proposed protocol, I-EESAA will enhance the clustering strategy used in EESAA and present many algorithms for each step of I-EESAA.

III. Improved - Energy Efficient Sleep Awake Aware Sensor Network Routing Protocol (I-EESAA)

We present a new routing protocol as an improvement in EESAA protocol called I-EESAA for heterogeneous networks. I-EESAA is based on grouping concept, which aimed to form groups of sensors, which have the same application type and located in the same communication range. A new algorithm is used to do grouping concept called Grouping process algorithm (GPA) is presented. The goal of grouping is to work together for sensing data and communication. Also, a new cluster head selection algorithm (CHSA) is presented. For scheduling sensor modes in each round, we present a new sensor mode scheduling algorithm (SMSA). Also, we present three system models based on our proposed protocol I-EESAA varies in the following points:

- Heterogeneity in sensors initial energy.
- Heterogeneity the application type of sensor (for example, temperature, pressure, natural disasters, and traffic).
- Number of Base Station in the work area.
- Locations of Base Stations.

In the system models, which are used more than one BS, a new algorithm called a base station selection algorithm (BSSA) is presented. Base on BSSA, each sensor selects the closed BS based on several steps explained in the coming sections. The deployed sensors have a different initial energy and different application type. One, two, and three sinks used in the proposed work area with the different location at each work start. The main goal is to minimize energy consumption in order to enhance network stability period and network lifetime to support service reliability. More details in the following sections.

A. .Grouping Process algorithm (GPA)

The grouping decision in GPA algorithm is coming from the base station (BS). BS is accessible and has good processing, memory, and energy properties. Firstly BS received all sensor location data, IDs, and stores all application types for all sensors based on its IDs. BS will calculate the distance between each sensor and other sensors from the same application type which located in its transmit range. By mathematical comparisons, BS selects the group of sensors from same application types and at the minimum distance. GPA is managed by BS, therefore, no extra power consumed from normal sensors. After distance calculation and group selection, BS broadcasts the grouped IDs, each sensor know its group from the neighbors sensors. Isolated nodes are still in active mode without grouping. Each group of sensors will be scheduling its modes between active and sleep to minimize power consumption based on the proposed scheduling algorithm. In the first round, each sensor in the active mode will sense and transmit data to its CH. On the other side, the sleeping sensors switch their transceivers in off mode, which leads to save their energy by avoiding overhearing and idle listening during sleep mode. In multi BS models, BSs send their data to the Main Base Station (MBS) and all BSs participate in a main database. GPA steps are explained below:

Algorithm 1: Groupring Process Algorithm (GPA)

```
first round begin
IF (number of BS >1)then
BSs received location ,energy ,and app. type data from sensors
BSs collect data at (MBS)
MBS calculate and decides the pairs based on:
    If ((Sensor.range) DONOT contain any another sensor)then
        Sensor .case = isolate
    Else IF ((Sensor.range) DONOT contain sensor from same type)then
        Sensor .case=isolate
    Else IF ((Sensor.range) contain more than one sensor from Same type)then
            MBS selects two sensors based on minimum distance
    End IF
    End IF
    End IF
Else IF (number of BS =1)then
        Repeat steps from 6 -19
End IF
```

B. *Sensors Mode Scheduling Algorithm (SMSA)*

In SMSA, the grouped sensors change their modes at the beginning of each round based on SMSA. After groups formation, BS transmits groups data to all sensors. A local negotiation occurs between each group of sensor to decide the active one. Firstly, the initial energy is used to decide the active mode sensor therefore, high energy level will switch on in active mode and the other sensors are switched off in sleep mode. Due to CHSP, if the sensor elected as CH for the next round, this means it will still another time in active mode for the next round and the other sensors in the same group are still in sleep mode for another round. SMSA steps are explained below:

Algorithm 3.4: Sensors Mode Scheduling Algorithm (SMSA)

```
IF (round==First) then
    IF( Sensor.case ==isolate)then
        Sensor.nextmode=Active
    ElseIF (sensor.case==group)then
        IF (Sensor A.energy is the higher in the group)then
            Sensor A.nextmode=Active
            Other sensors .nextmode=Sleep
        End IF
    End IF
Else IF(round!=First)then
    IF (Sensor. case==isolate)then
        Sensor. Nextmode=Active
    End IF
    IF (Sensor.case==group && Senser.Lastmode==Active)then
        IF (sensor.NCHF==1) then
            Sensor.nextmode=Active
        ElseIF(sensor.NCHF==0)then
            Sensor.nextmode=Sleep
    End IF
End IF
```

SMSA defines how the modes in each sensor switched in active mode or sleep mode. If the value of the Next cluster head flag (NCHF) equals 1 this means the sensor was selected as CH for the next round and continue in active mode.

