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Survey on Energy Optimizing Protocol in Hierarchical Wireless Sensor Networks

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ABSTRACT: In Wireless Sensor Network, the proper energy utilization is the main issue for designing the protocol because sensor nodes have limited battery backup. There are many modern protocols which increase the lifetime of the wireless sensor network by efficiently using battery power of the sensor node. In this paper, we study modern protocols like LEACH, SEP, ESEP, TEEN and EDDEEC Energy Dissemination Clustering for Mobile Sink Based Heterogeneous Wireless Sensor Networks. We analyze and compare the performance.

KEYWORDS: Wireless Sensor Networks, Clustering, Energy Efficiency, Stable Election, Network Lifetime.

I. INTRODUCTION

Wireless sensor networks (WSNs) [1][2] are group of sensor nodes that sense the environment and send the data to the users. Each sensor node in WSN is an electromechanical observing device. The microelectronic mechanical systems (MEMS) is a new developed technology today, MEMS with wireless transmission technologies have developed small sized, low-energy and low-cost multifunctional smart sensor nodes in a wireless sensor network (WSN) [9][10]. For monitoring physical and environmental conditions such as temperature, humidity, radiation, sound, vibration, motion, light and pressure the sensor nodes cooperate together to collect environmental information and data.

Earlier, the developments, application and usage of wireless sensor networks were initiated by military such as battlefield surveillance; today the modern sensor [9][10] networks are bi-directional and have self-controlling ability. Modern sensor networks are used in many industrial, commercial and consumer applications, such as industrial process control and monitoring, instrument health monitoring, healthcare applications, traffic control system, home automation and so on.

The WSN [1] consists of hundreds to thousands sensor nodes, where each sensor node is connected to several sensor external antenna, a microcontroller, an electronic circuit for interfacing to the sensors and a power source, typically a battery or an embedded form of energy source. The cost of sensor nodes may vary, according to the type, size, functionality, applications and complexity of the individual sensor nodes. The cost of the multifunctional sensor is usually 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. The information propagation technique among the multiple hops of the sensor network may be routing or flooding. To resolve the scalability and expandability issues the cluster based techniques and protocols have been originally proposed for the wire line networks. Now, the cluster based protocols are used in WSNs to minimize the energy consumption [3]. Once WSN is deployed, then the power backup or replacement of sensor nodes are not possible practically. Therefore, WSN must operate without human manipulation or involvement so our main focus is to enhance the lifetime of the network in any way and for this purpose many protocols and techniques were introduced and proposed.

Sensor Selection Criteria:

There are a number of parameters to be considered when selecting wireless sensor measurement devices.

Type of Measurements: Type of Measurements: It is important to understand what parameter is being measured. The

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wireless transmitters of sensor which incorporate process of measurement and process control typically have a defined unique function. Generally, sensors are specially designed for measuring temperature, pressure, humidity, light, radiation, motion, flow, etc., and it must be selected accordingly.

Accuracy and Its Response Time: How accurate and precise the measurement to be needed, and how quickly and early should the measurement be updated. Now, most wireless sensors are as precise as their wired devices, however the recorded readings are generally transmitted every few seconds for preserving battery power backup. If any instantaneous measurement is urgently required, then it must be taken into consideration while selecting a wireless transmitter because some certain models may not present the desired response time.