C. *Cluster Head Selection algorithm (CHSA)*

CHSA is used to manage the selection process of of CHs in each round. In the proposed techniques an optimal number of CHs are considering. Because the heterogeneity in sensors initial energy, sensors which have a high initial energy level will have the highest chance to be CHs than others sensors. A new algorithm for cluster head selection is proposed, which is used to prevent selection the low energy sensors as CHs. Due to CHSA, the CHs selection algorithm is based on remaining energy in the sensors after each round. This point gives the ability to expand and support the network by dropping a new high energy sensors in the working area, which will be selected as a CHs and give us extra working rounds. Due to GPA and SMSA algorithms, only sensors in active mode will participate in CHs selection from the first round due to heterogeneity in initial energy. The main difference between I-EESAA and the previous proposed techniques is the selection of the CHs in the first round. In I-EESAA the selection based on the remaining energy from the first round and do not based on the distributed algorithm.

Based on CHSA, the CHs selection process can be explained in the following points:

- Firstly, BS participates in CHs selection in the first round only. BS select CH based on the initial energy of the sensor and its location to ensure covering all the working area and also ensure the desired percentage of CHs.
- BS transmits the CHs data to the selected CHs based on stored data, such as IDs, locations, and application types.
- The selected sensors as CHs will receive the transmitted data and begin work.
- CHs broadcast their data to all networks, only sensors in active mode will receive these data
- Due to Received Signal Strength Indication (RSSI), each sensor will select the nearest CH.
- Selected CHs gathers the energy level from their associated sensors and select one sensor to be CH in the next round CH (NCH) based on remaining energy.
- This process will continue until the last sensor is dead.

D. Network Transmission Process (NTP) of I-EESAA:

After CHs selection, each cluster contains (N/Z) members, where Z is the number of clusters, N are the total number of sensors, therefore, the average number of sensors in each cluster (Nav) can be calculated by equation 1:

$$\text{Nav} = \frac{N}{Z} - 1 \quad (1)$$

But due to the GPA, some of sensors were switched to sleep mode and this mean that these sensors do not participate in sensing and transmitted data, therefore, the number of active sensors in each cluster(SAC) can be calculated by equation 2:

$$\text{SAC} = G_{no.} + 1 \quad (2)$$

Where, $G_{no.}$ is the number of groups in each cluster. But, in instability period the cluster loses many of the sensors after consuming its available energy, therefore, equation 2 can be written as shown in equation 3.

$$\text{SAC} = (G_{no.} + 1) - \text{Ds} \quad (3)$$

Where, Ds is the number of sensors which consumed its energy and become out of work in each round. CHs aggregates received data from its active mode member sensors and transmit to BS. Due to PPC the energy is saved.

Due to NTP, in order to transmit data, non CHs sensors will consume the calculated by equation 4:

$$E_{nonCH} = \left[\left(\frac{N}{X} - 1\right) - S_s\right] * E_{TX} * E_{amp} * M^2 * \mathrm{D}^2{}_{toCH} \quad (4)$$

Where, ETX is the energy consumed to run the transmitter circuitry, Eamp is the energy consumed to transmit amplifier to achieve acceptable SNR (Signal-to-Noise Ratio), M is the length of the message, S_s is the sleep sensors, and DtoCH is the distance between sensors and its CHs, which is calculated by the mathematical law of distance between two points(Cartesian law). But, in instability period, equation 3.20 converted to equation 5.

$$E_{nonCH} = \left[\left(\frac{N}{X} - 1\right) - S_s - D_s\right] * E_{TX} * E_{amp} * M^2 * \mathrm{D}^2{}_{toCH} \quad (5)$$

To receive data, the non CHs sensors consumed energy can be calculated by equation 5:

$$E_{rec} = \left[\left(\frac{N}{X} - 1\right) - S_s\right] * M * E_{RX} \quad (6)$$