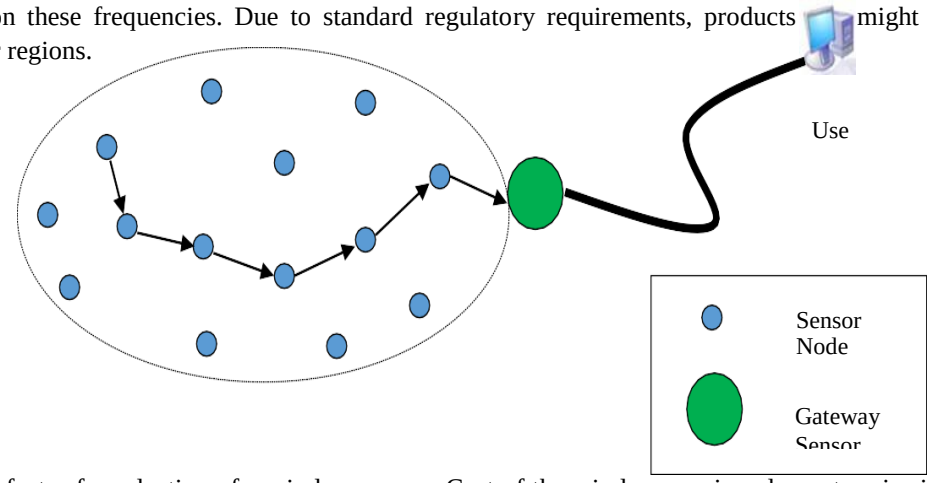
Environmental Condition: While selecting a wireless sensor node device, the environmental and physical condition is observed because sometimes wireless sensor nodes are deployed in such region where human staying or manipulation isn't doable for brief or very long time. Wireless sensing devices may be deployed in highly polluted area, high temperature area, high radiation zone, high pressure area and unsuitable condition for human to stay or survive.

Functionality: A wireless sensor may have only one function like only one physical condition detection such as temperature measurement or it may have multifunction like temperature detection as well as humidity detection. Modern wireless sensors are multifunctional as they can detect more than one physical condition at a time. Wireless sensors are also unidirectional or bifacial as they will receive management signal from the user.

Range: The range of wireless sensors varies widely according to the applications. Some sensors are designed usually for indoor, short-range applications of a few twenty meters, whereas other sensors can transmit information to a receiver located so far away. Regardless of the sensors capability the interference, attenuation and other obstructions always affect range limit of a wireless signal. Transmitting signals through machines, walls, structures and building degrades the signal strength and reduces limited range capability. As a result, range limit of a transmitter located indoors is significantly less than the exact same transmitter broadcasting it outside in wide open area.

Repeatability: Some wireless sensors can be reused after long time duration with replacing some components of the sensor node. For more use in future, as an electromechanical device, damage or non-working wireless sensors can be recycled. Modern technology MEMS (Micro Electronic Mechanical System) usually produces such sensors which have reusability and repeatability.

Frequency: The frequency of radio transmission is also important factor to be considered. Laws and standards vary by country and area as to which parts of the limited wireless spectrum are available for use or observer without specific licenses. From 800 MHz to 2.4GHz in case of WiFi are the major frequencies factories which can be used to transmit signals. As part of the industrial, scientific, engineering and medical band, users usually do not need a radio license to completely operate on these frequencies. Due to standard regulatory requirements, products might only be available in particular regions.



Cost: Cost is a major factor for selection of a wireless sensor. Cost of the wireless sensing element varies in step with their practicality, as the multifunctional wireless sensor devices are more costly compared to uni-functional wireless sensor. Cost conjointly depends on the sort of applications wherever wireless sensors are deployed..

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II. LITERATURE REVIEW

In this paper we reviewed, explored and analyzed some modern energy efficient protocols [19] like LEACH, SEP, ESEP, TEEN and TSEP.

A. LEACH (Low Energy Adaptive Clustering Hierarchy)

LEACH [4] is a proactive and cluster based routing protocol. In LEACH clustering reduces the energy consumption in sensor nodes. In a wireless sensor network, to distribute the load evenly among all sensor nodes the hundreds and thousands of sensor nodes are dispersed randomly. These sensor nodes continuously sense data, transmit it to their associated cluster heads (CHs) which receive, aggregate and send this data packets to the Base Station (BS) or sink. In LEACH, all the sensor nodes deployed in the environment are homogeneous and each node has limited battery power. To distribute the work load among all nodes and to improve the lifetime of the network clusters are formed. In this network, each sensor node is made to become CHs on their turns [4]. Each node randomly elect itself as a CH (cluster head) and this process is done in a way that each node becomes a CH once in the time period of 1/ round. Once a node becomes cluster head (CH) then again the same node will become CH after all other nodes get a chance to become a CH. The cluster heads (CHs) selection procedure is done on the probabilistic basis [4], each node generates a random number in the rage of 0 and 1, if generated value is less than threshold value computed by the equation given below [4],

$$T_N = \begin{cases} \dfrac{P}{1 - P\left[r.mod\dfrac{1}{P}\right]} & if\ n \in G \\ 0 & otherwise \end{cases}$$

and then that node becomes a CH.

$$T_N = \begin{cases} \dfrac{P}{1 - P\left[r.mod\dfrac{1}{P}\right]} & if\ n \in G \\ 0 & otherwise \end{cases}$$

where,

TN = Threshold

P = Probability or change of node to become a CH r = Current round number

G = Set of nodes which are not became a CH in 1/P round. By using this threshold value, each sensor node will become a CH in 1/P rounds, thus probability of becoming CH among remaining nodes must be increased, and however there are some nodes that are eligible to become CH.