Where ERX is the energy consumed to run the receiver circuitry. But, during instability period, equation 6 converted to equation 7.

$$E_{rec} = \left[\left(\frac{N}{X} - 1\right) - S_s - D_s\right] * M * E_{RX} \quad (7)$$

On the other side, for data aggregation CHs for consumed energy can be calculated by equation 8:

$$E_{AGR} = \left[\frac{N}{X} - S_s\right] * E_{AD} * M \quad (8)$$

Where, EAD is the consumed energy to aggregate each bit from the members and in instability period, the equation 8 can be written as shown in equation 9

$$E_{AGR} = \left[\frac{N}{X} - S_s - D_s\right] * E_{AD} * M \quad (9)$$

To transmit these aggregate data to BS, CHs consume energy, calculated in equation 10:

$$E_T = E_{TX} * E_{amp} * AD^2 * D^2{}_{toBS} \quad (10)$$

Where AD is aggregated data length, DtoBS is the distance between CH and BS, which represents one hop size or the summation of multi hops. The total consumed energy by CH is calculated by equation 11:

$$E_{CH} = E_{rec} + E_{AGR} + E_T \quad (11)$$

Where E_{CH} represents the total CH energy consumed to receive data from its members sensors, aggregation received data, and transmit these data to BS.

E. Base station selection algorithm (BSSA)

In I-EESAA, many system models can be presented. In some of these models, more than BS are used to manage the network. Therefore, this section explains BSSA algorithm to declare how the sensors can select one BS from many BSs. BSSA is explained through the following steps:

- Each BS connects with other BSs with high-quality communication way and works in the main database, therefore, each BS has the same data about all sensors.
- The sensors transmit their locations, energy, and application type's data to all BSs.
- Each BS calculates the distance between it and all sensors.
- BSs collect the data in the main base station (MBS).
- MBS makes a comparison between the distance columns of all BSs and divide the sensors based on minimum distance.
- Each BS received from MBS the IDs of its sensors.
- BSs broadcast a special message contains their location coordinates in the work area.
- All sensors received the special messages and due to a Received Signal Strength Indication (RSSI), each sensor will select the nearest BS.
- Finally, each sensor knows the nearest BS and communicates with it when selects as CH.

IV. PROPOSED SYSTEM MODELS:

To test the proposed protocol I-EESAA with different system models and show the effect of the heterogeneity in sensor application type, the heterogeneity in initial energy, the effect of increasing number of BS and to test BSSA algorithm to select BSs, we present three system models shown in the following sections.

A. One base station with heterogeneity application and energy (1BWH):

In IBWH model, sensors deployed randomly, heterogeneity in initial energy, heterogeneity in sensors application types and one base station used to manage the network. The location of BS varied at the start of each work. Figure 4 illustrates IBWH model.

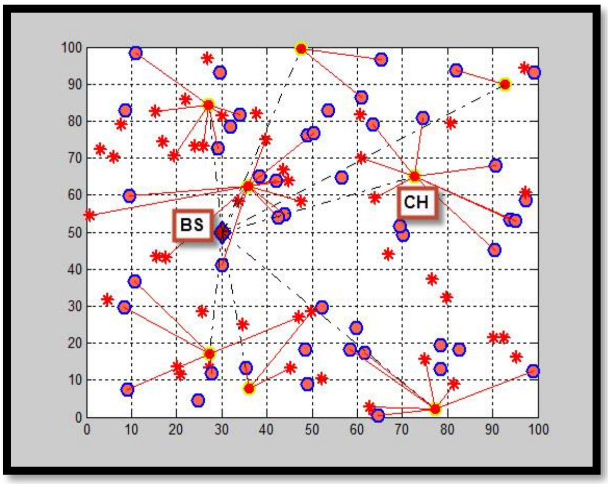

Figure 4: IBWH model

B. Two base station with heterogeneity application and energy (2BWH)

In 2BWH model, also sensors deployed randomly, heterogeneity in initial energy, heterogeneity in sensor application types and two base stations used to manage the network. The location of BSs fixed on the sides of area work. Figure 5 illustrates 2BWH model.

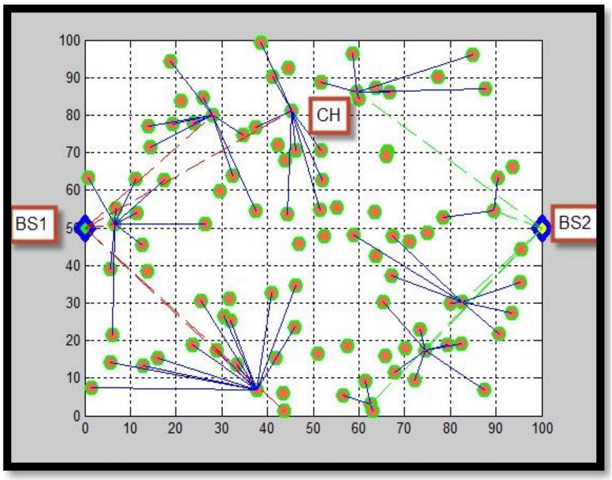

Figure 5: 2BWH model

C. Three base stations with heterogeneity application and energy (3BWH):

In this 2BWH model, also sensors deployed randomly, heterogeneity in initial energy, heterogeneity in sensors application types and three base stations used to manage the network. The location of BSs varied at the start of work. Figure 6 illustrates 2BWH model.

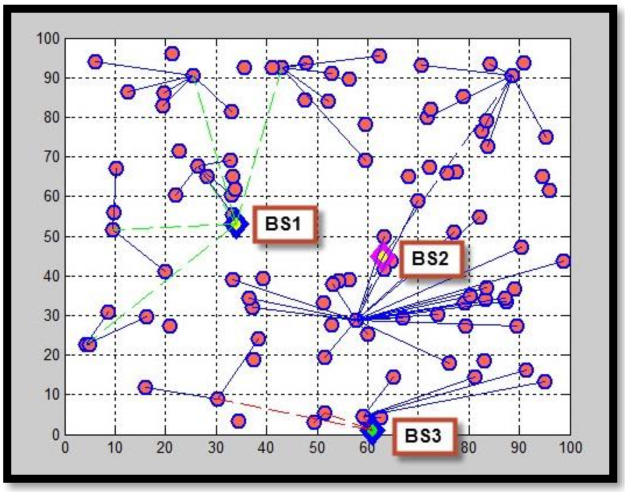

Figure 6:3BWH model

V. SIMULATION AND RESULTS

A. I-EESAA performance compared with other protocols

In the simulations, a working area of 100m× 100m size is used. In this area, randomly use (100) sensor nodes with initial energy (Eo) less than 1 J for each node. For examining and comparing the performance of the proposed technique and the effect of heterogeneity, sink position and the number of sinks use to serve the network area. A comparison is made with DEEC, DEV-DEEC, and EESAA protocols. The parameters of the simulation are shown in Table 1

In the simulation, the following metrics will be calculated

- Stability period: is the work duration of network from starting network operation until the first node consumes its energy and dies.
- Network lifetime: Network lifetime is duration from starting network operation until the last node is alive.
- Number of Cluster Heads: It indicates the number of clusters selected per round.
- Instability period: is the work duration of network operation from the first node dies till the last node dies.
- Packet to BS: It is the rate of successful data transmission to BS from CHs.

Table 1: simulation parameters

Parameter	Value
Network size	100m * 100m
Initial Energy	(0.5-1)J
Data Aggregation Energy cost	50pj/bit j
Transmit amplifier (Eamp)	100 pJ/bit/m2
Pd	0.1 J
Number of nodes	100

Transmitter Electronics (EelectTx)	50 nJ/bit
Receiver Electronics (EelecRx)	50 nJ/bit
Packet size	4000 s

Figure 7 illustrates the enhancement occur in I-EESAA comparing with EESAA, developed DEEC (DEV-DEEC), and DEEC protocols. The stability period is prolonged in I-EESAA comparing with other protocols. The first round dead in I-EESAA after 2230 rounds while in EESAA after 1800 rounds, in developed DEEC after 1350 rounds and in DEEC after 1300. This mean the enhancement percentage in stability period is 23%, 65%, and 71% comparing with EESAA, DEV-DEEC, and DEEC. The network lifetime also is maximized to 56%, 102%, and 127% comparing with EESAA, DEV-DEEC, and DEEC.