Advantages of LEACH:

The strategy of LEACH [4] protocol is completely distributed, it minimizes energy consumption 4 to 8 times lower in case of multi-hop data packets transmission.

All the sensor nodes in the network die at about the same time due to even distribution of CH work in LEACH protocol. The control information from base station is not required for sensor nodes in LEACH [4] protocol. LEACH [4][6] minimizes 7 to 8 times low overall energy consumption as compared to direct transmission and minimum transmission energy (MTE) [6] routing protocol. Sensor nodes do not require knowledge of global network or identification in completely distributed wireless sensor network.

Limitation of LEACH:

Nodes have different energy level, but CH is selected unreasonably.

The performance of LEACH protocol is not ideal for large geographical areas.

B. SEP (Stable Election Protocol)

SEP [7] protocol is an improvement and enhancement of LEACH [4] protocol which uses clustering based routing strategy based on the node heterogeneity of the sensor node in the networks. In this protocol and technique, some of the

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sensor nodes have high energy they are referred to as the advanced nodes and the probability of the advanced nodes to become CHs is more as compared to the normal nodes and the normal nodes have lower energy as compared to the new nodes in the network. SEP strategy uses a shared method to select a CH in WSNs. It is heterogeneity-aware protocol and CH selection probabilities of nodes are weighted by initial energy of each node compared to the other nodes in WSN. So basically, SEP protocol is based on two levels of node difference as normal nodes and advanced nodes.
Let, m is the fraction of total number of nodes n, which are deployed with α times more energy than the others nodes.

These powerful nodes are as advanced nodes.

The remaining (1 − m) × n nodes are as normal nodes.

Probability of normal nodes to become CHs is calculated as

$$P_{nor} = \frac{P_{opt}}{1 + m.\alpha}$$

- Probability of advanced nodes to become CHs is calculated as

$$P_{adv} = \frac{P_{opt}}{1 + m.\alpha}(1 + \alpha)$$

Popt is the optimal probability of each node to become CH in the network. In SEP [7][8] strategy, selection of CH is done randomly on probability basis for each node. Sensor nodes endlessly sense data and transmit it to their related CH and CH transmit that data it to the sink or base station (BS). This system can be further improved by increasing the value of or P . Due to advance nodes with two level of node heterogeneity, SEP [7] strategy results in high stable time period, high network lifetime and high throughput.

Advantage of SEP:

Any identification or global knowledge of energy of sensor node is not required in SEP [7] technique at each selection round of cluster head.

Limitations of SEP:

The cluster head (CH) selection among sensor nodes are not dynamic, which results that nodes that are far away from the powerful nodes will die first.

C. ESEP (Enhanced Stable Election Protocol)

ESEP [7][11] is improvement and enhancement of SEP technique. Three types of sensor nodes are considered in ESEP method, as normal, advance and intermediate nodes on the basis of their power levels. The purpose of ESEP is to build a self-configured WSN which enhances network lifetime and stability period. Each sensor node in a network, continuously sense environment and transmits data to their associated CH, whereas, CH aggregates data to reduce data redundancy and sends that data to base station. In ESEP, advance nodes are some of total nodes having additional energy as in SEP. Intermediate nodes are those nodes having extra energy greater than normal nodes but less than advance nodes, and normal nodes are the remaining nodes. In ESEP, CHs are selected on probability based method for each type of node.

Advantage of ESEP:

Due to three levels of diverse in ESEP [7][11], the energy saving advantage is little enhanced as compared to SEP. The limitation of ESEP is same as SEP.

D. TEEN (Threshold Sensitive Energy Efficient sensor Network protocol)

TEEN [13] is a reactive network routing protocol which is basically used for time critical applications. In TEEN [13] protocol, nodes continuously sense the medium, but the data packets are transmitted less frequently. In TEEN [13] strategy, data packets are transmitted only when there is any change occurs in the environment. TEEN [13] is basically

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threshold sensitive protocol which is based on two levels of threshold value, first hard threshold and second soft threshold. In hard threshold mode, the nodes transmit data packets if the sensed data value exceeds the limited range and thus it reduces the number of data packet transmissions or frequent data transmission. In soft threshold mode, the nodes transmit data packets if there is any little variation in the sensed data value. The sensor nodes continuously sense the environment and store the sensed data value for transmission up to the hard threshold limit exceeds. Whenever the sensed data value equals or exceeds the hard threshold value, then sensor nodes transmit their data packets to associated CHs. Next time, data packets are transmitted if there is any difference between the sensed data value and previously saved data value is equals or exceeds the soft threshold value. So, in TEEN [13] routing strategy, energy consumption is reduced as well as great throughput is achieved, network lifetime is increased and stability time period is improved than proactive based protocols.

Advantages of TEEN:

TEEN [13] is well suited for the time bounded applications. In terms of energy utilization and response time TEEN protocol is quite efficient.

According to the applications and criteria, soft threshold [14] value can be varied.

Smaller value of soft threshold produces more precise result of the WSN.

Limitations of TEEN:

The sensor nodes will never shared, if the threshold value is not reached. No data will be achieved from the sensor network at all and it will be unknown even if all the sensor nodes die.

Cluster heads (CHs) will always wait for data from their nodes and keep their transmitter on.

E. TSEP (Threshold-Sensitive Stable Election Protocol)

TSEP [12] combines the features of ESEP and TEEN protocols. TSEP is also a reactive routing protocol and it posses three different levels of energies. Cluster head (CH) selection is done by threshold value, due to three levels of node heterogeneity and being reactive network routing protocol, it produces increased stability period and network lifetime. By comparing TSEP with SEP, LEACH, ESEP and TEEN it is concluded that TSEP protocol performs well in small as well as large geographical networks.

Advantages of TSEP:

TSEP [12] combines the best features of ESEP and TEEN protocols. The performance of TSEP is better than LEACH, SEP, ESEP and TEEN protocols.

Limitation of TSEP:

There is no calculation of energy levels for cluster head (CH) selection, CH is still probability based in TSEP protocol.

Table 2.1: Summarized Review of Modern Energy Efficient Protocols

S.No.	Protocols	Year	Type	Max Throughput	Advantages	Limitations
1.	LEACH	2000	Proactive	1.5×104 Packets	Clustering	Not ideal for large areas
2.	SEP	2004	Proactive	1.5×104 Packets	2 level of heterogeneity	CH Selection is not dynamic
3.	ESEP	2012	Proactive	1.5×104 Packets	3 level of heterogeneity	CH Selection is not dynamic
4.	TEEN	2001	Reactive	2.5×104 Packets	Hard & Soft Threshold	Threshold Limitation

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5.	TSEP	2014	Reactive	2.5×104 Packets	Hard & Soft Threshold with 3 level of heterogeneity	Still probability based CH selection

LEACH, SEP, ESEP, TEEN and TSEP protocols still use probability based cluster head (CH) selection. On probability based cluster head selection, low energy nodes may be selected as cluster head and high energy nodes may not be selected as cluster head. LEACH, SEP and ESEP are proactive network routing protocols where nodes regularly transmit data to base station and transmission consumes more energy compared to sensing. SEP and ESEP are node heterogeneity aware protocols which improve network lifetime but the limitation of node heterogeneity is this that throughput is also increased which decrease lifetime of WSN. TEEN and TSEP are reactive network routing protocols where frequent data transmission is limited by threshold value. To improve energy efficiency, and network lifetime, our proposed protocol EEDCP is observed to be better than these protocols.

III.PROBLEM STATEMENTS

The problem statement is basically not problems in the energy efficient routing protocols rather these are limitations of the routing protocols. In this chapter of the thesis report, limitations of modern energy efficient routing protocols are pointing out which was analyzed in the chapter of literature survey.