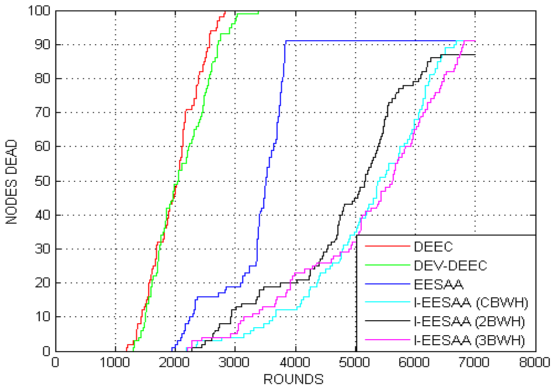

Figure 7: Dead nodes in 100m * 100m network

Figure 7 also explains that there is a quick, sudden increase in the number of dead sensors in DEEC and DEV-DEEC protocols, and in a moderate manner in EESAA while in I-EESAA sensors deads at a constant average rate. This observation appears that in I-EESAA energy consumption is properly distributed among all the sensors in the network which leads to increase the network lifetime.

Figure 8 shows that the rate of data transmission to BS is better than other protocols and take an increasing line form because the efficient CHs selection algorithm CHSA used in I-EESAA which helps to make the constant data rate transmission to BS. GPA and SMSA also caused maximizing network lifetime, which leads to increase successful data delivery and higher data rate compares with other protocols.

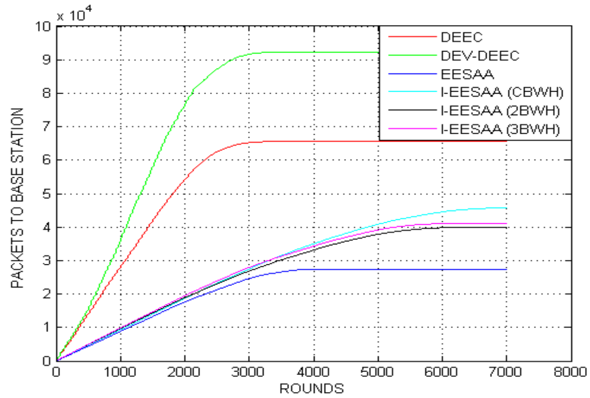

Figure 8: Packets sent to BS

In Figure 9, we compare the number of CHs selected in every round for all routing protocols. We notice that random numbers of CHs are selected in every round and unlimited selection mode used in DEEC and DEV-DEEC while in I-EESAA we used an efficient CHSA algorithm which leads to select a suitable number of CHs with fixed limits in each round but EESAA has some patterns and controlled CHs selection.

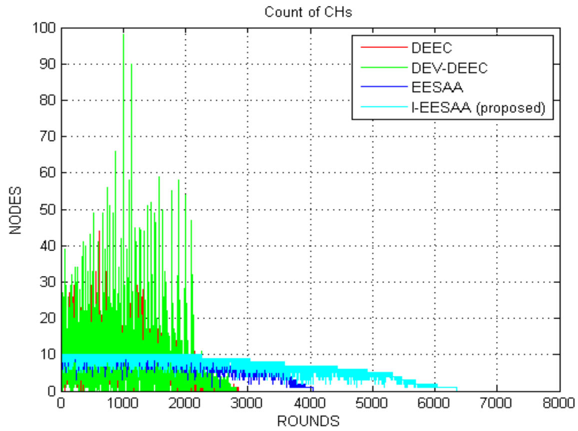

Figure 9: CHs pear round

CONCLUSION

In this paper, we proposed a new routing technique for WSNs as an improvement on EESAA protocol. Our proposed based on grouping concept and we also present a new algorithm to schedule sensors mode between active and sleep modes. The main goal was to maximize network lifetime by using efficient energy consumption model and cluster head selection process to enhance service reliability. In our models, CHs were selected on the basis of remaining energy from the first round. Before begin work, BS select the cluster heads based on energy and coverage. SMSA algorithm makes a good enhancement in power consumption by changing sensor mode phase between sleep and active. Stability period of the network and lifetime has been improved. Simulation results show that there is significant improvement in first node dead, tenth node dead, packets sent to BS, and packets sent to CHs when compared with related work in the same area such as DEEC, DEV-DEEC, and EESAA protocols. The main drawback in the I-EESAA is the centralization in the proposed algorithms, which based on BS.

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