A.Probability Based Cluster Head Selection:

The cluster head (CH) selection in LEACH, SEP, ESEP, TEEN and TSEP protocols is on the bases of the probability. There are not any calculations of energy of the device nodes from cluster throughout the cluster head choice. Because the quantitative relation of current energy to initial energy among the device nodes area unit totally different therefore cluster head choice on likelihood based mostly produce unbalancing in choice of cluster head.

B. Proactive Routing Protocol:

LEACH, SEP and ESEP protocols work as a proactive routing protocol, where all sensor node devices continuously sense the environment and continuously send the data packets to the base station. Because transmission of information packets consumes a lot of energy as compared to sensing therefore proactive routing protocol has this limitation.

The continuously received sensed data packets have same repeated attributed or values in the data which may be useless for the observer of the sensor network.

C. Limitation of Heterogeneity:

SEP and ESEP protocols are heterogeneity aware protocols which improve stability period and network lifetime but here a limitation of heterogeneity is this that throughput is also increased which decrease network lifetime. To improve and enhance energy potency, accuracy and also to enhance network lifetime, the proposed protocol is observed to be better than other protocols.

IV. SOLUTION APPROACH

In this section, we proposed A Novel Energy Aware Clustering for Multilevel Heterogeneous Wireless Sensor Networks is discussed which is based on energy level calculation as well as three levels of node heterogeneity and threshold estimation. Cluster head (CH) selection is based on energy level of nodes in the proposed work unlike LEACH, SEP, ESEP, TEEN and TSEP as cluster head is selected on probability bases. Clustering method [20] provides an efficient and effective way to increase the network lifetime of a WSN. The clustering algorithms discussed in literature review basically utilize two techniques, first the selection of a cluster head (CH) with more residual energy and second the rotation of cluster heads (CHs) on the probability basis periodically, for an equal distribution of energy consumption among sensor nodes in each cluster and enhance the lifetime of the WSN. To forward data packets to the base station, cluster heads usually cooperate with other cluster heads, the cluster heads is selected basically on the probability bases and high residual energy node might not be chosen as cluster head (CH) and low residual energy node is also chosen as cluster head (CH).

To address this problem, the proposed work, which is based on residual energy level estimation of sensor nodes as well

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as it combines the best feature TSEP protocol and also provides mechanism for periodical knowledge packet gathering in WSN.

Formation of Cluster:

In Wireless Sensor Network [21], all sensor nodes are grouped into many clusters and one cluster head is selected in each group of cluster. All device nodes sense their atmosphere and therefore the perceived values area unit transmitted to their associated cluster heads (CHs) and eventually the collected perceived knowledge packets area unit transmitted to the base station (BS).Clustering [18] provides an efficient and effective way to enhance the lifetime of a wireless sensor network. The clustering algorithms discussed in previous section usually utilize two techniques, selection of cluster heads with more residual energy and rotating cluster heads (CHs) on the probability basis periodically, for distribution of energy consumption among sensor nodes in each cluster and enhance the network lifetime. When cluster heads cooperate with other cluster heads to forward their data packets to the base station, usually the cluster heads nearer to the sink or base station of the network area unit loaded with high knowledge packet transmission traffic and it tend to discharge or die early, leaving remaining region of the network uncovered and causing network partition.

For cluster formation [7] in the WSN, the base station (BS) broadcasts a signal at a fixed energy level. Each node within the network computes its approximate distance from base station supported received signal strength. It provides the sensor nodes to estimate the proper power strength level to communicate with base station [7].

V. CONCLUSION AND FUTURE WORK

In this paper, we studied a reactive network routing method with three different levels of node heterogeneity. This work combines the best features of TSEP and energy level estimation method. Due to the concept of energy level based cluster head selection, hard and soft threshold value, three levels of node heterogeneity and being reactive routing network method produces increase in energy efficiency, enhanced lifetime of network and maximum throughput as shown in the simulation result. In comparison with SEP, LEACH, ESEP, TEEN and TSEP it can be concluded that this work will perform well in small as well as large geographical networks and best suited for time critical applications. However this work is not suitable where frequent information is received from wireless sensor network. Our future direction we will overcome limitation of above said protocol. Finally, in future, the concept and implementation of mobile base station can be introduced in this work to perform the next level of technology of wireless sensor network.

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